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# Morphological Characterization of *Baladi* Goats in the West Bank, Palestine

# الصفات الشكلية والمظهرية للماعز البلدي في الضفة الغربية – فلسطين

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## Abstract

A field survey was conducted to characterize local "*Baladi*" goats in the West Bank, Palestine. A total of 104 flocks were sampled in the Southern, Central and Northern geographical regions. Qualitative and quantitative characteristics were recorded on 104 bucks and 416 does. Significant differences were found between males and females and among regions. The multivariate discriminant analyses were able to identify seven body measures for bucks and eight body measures for does which were significant in discriminating *Baladi* goat populations from the three regions. For bucks, the squared Mahalanobis distances showed higher differentiation between the Southern and Central regions (11.83) and between the Southern and Northern regions (8.02) than between the Central and Northern regions (4.27). For does, distances were similar (3.05, 2.90, and 3.13 between Southern and Central, between Southern and Northern, and between Central and Northern regions, respectively). Canonical discriminant analyses showed that 81.6% of bucks and 74.1% of does were correctly classified into their geographic areas with highest rates found in the Southern region (96.9% of bucks and 88.3% of does). These results form the basis for the development of future characterization and conservation plans of *Baladi* goats in Palestine.

**Keywords**: *Baladi* goats, morphological characteristics, Multivariate Discriminant Analysis, West Bank, Palestine.

**ملخص**

لقد تم دراسة الصفات الشكلية والمظهرية للماعز البلدي في الضفة الغربية باستخدام المسح الميداني. وكان عدد قطعان الماعز المستهدفة 104 موزعة على مناطق شمال ووسط وجنوب الضفة الغربية. وقد تم دراسة الصفات النوعية و الكمية ل 104 من الذكور و416 من الاناث. وبينت نتائج الدراسة فروقات معنوية بين الذكور والاناث وبين المناطق المختلفة (الشمال، الوسط و الجنوب). وقد حدد تحليل multivariate discriminant analysis سبع صفات في الذكور وثمان في الاناث مهمة في التمييز بين الماعز في المناطق المختلفة. وبالنسبة للذكور فقد بين التحليل ان مسافة Mahalanobis كانت اعلى بين المناطق الجنوبية والوسطى (11.8) وبين قطعان الجنوب والشمال (8.02)، مقارنة بين الوسط والشمال (4.27). اما بالنسبة للاناث فقد كانت المسافات متشابهة بين المناطق المختلفة (3.05، 2.90، 3.13 بين الجنوب والوسط، والجنوب والشمال، والوسط والشمال، على الترتيب). كما بين تحليلcanonical ان 81.6 من الذكور و74.1 من الاناث في مناطق الدراسة قد صنفت بطريقة صحيحة حسب مناطقها وكان اعلى معدل للتصنيف الصحيح في المنطقة الجنوبية من الضفة الغربية (96.9% للذكور و 88.3% للاناث).ومن هنا، يمكن اعتماد نتائج هذه الدراسة كاساس لتطوير الخطط المستقبلية والبرامج المتعلقة بتشخيص والمحافظة على الماعز البلدي في فلسطين وتحسينه.

**الكلمات المفتاحية:** الماعز البلدي، الصفات الشكلية، Multivariate Discriminant Analysis، الضفة الغربية، فلسطين.

## Introduction

In 2010, the total goat population in Palestine was 219, 364 heads (207, 214 heads in the West Bank and 12, 150 heads in Gaza) with the *Baladi* breed comprising 85.6%, Shami (Damascus) breed comprising 6.2%, and *Baladi* x Shami comprising 7.9% (PCBS, 2011). The *Baladi* goat breed is an important breed in several other Middle East countries including Jordan, Syria, Lebanon, and Iraq (Alrousan, 2009; Azmi*et al*., 2011; Hassen *et al*., 2016; Zaitoun, Tabbaa & Bdour, 2005). The breed is also known by other names such as the Mountain Black, Mountain, and Black in Jordan (Alrousan, 2009) and Mamber and Syrian Mountain in other countries (Devendra & Mcleory, 1982, Al-Khoury, 1997). It is a dual-purpose breed (milk and meat), well adapted to local arid conditions and capable of grazing in steep mountainous areas (Azmi*et al.*, 2011). Therefore, it is a valuable genetic resource for the region. However, its milk production is low and sometimes farmers crossbreed *Baladi* goats with Shami bucks to enhance milk production (Abdallah, 1996; Azmi *et*

*al*., 2011). Random uncontrolled crossbreeding results in loss of locally-adapted genetic resources like the *Baladi* breed. Therefore, conservation and improvement programs are needed to be implemented.

