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Major Udder Morphology Traits and Their Relationship with Milk Production in Tunisian Local Goats

Research Article

A. Ahlem[1*], M.J. Carabaño[2*], L. Aicha[1], A. Mouldi[1], B.S. Farah[1] and N. Sghaier[1]

[1] Laboratory of Livestock and Wildlife, Institute of Arid Regions, University of Gabès, Medenine, Tunisia
[2] Departamento de Mejora Genética Animal, Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (INIA), Ctra Coruña, Madrid, 28040, Spain

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*Correspondence E-mail: ahlematoui@gmail.com; ira.med@ira.rnrt.tn

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ABSTRACT

Improving the productivity of local goat population adapted to harsh environments is crucial for their sustainability. For local goat population oriented to meat production, this improvement relies on the capacity of goats to produce more milk to increase kids weight at weaning. In this context, the present study aimed to describe the main measurements of the mammary gland and to establish their possible relationships with daily milk production. A total of 85 lactating goats from a local goat population from an agro pastoral herd in the Southern region of Tunisia were used. Udder morphological traits recorded were udder depth, udder circumference, teat length, teat diameter, teat circumference, teat height from ground, distance between teats and udder volume. The morphological component has shown strong heterogeneity between the animals under the same breeding conditions. Teat's form has shown high heterogeneity between individuals and within the same animal. The values of all udder morphological parameters were significantly (P<0.05) higher in multiparous than primiparous goats, except the teat height from ground, which had a reverse result. Daily milk production was positively (P<0.01) correlated with all udder morphological traits, except teat height from ground (THG) where the correlation was negative. Overall, measurements relative to udder capacity (volume, depth and circumference) showed good potential as morphological candidates to be used as indirect indicators of milk production in extensive systems. In addition, teat characteristics, mainly length, but also diameter and circumference showed potential as indicators for milk production and milk ability, important for a good suckling yield and good adaptation to milking machines. Some environmental factors such as lactation stage and age of the doe affect the mammary morphology and this will have to be taken into account when designing the optimal time of recording for these traits. Such knowledge will help to get better management and improved performance of this population, adapted to arid conditions and exploited in an area threatened by desertification.

KEY WORDS agro pastoral farming, local goats, milk production, udder morphology.

INTRODUCTION

Despite of the secondary economic role of dairy production in the agro pastoral breeding mode of small ruminants in the Tunisian arid zone, the goats' milk production contributes to the farmers' income mainly by its impact on lactating kids' growth, and more and more, by the emergence of a caprine milk chain value in the region. Local goat population are famous for their walking ability, resistance to hydric restrictions and high temperatures and good fertility. However, this population is also characterized by a very small size and low productivity (Najari, 2005). This makes farmers tend to resort to using foreign selected population, which lack of adaptation to harsh conditions. Therefore, improvement of dairy characteristics of local population is important to increase farm benefits (Zhang *et al.* 2008) and ensure the sustainability of genetic resources and goat farming in these areas. In this context, developing a global strategy for the sector in this arid environment to improve the pastoral farming system as well as the productive potentials of individuals without damaging the adaptive capacity is of great interest in this region.

The dairy performance of local goats raised in arid conditions is known to be low (Jalouali, 2000). This low productivity has been partly attributed to their genetic potential (Najari *et al.* 2002), but udder conformation may also be a limiting factor to improve milk production. In fact, evaluation of anatomy and mammary gland functionality is important for the characterization of animals and to optimize milk production (Capote *et al.* 2006).

The study of udder measurements in goats serves to identify the correlations between morphological characters and milk production as well as milk ability. The udder and teat measurements of goats vary depending on several factors (Atigui, 2014). Clément *et al.* (2006) defined a morphological synthesis index that includes descriptive variables of udder morphology, illustrating the possibility of selection on these traits.

Estimation of dairy production and its correlation with mammary traits is therefore essential for successful genetic selection scheme. Genetic improvement programs are based on the determination of the genetic variation, identification of superior animals for specific traits or trait combinations, and widespread utilization of these animals in a population. In this context, knowledge of the correlation between milk production and mammary traits is fundamental for achieving unbiased estimates of the breeding values.