Despite the importance of the *Baladi* goat breed, few researches were done on *Baladi* goats, particularly in Palestine. Thus, information on morphological characteristics is very scarce. Such information is important to study genetic diversity and design genetic improvement and conservation plans (FAO, 2012; Herrera, Rodero, Gutierrez, Pena, & Rodero, 1996; Jordana, Ribo, & Pelerin, 1993). Furthermore, morphological characterization is the first step for the characterization of local genetic resources (Delgado *et al*., 2001) and precedes molecular genetic characterization. The main objective of this study was to describe the qualitative and quantitative morphological characteristics of *Baladi* goats of the West Bank and investigate if any differences exist among the main geographical areas (Southern, Central, and Northern).

## Material and methods

### Sampling procedure

Within each of the thirteen districts of the West Bank, 8 flocks raising *Baladi* goats were randomly selected based on information provided by the extension services of the Palestinian Ministry of Agriculture. Four *Baladi* does and one *Baladi* buck were selected from each flock (total of 416 does and 104 bucks). Selected bucks were at least one-year-old while does were selected if they have given at least one birth. Sampling of does in each herd was such that the four selected does in the same flock were of different parities.

### Data collection

The data were collected in late summer of 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 *Baladi* goats in the flock, and percentage of horned males

and females at the flock level. Flock characteristics were obtained through observation of the flocks on site and by questioning the farmers. The methods of studying goat's characteristics and measurements were according to the FAO Animal Production Health Guidelines (FAO, 2012). Qualitative characteristics included body color, coat color pattern, presence of horns, horn orientation, ear orientation, head (nose) profile, backline profile, presence of wattles, and presence of beard. Quantitative characteristics included body length, chest girth, chest depth, height at withers, pelvic width, ear length, ear width, horn length, head length, head width, teat length (for does), and scrotal circumference (for bucks). 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 analyzed using SPSS statistical package (SPSS, 2007). Differences in frequencies among males and females and differences among regions were tested using Fisher's Exact test. Quantitative characteristics were analyzed using the SAS/STAT package (SAS, 2002). The GLM procedure was used to test the effects of sex (where applicable) and region on measured quantitative traits. The fitted model included the effects of sex (two levels), region (three levels), district nested within region, and age (four classes: 1-2yr, 3yr, 4yr, and 5 yr) for all traits measured on both sexes. The same model was used for teat length and scrotal circumference but without fitting the effect of sex. A stepwise discriminant analysis was performed using the STEPDISC procedure to identify quantitative variables which are important in discrimination among regions. The SCANDISC and DISCRIM procedures were used on these identified variables to derive the canonical functions (which are linear functions of variables used to summarize variation among regions) and compute the percentage of correct assignment of each animal to its sampling region. Squared Mahalanobis distances were obtained to test differentiation among regions. These multivariate discriminant analyses were carried out for does and bucks separately.

## Results

### Flock characteristics

Characteristics of sampled goat flocks are in Table 1. Overall average flock size was 90 heads. The lowest flock size was found in the central districts (average of 68) while the highest number was found in the Northern districts (average of 104 heads). Female to male ratio was on average about 19 does per buck. However, flocks in the Southern region had a lower average female to male ratio (14 does per buck) than the Central (19 does per buck) and Northern regions (20 does per buck) which indicates that farmers in the Southern region keep more bucks with females. The overall average replacement rate was about 20%, in agreement with standard breeding practices. Average percentage of horned animals on the flock level was 58.6% for males and 69.1% for females. All owners of sampled flocks declared rearing crossbred goats "Shami x *Baladi*" in addition to "*Baladi*" goats. The proportion of "*Baladi*" in most flocks exceeded 80% of flock size (i.e., crossbreds represented < 20% of flock size) except in the Central region (only 31.2% of the flocks).

### Qualitative characteristics

Qualitative characteristics of sampled goats are in Table 2. Various body colors were identified for does and bucks. About 55% had single plain color (black, white, brown, red, blue, and gray) and about 45% had mixed colors including black and white, black and brown, black and red, red and white, white and brown, white and gray, gray and brown (about 35% had patchy color pattern, and 10% had spotty color pattern).

**Table (1):** Characteristics of sampled flocks raising *Baladi* goats in the West Bank, Palestine.

| Characteristic | Region [1] | | | All (n = 104) |
|---|---|---|---|---|
| | Southern (n = 32) | Central (n = 32) | Northern (n = 40) | |
| | **Mean ± SD** | | | |
| Flock size [2] | 96.1±54.5 | 67.7± 46.2 | 103.8±106.2 | 89.8±79.7 |
| Female to male ratio[3] | 14.2±6.2 | 19.4±11.3 | 20.3±10.1 | 18.5±10.0 |
| % Replacement animals[4] | 18.1±4.3 | 21.3±7.3 | 20.3±10.4 | 20.1±8.3 |
| % Horned males | 45.0±21.5 | 68.9±37.7 | 58.2±37.5 | 58.6±35.2 |
| % Horned females | 94.6±2.6 | 63.4±22.9 | 58.9±19.4 | 69.1±23.3 |
| Proportion of *Baladi* breed in the flock | **% of flocks** | | | |
| <50% | 4.3 | 18.8 | 5.0 | 9.5 |
| 50-80% | 13.0 | 50.0 | 2.5 | 21.5 |
| >80% | 82.6 | 31.2 | 92.5 | 69.5 |

[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 females/ no of breeding and replacement males.

[4] % of replacement males and females in the flock.

About two-thirds of sampled animals (64.8% of does and 60.6% of bucks) were horned which was consistent with the results found at the flock level. About three-fourths of does had backward horn orientation compared to about one-third for males (about two-thirds of males had lateral or upward horns).

About 70% of bucks and does had semi-pendulous and pendulous ears and less than 6% had erect ears. Convex head profile was more common in bucks (54.8%) than does (36.9%) while straight head profile was more common in does (48.5% of does vs. 24% of bucks). Ultra convex head was rare (1.2% of does and 5.8% of bucks) while concave head was found in about 15% of does and bucks.

About half of sampled goats (53.8% of does and 40.8% of bucks) had straight backline and about one-fourth (22.2% of does and 28.2% of bucks) had backline which slopes up towards the rump. Wattles were present in 65.3% of all sampled goats (70% of does and 46.5% of bucks) while 92.9% of bucks and 2.6% of does had beards.

Fisher's exact test showed significant differences ($P < 0.05$) among regions for all qualitative characteristics except for presence of horns, presence of wattles, and presence of beard (data not shown).

**Table (2):** Percentage values of qualitative morphological characteristics of local "*Baladi"* goats in the West Bank, Palestine.

| Characteristic | P value[1] | | Does (n = 416) | Bucks (n = 104) | Total (n = 520) |
|---|---|---|---|---|---|
| | | | % | | |
| Body color | 0.18 | Black | 22.0 | 32.7 | 24.1 |
| | | Brown | 6.8 | 6.7 | 6.8 |
| | | White | 14.0 | 6.7 | 12.5 |
| | | Red | 9.4 | 8.7 | 9.3 |
| | | Gray | 2.4 | 1.0 | 2.1 |
| | | Blue | 0.7 | 1.0 | 0.8 |
| | | Mixed colors | 44.7 | 43.3 | 44.4 |
| Coat color pattern | 0.91 | Plain | 55.3 | 56.7 | 55.6 |
| | | Patchy | 34.3 | 34.6 | 34.4 |
| | | Spotted | 10.4 | 8.7 | 10.0 |
| Presence of horns | 0.43 | Horned | 64.8 | 60.6 | 64.0 |
| | | Polled | 35.2 | 39.4 | 36.0 |
| Horn orientation | < 0.0001 | Lateral | 11.3 | 42.6 | 17.1 |
| | | Upward | 16.2 | 19.7 | 16.8 |
| | | Backward | 72.6 | 37.7 | 66.1 |
| Ear orientation | 0.28 | Erect | 5.1 | 8.7 | 5.8 |
| | | Semi-pendulous | 35.1 | 27.2 | 33.5 |
| | | Pendulous | 33.7 | 35.9 | 34.1 |
| | | Carried horizontally | 26.1 | 28.2 | 26.5 |
| Head profile | < 0.0001 | Straight | 48.5 | 24.0 | 43.6 |
| | | Concave | 13.3 | 15.4 | 13.8 |
| | | Convex | 36.9 | 54.8 | 40.5 |
| | | Ultra convex | 1.2 | 5.8 | 2.1 |
| Backline profile | 0.008 | Straight | 53.8 | 40.8 | 51.2 |

*... continue table (2)*

| Characteristic | P value[1] | | Does (n = 416) | Bucks (n = 104) | Total (n = 520) |
|---|---|---|---|---|---|
| | | Slopes up towards rump | 22.2 | 28.2 | 23.4 |
| | | Slopes down from withers | 10.5 | 21.4 | 12.7 |
| | | Dipped or curved | 13.4 | 9.7 | 12.7 |
| Presence of wattles | < 0.0001 | Yes | 70.0 | 46.5 | 65.3 |
| | | No | 30.0 | 53.5 | 34.7 |
| Presence of beard | < 0.0001 | Yes | 2.6 | 92.9 | 26.5 |
| | | No | 97.4 | 7.1 | 73.5 |
| | | | | | |

[1] Fisher's Exact test of differences between males and females.