Many studies in the past have dealt with the estimation of the correlation between milk production and udder traits mainly in Alpine and Saanen goats (Mavrogenis *et al.* 1989).

Although the Tunisian local goat population has been extensively studied in terms of lactation curves, dairy performance and its variation factors (Najari, 2005), no studies have been carried out on udder measurements and its correlation with milk production in this population. The present study involved the statistical analyses of data base of dairy information of local goat population. The goal was to establish the basis for the inclusion of mammary morphology in the selection scheme of the Tunisian goat, which will allow producers to improve profitability of goat flocks and ensure sustainability of goat production based on the Tunisian goat population. Characterizing the mammary gland and its relationship with daily milk production is an essential step in this endeavour.

MATERIALS AND METHODS

Animals and management

Animals belonged to the goat experimental herd "El-GORDHAB" in the southeastern region of Tunisia. This region is characterized by an arid continental Mediterranean climate; with irregular precipitations and an average annual rainfall of about 100 mm. The summer is the hottest and driest season with a maximum temperature of 47 ˚C (Atoui *et al.* 2019).

The studied herd has been built since 2019 by collecting local goats, and coming from pastoral herds from different areas of the arid zone. Local goat population exploited for centuries in the Tunisian arid rangelands. This population has genetically evolved to buffer the multiple environmental stresses and irregularities of the arid and Saharan areas and, also, to play the role of suckler to valorise pastures.

Indeed, in agro pastoral breeding, the main production objective is the meat of the slaughtered kid at six months of age. The kid is at slaughtering; hence the importance of characterizing the dairy potential of goats and their modes of variation.

The local goat population is genetically and morphologically very heterogeneous. A photograph of the Tunisian goat is provided in Figure 1.

Figure 1 Photograph of the Tunisian local goat population

These goats have small size with average height of 73 cm for males and 60 cm for females, and average adult weight of 35 kg for males and 24 kg for females (Atoui *et al.* 2019; Najari, 2005). The reproductive management of the flock follows a breeding system of one kidding per year. The main mating period was from June to August. The season of kidding begins in October and continues until February, with a peak during November and December. The suckling period lasts for 120 days on average. The female kids are mated for the first time between 12 and 18 months of age, depending on their season of birth. The number of goats mated per sire varied from 5 to 17. Goats were randomly assigned to bucks. Bucks were replaced every 5 years with replacements coming from outside flocks in order to control inbreeding or from the experimental flock (Atoui *et al.* 2019).

The identities of newborns and their parents, date of mating, date of kidding, sex of kid, litter size and parity of does were recorded. For each individual under study a record sheet with full details of each parameter along with pedigree information were maintained. New-born kids were allowed to suckle their does and were left with them up to 5 months of age.

Generally, animals are managed following semi extensive systems of production. Natural pasture is the main source of feed. The quantity and quality of the pasture varyconsiderably during the year. With the dry season, the quantity and quality of the pasture decrease and supplemental feeding had to be provided. Animals grazed in natural pastures during the day. In general, grazing pasture grasses covered about 50% of breeding animals feed requirements. Before kidding, they received a fixed diet based on Lucerne (*Medicago sativa*) hay (dry matter (DM): 92.9%; crude protein (CP): 13.7%; neutral detergent fiber (NDF): 47.6%; Ash: 13.5%; Net energy content: 1360 kcal·kg−1 DM) at 9:00 and commercial concentrate mixture (DM: 93.0%; CP: 14.0%; NDF: 35.2%; Ash: 7.9%; Net energy content: 1700 kcal.kg−1 DM) at 13:00. Animals had access to freshwater and trace-mineral salt blocks *ad libitum*.

Data recording and studied traits

Overall, 135 kids, progeny of 9 bucks and 85 goats were involved in the study. A total of 85 lactating goats were milked (30 primiparous and 55 multiparous with 35 and 50 goats having births of single and multiple kids, respectively). The daily milk production (DMP, mL) of goats was determined by machine milking (every 14 days) from the second week after kidding until weaning of the kids at 120 days. The kids were separated from their dam at 18:00 h. After 12 h of separation, the goats were milked. The milk obtained was defined as the daily milk production (DMP), which is a combination of milk off take and 12-hours milk production.

Before milking was performed, the teats of the goats were disinfected using an iodine solution and, after about 30s, the teats were dried with paper towels. Before milking, the following udder measurements (cm) were recorded (Figure 2) for each goat: udder depth (UD: the distance between the udder attachment and the base of the teats), udder height (THG: measured between the teat tip and the ground), udder horizontal circumference (UC: measured by matching the tape to the surface distance of the udder half from the median suspensory ligament between the front quarters till the median point between the rear quarters), udder volume (UV: measured in ml by the water displacement method). Teat measurement included: teat diameter (TD: measured in the middle of the teat using a Vernier caliper), teat length (TL: distance from the teat base to the teat tip), distance between teats were measured at the tip of the teats (DBT), and teat circumference (TC: measured at maximum diameter of teat), Distance between rear teats (DBT: distance in cm placed between the two teats taken by a tape measure). The shapes of udder and teat were classified by visual appraisal. Udder symmetry was also determined as either symmetrical with equal halves or asymmetrical within equal halves. For each goat, the final analysis file contained the following data: number of the goat, date of kidding, values of the 8 udder measurements, and the daily milk production (DMP). In addition to the descriptive parameters of the udder and teats, an analysis of variance generalized linear model (GLM), of SPSS.20 statistical software (SPSS, 2011), was applied to determinate the effect of litter size, parity and lactation stage of the goat. The statistical model used was as follows:

$$Y_{ijkl} = \mu + TP_i + Pa_j + LS_k + e_{ijkl}$$

Where:

Y_{ijkl}: performance to analyze (DMP or udder/teat morphological parameters).

μ: general mean.

TP_i: effect of litter size (single or double).

Pa_j: effect of goat's parity (primiparous or multiparous).

LS_k: effect of lactation stage (early or mid: this factor has two level, the first regrouping the observed data during the first month after kidding, and the second group for later dates till weaning).

e_{ijkl}: residual error.

In order to test the correlation between the studied traits, Pearson correlation coefficients for udder and teat measurements and DMP were calculated.

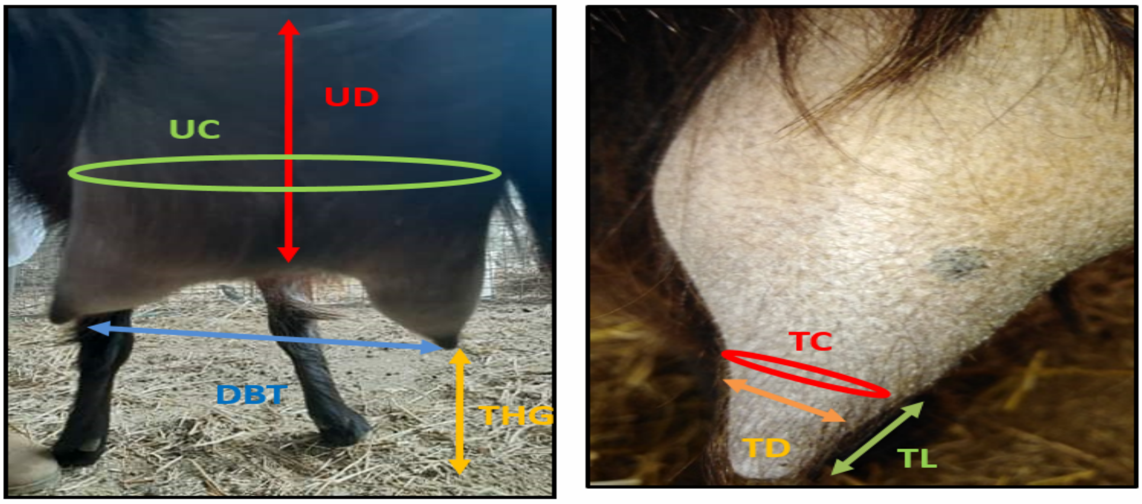

Figure 2 Udder and teats measurements of local goat population. UD: udder depth; UC: udder circumference; DBT: distance between teats; THG: udder height; TC: teat circumference; TD: teat diameter and TL: teat length

RESULTS AND DISCUSSION

The udder shapes found in local goats were funnel-shaped (12%), cylindrical (43%), round (4%), and bowl (41%). The study of the shape of the teat has shown high heterogeneity between individuals and within the same animal between teats. It is common to find different forms of teats in the same udder. There were three main classes of teat shape: funnel, balloon and cylindrical, with an average of 45; 22 and 33% respectively. The udder abnormalities found in local goats were the occurrence of extra, functional teats (33%) and asymmetric udders (67%).