## Quantitative characteristics

Least squares means of quantitative characteristics of goats are presented by sex and region (Table 3). Bucks had larger values ($P < 0.01$) than does for all body measures. Significant differences ($P < 0.05$) were found among regions for all measured characteristics except ear width and horn length ($P > 0.05$). The Central region had the highest means of body length, chest girth, chest depth, head length, and ear length. The Southern region had larger means for scrotal circumference and teat length while the Northern region had larger mean head width and pelvic width.

**Table (3):** Least square means of quantitative traits of *Baladi* goats by sex and region.

| Trait[1], cm | By sex | | | By region | | | |
|---|---|---|---|---|---|---|---|
| | Bucks | Does | P value | Southern | Central | Northern | P value |
| BL | 85.18 | 76..48 | < 0.0001 | 80.64[a,b,2] | 81.76[a] | 80.08[b] | 0.013 |
| WH | 85.92 | 75..66 | < 0.0001 | 81.79[a] | 80.69[a,b] | 79.89[b] | 0.004 |
| CG | 92.99 | 84.93 | < 0.0001 | 86.18[b] | 93.09[a] | 87.62[b] | < 0.0001 |
| CD | 47.96 | 42.65 | < 0.0001 | 43.73[c] | 47.38[a] | 44.81 [b] | < 0.0001 |
| PW | 23.27 | 21.27 | < 0.0001 | 21.23[b] | 20.88[b] | 24.71[a] | < 0.0001 |
| HL | 25.55 | 23.96 | < 0.0001 | 24.62[b] | 25.53[a] | 24.11[b] | < 0.0001 |
| HW | 10.99 | 9.98 | < 0.0001 | 9.97[b] | 9.91[b] | 10.59[a] | < 0.0001 |
| EL | 26.43 | 24.71 | 0.0018 | 21.57[b] | 28.11[a] | 27.03[a] | < 0.0001 |
| EW | 11.15 | 10.51 | 0.0041 | 10.77[a] | 11.06[a] | 10.66[a] | 0.189 |
| HNL | 37.01 | 26.58 | < 0.0001 | 32.62[a] | 32.51[a] | 30.26[a] | 0.066 |
| SC | | | | 32.34[a] | 31.39[a,b] | 30.99[b] | 0.024 |
| TTL | | | | 4.74[a] | 4.05[b] | 4.03[b] | < 0.0001 |

[1]BL = body length, WH = height at withers, CG = chest girth, CD= chest depth, PW = pelvic width, HL = head length, HW = head width, EL= ear length, EW = ear width, 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.

The stepwise discriminant analysis (Table 4) identified seven significant discriminatory traits for bucks (chest girth, pelvic width, scrotal circumference, body length, head width, ear length, and ear width) and eight traits for does (pelvic width, ear length, chest depth, height at withers, teat length, chest girth, ear width, and head length), which were then used in the canonical and discriminant analyses. This was also confirmed by the bi-dimensional plots constructed with the standardized canonical discriminant coefficients (Figure 1 and Figure 2).

**Table (4):** Summary of stepwise selection of traits for bucks and does separately.

| Step | Variables entered[1] | Partial R squared | F value | P > F | Wilks' Lambda | P < Lambda | ASCC[2] | P > ASCC |
|---|---|---|---|---|---|---|---|---|
| **Bucks** | | | | | | | | |
| 1 | CG | 0.4327 | 37.76 | < 0.0001 | 0.5673 | < 0.0001 | 0.2164 | < 0.0001 |
| 2 | PW | 0.3457 | 25.89 | < 0.0001 | 0.3712 | < 0.0001 | 0.3888 | < 0.0001 |
| 3 | SC | 0.2387 | 15.21 | < 0.0001 | 0.2826 | < 0.0001 | 0.4581 | < 0.0001 |
| 4 | BL | 0.1117 | 6.04 | 0.0034 | 0.2510 | < 0.0001 | 0.4905 | < 0.0001 |
| 5 | HW | 0.0856 | 4.46 | 0.0141 | 0.2295 | < 0.0001 | 0.5099 | < 0.0001 |
| 6 | EL | 0.0832 | 4.27 | 0.0168 | 0.2104 | < 0.0001 | 0.5261 | < 0.0001 |
| 7 | EW | 0.0512 | 2.51 | 0.0868 | 0.1996 | < 0.0001 | 0.5356 | < 0.0001 |
| **Does** | | | | | | | | |
| 1 | PW | 0.2724 | 75.42 | < 0.0001 | 0.7276 | < 0.0001 | 0.1362 | < 0.0001 |
| 2 | EL | 0.1368 | 31.85 | < 0.0001 | 0.6218 | < 0.0001 | 0.2045 | < 0.0001 |
| 3 | CD | 0.1005 | 22.40 | < 0.0001 | 0.5650 | < 0.0001 | 0.2447 | < 0.0001 |
| 4 | WH | 0.0955 | 21.12 | < 0.0001 | 0.5110 | < 0.0001 | 0.2832 | < 0.0001 |
| 5 | TTL | 0.0546 | 11.53 | < 0.0001 | 0.4831 | < 0.0001 | 0.3042 | < 0.0001 |
| 6 | CG | 0.0403 | 8.36 | 0.0003 | 0.4637 | < 0.0001 | 0.3188 | < 0.0001 |
| 7 | EW | 0.0288 | 5.89 | 0.0030 | 0.4503 | < 0.0001 | 0.3288 | < 0.0001 |
| 8 | HL | 0.0193 | 3.90 | 0.0210 | 0.4416 | < 0.0001 | 0.3353 | < 0.0001 |

[1] 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, WH = height at withers.

[2]ASCC = Average Squared Canonical Correlation

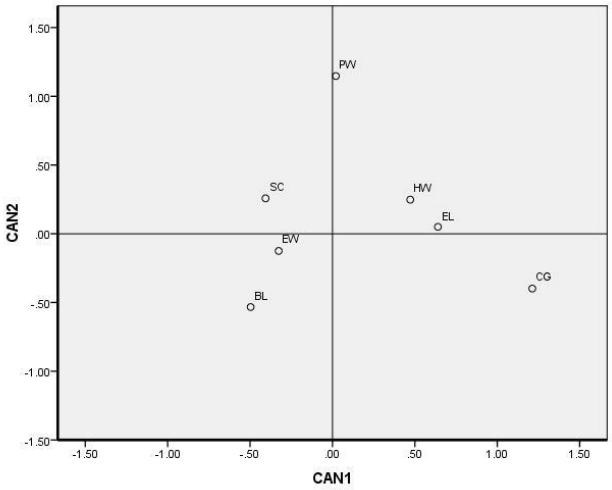


**Figure (1):** Bi-dimensional plot illustrating the association between body measures of *Baladi* bucks assessed via canonical analysis. Traits: BL = body length, CG = chest girth, EL = ear length, EW = ear width, HW = head width, PW = pelvic width, SC = scrotal circumference.

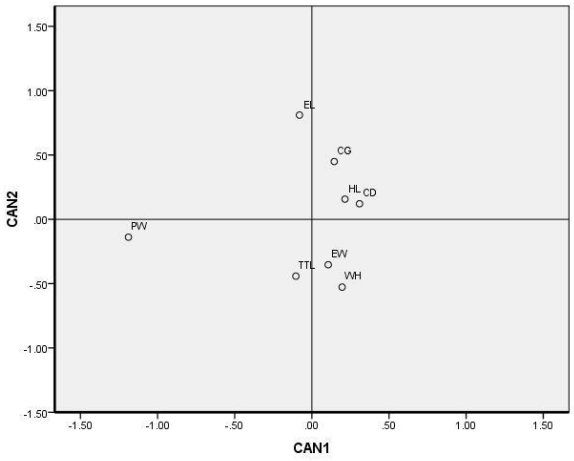


**Figure (2):** Bi-dimensional plot illustrating the association between body measures of *Baladi* does assessed via canonical analysis. Traits: CD = chest depth, CG = chest girth, EL = ear length, EW = ear width, HL = head length, PW = pelvic width, TTL= teat length, WH = height at withers.

The canonical analysis on the data for bucks identified two statistically significant ($P < 0.001$) canonical variables, CAN1 and CAN2 accounting for 74.98% and 25.02% of the total variation, respectively. The pair-wise squared Mahalanobis distances between areas (Table 5) were all highly significant ($P < 0.0001$). The squared distances were 11.83 between the Southern and Central regions, 8.02 between the Southern and Northern regions, and 4.27 between the Central and Northern regions.

**Table (5):** Squared Mahalanobis distances between regions for bucks (above diagonal) and does (below diagonal).

| **Region** | **Southern** | **Central** | **Northern** |
|---|---|---|---|
| Southern | ---------- | 11.83*** | 8.02*** |
| Central | 3.05*** | ---------- | 4.27*** |
| Northern | 2.90*** | 3.13*** | ---------- |

*** $P < 0.0001$

Figure 3 shows a bi-dimensional plot constructed from the canonical functions. The horizontal axis (CAN1) separated bucks of the Central region from the bucks in the Southern region while the vertical axis (CAN2) separated the bucks of Northern region from those in the Central and Southern regions. For does, two significant canonical functions were also identified ($P < 0.001$) accounting respectively for 53.4% and 46.6% of the total variation.

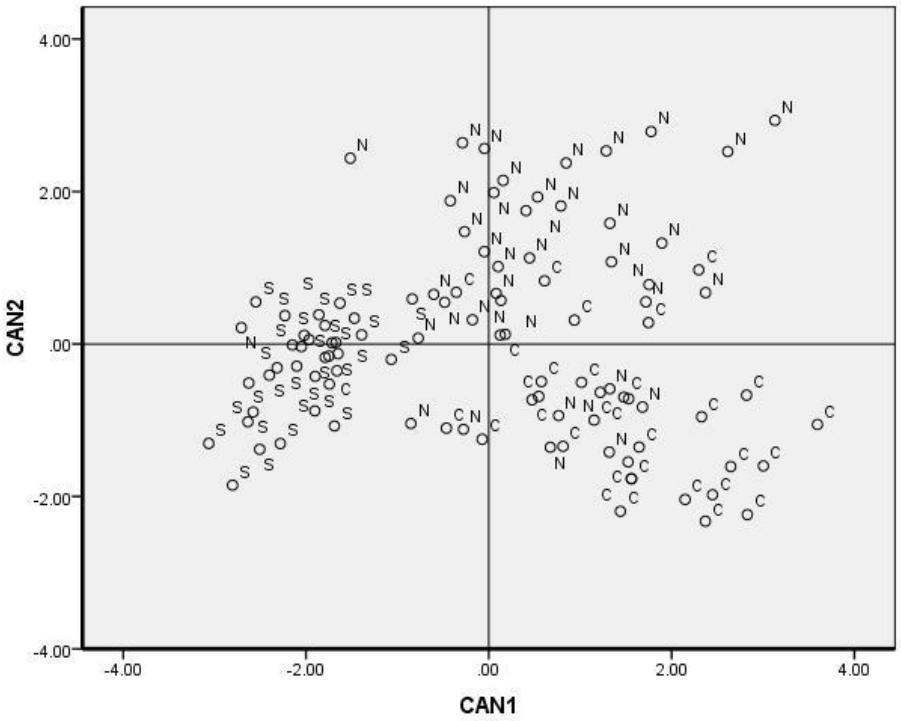


**Figure (3):** Bi-dimensional plot of canonical variables associated with *Baladi* bucks sampled in three different regions of the West Bank, Palestine (S = Southern, C = Central, N = Northern).

Pair-wise squared Mahalanobis distances between areas (Table 5) were all highly significant ($P < 0.0001$), but were lower than those found for bucks (3.05, 2.90, 3.13, between the Southern and Central regions, between the Southern and Northern regions, and between the Central and Northern regions, respectively). These results were confirmed by the Bi-dimensional plots constructed from CAN1 and CAN2 to illustrate the differentiation between regions (Figure 4). 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.

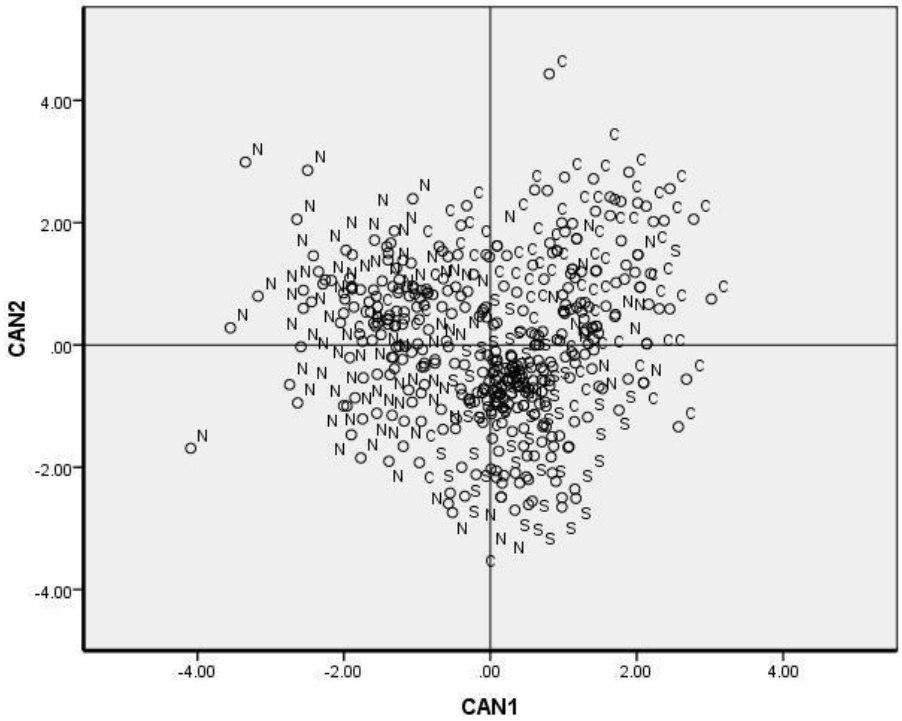


**Figure (4):** Bi-dimensional plot of canonical variables associated with *Baladi* does sampled in three different regions of the West Bank, Palestine (S = Southern, C = Central, N = Northern).

The correct assignment of bucks to their geographic area (Table 6) was 96.9% for the Southern region, 74.2% for the Central region, and 75.0% for the Northern region with 81.6% of the total sample correctly assigned (overall error count estimate of 18.4%). For does, the correct classification rate was 88.3% for the Southern region, 61.0% for the Central region, and 72.9% for the Northern region (Table 6).

**Table (6):** Percentage ofbucks and does classified in different regions based on the multivariate discriminant analyses.

| Region | % of animals classified in the indicated region[1] | | | Total no of animals |
|---|---|---|---|---|
| | Southern | Central | Northern | |
| | | **Bucks** | | |
| Southern | 96.9 | 0.0 | 3.1 | 32 |
| Central | 6.5 | 74.2 | 19.3 | 31 |
| Northern | 7.5 | 17.5 | 75.0 | 40 |
| | | **Does** | | |
| Southern | 88.3 | 5.5 | 6.2 | 128 |
| Central | 21.1 | 61.0 | 17.9 | 123 |
| Northern | 13.5 | 13.5 | 72.9 | 155 |

[1]Numbers on diagonal represent the percentage of animals correctly classified and those off diagonal represent the percentage incorrectly classified in other regions.

The overall percentage of does correctly classified was 74.1% (overall error count rate of 25.9%).

## Discussion

In this study, Black, white, red, and mixed were the most common body colors found in studied goats. This indicates that the *Baladi* goat breed may originally be a mixture of several breeds. The term "*Baladi*" is given to all native goats except Shami (Damascus breed). To our knowledge, flock mating is generally practiced by farmers where bucks and does are kept together with no control on mating. In addition, mixing of flocks may occur on pastures during the breeding season which increases the possibility of breeding between animals from different flocks. Hassen *et al*. (2016) found that most Syrian *Baladi* goats had brown (34.15), crème/grey (26.2%) or black (25.4%) body colors and only 0.4% had mixed body color. Black colored animals have superior adaptation to cold weather as the dark pigment helps them warm up earlier than animals with other coat (Robertshaw, 2006). About two-thirds of *Baladi* goats in the West Bank were horned similar to the results reported for Jordanian

*Baladi* goats where 60% were horned (Alrousan, 2009). In contrast, 62.1% of Syrian Baladi goats were hornless (Hassen *et al*., 2016). All Cuban Creole goats and most Ethiopian indigenous goats (about 95%) had horns (Chacón *et al*., 2011; Hassen, Baum, Rischkowsky, & Tibbo, 2012). The presence of horns in animals is considered as an advantage for the drainage of blood through the cavernous sinus as a control mechanism for thermal homeostasis (Robertshaw, 2006). Horn orientation was mostly backward consistent with the results found for Syrian and Jordanian *Baladi* goats (Alrousan, 2009; Hassen *et al*., 2016). Straight nose was more common among does compared to bucks (half of does and one-fourth of bucks) while convex nose was more common among bucks than does. This may be due to farmer preference of males with convex nose. Hassen *et al*. (2016) also found that straight nose was more common in does (73.7%) than bucks (56.9%) for Syrian *Baladi* goats.

The measures of body length, height at withers, chest girth and ear width found in our study are similar to those reported by Hassen *et al*. (2016) for Syrian *Baladi* goats (73.54, 76.99, 87.4, and 9.48 cm, respectively) but Syrian *Baladi* goats had shorter ears (average of 21.04 cm). In general, *Baladi* goats of the West Bank have larger body measures than those found for Cuban Creole goats (Chacón *et al*., 2011) and Ethiopian indigenous goats (Hassen *et al*., 2012).

The stepwise discriminate analysis identified seven significant discriminatory traits for bucks (chest girth, pelvic width, scrotal circumference, body length, head width, ear length, and ear width) and eight traits for does (pelvic width, ear length, chest depth, height at withers, teat length, chest girth, ear width, and head length). For bucks, CAN 1 showed highest discrimination power forchest girth and CAN2 showed the highest discrimination power forpelvic width (Figure 1).For does, pelvic width and ear length showed highest discriminating power on CAN1 and CAN2, respectively (Figure 2). These two body measures had the highest partial $R^2$ and F values in the stepwise discriminant analyses (Table 4). Most of the discriminant variables found in this study were also reported as discriminate traits in other studies on goat characterization (Dekhili*et al.,* 2013; Herrera *et al*., 1996; Selolo, Mashiloane, Norris, Ng'ambi, &

Brown, 2015; Traore *et al*., 2008; Yakubu, Salako, Imumorin, Ige, & Akinyemi, 2010; Zaitoun *et al*., 2005). Head length, body length, and ear length showed high power in discriminating Algerian goat populations of Southern, Central, and Northern regions of Sétif area (Dekhili *et al*., 2013). Herrera *et al*. (1996) found that head length, head width, and height at withers were the most discriminative variables in differentiating Andalusian caprine breeds. Withers height and ear length were among important traits in discriminating goat populations in three environmental areas of Burkina Faso (Traore*et al*., 2008). Selolo *et al*. (2015) found that body length had the most discriminating power among five studied body measures in differentiating goat populations in three agro-ecological zones in South Africa, with heart girth showing significant discriminatory power. Body length, head length, chest girth and head width were among the seven most discriminating traits among Nigerian goats (Yakubu *et al.,* 2010). However, Zaitoun *et al.* (2005) found that withers height and body length showed higher power than pelvic width and chest girth in differentiation among Jordan native goat breeds.

The Mahalanobis distances found in this study indicated the existence of adaptive morphological divergence between goat populations reared in different geographical areas of the West Bank. *Baladi* bucks kept in the Southern region have more distinct characteristics from those in the Central and Northern areas with less differentiation found between bucks of Central and Northern regions. This is confirmed by the higher percentage of correct assignment of bucks sampled in the Southern region (96.9%) compared to Central (74.2%) and Northern (75.0%) regions with higher percentage of bucks erroneously cross classified between the Central and Northern regions. These results may reflect higher exchange of bucks between the Central and Northern regions facilitated by geographic proximity. For females, squared Mahalanobis distances indicated significant divergence between regions but the values among regions were smaller than those found for males (less divergence between the female populations compared to male populations). Our results are in agreement with other researchers who found significant geographic divergence among goat populations. Dekhili *et al*. (2013) found high

geographic differentiation between Southern, Central and Northern regions in Algerian goat populations of Sétif. Significant geographic differentiation was also found in Canindé goat breed in Brasil (Arandas *et al.*, 2017) and goat populations in Ethiopia (Hassen *et al.*, 2012), South Africa (Selolo*et al.*, 2015) and Burkina Faso (Traore *et al.*, 2008). The significant Mahalanobis distances indicate that despite belonging to the same breed, there are differences among goat populations (Arandas*et al.*, 2017). The geographical divergence found in this study in the *Baladi* breed may be due to geographic isolation, different selection preferences of farmers (particularly bucks), and differences in rearing systems and management practices among regions.

Genetic analysis based on DNA markers will complement the results of the current study and help link the identified morphological differences to genetic differences. To this end, blood samples were obtained in this study and DNA was extracted and conserved for future use.

## Conclusion

The current study presented qualitative and quantitative characteristics of local *Baladi* goats in the West Bank, Palestine. These identified characteristics could be used as references and utilized to develop future characterization, conservation and breeding strategies.

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