The means, standard deviations, and coefficients of variation of DMP and the variables of the mammary gland are presented in Table 1. The DMP was 1600 mL, and varied widely between 850 and 2600 mL.

Figure 3 illustrates the change in daily milk production as a function of lactation days. In terms of dispersion, a concentration was observed below 1500 mL. However, some goats produce more than 2000 mL. The variability detected in the studied population allows to forecast that a genetic improvement program might be successful.

The mean udder depth value was 13.80 ± 0.44 cm and teat length was 9.43 ± 0.30 cm (Table 1). After the estimation of the mammary gland measurements, tests of normality were applied in order to assess the nature of statistical distribution of studied traits. The distribution of some traits may not meet assumptions of normality under arid conditions. The normality hypothesis was only accepted for UV, UD and UC (Table 1; Figure 4).

Table 2 shows the results of the ANOVA analyses to test the significance of fixed effects on different studied traits. Effect of parity number was significant for all traits except the TD, the DBT and the THG.

The coefficient of determination (R^2) varied between0.68 and 0.84across traits, which reflects the importance of these factors in the udder morphology.

Multiparous goats produced more DMP than primiparous animals (1670.28±60.72 *vs.* 1380.00±90.72 mL; P<0.05, Table 3). Similar results were reported by Hassan *et al.* (2010). Udder volume (UV) in primiparous and multiparous goats was 1500.54 ± 75.00 and 1735.06 ± 47.00 mL, respectively (Table 3). The UD and UC were significantly (P<0.05) higher in multiparous goats than in primiparous goats. A similar trend was also observed for all teat parameters except the TL and the DBT. Overall THG varies from 18.52 to 20.74 cm. The mean values of THG in local goat population did not differ significantly (P>0.05) between primiparous and multiparous group although it was higher in primiparous group. Amao *et al.* (2003) concluded that parity had no significant effect on udder traits.

The effect of litter size was significant (Table 3), where UV, UD and UC were 1213.87 ± 76.00 mL, 12.52 ± 0.60 cm, and 30.09 ± 1.02 cm, respectively for simple births. Goats that delivered double kids produced more DMP than goats that delivered a single kid (1732.26±71 *vs.* 1312.00±60.11 mL/d; P<0.05), as in Strzalkowska *et al.* (2009). Hassan *et al.* (2010) reported that udder characteristics of twin bearing does were higher compared to single bearing does. Consequently, their udder characteristics were more developed than for single bearing does.

The morphology of the udder was statistically different at early and mid-lactation (Table 4). The mean values of UV in local goats was significantly higher (P>0.05) at early lactation as compared to the mean value obtained at mid lactation. Overall udder depth varies from 11.77 to 13.69 cm. The mean values of UD differed significantly (P<0.05) according to the stage of lactation.

Table 1 Basic statistics for daily milk production and mammary gland of Tunisian local goats

Variables	Mean	SD	Minimum	Maximum	Shapiro-Wilk normality test
DMP (mL)	1600	92.00	850	2600	Accepted
TD (cm)	3.91	0.18	3.65	4.14	Accepted
TL (cm)	9.43	0.30	8.14	10.14	Accepted
TC (cm)	12.47	0.56	11.93	14.22	Rejected
DBT (cm)	9.61	0.45	8.75	10.50	Accepted
UD (cm)	13.80	0.44	13.20	14.14	Rejected
THG (cm)	19.30	0.58	18.20	21.00	Rejected
UC (cm)	33.28	0.86	32.00	35.00	Accepted
UV (mL)	721.0	54.80	660.0	900.0	Accepted

DMP: daily milk production; UD: udder depth; THG: udder height; UC: udder circumference; UV: udder volume; TD: teat diameter; TL: teat length; DBT: distance between teats and TC: teat circumference.
SD: standard deviation.

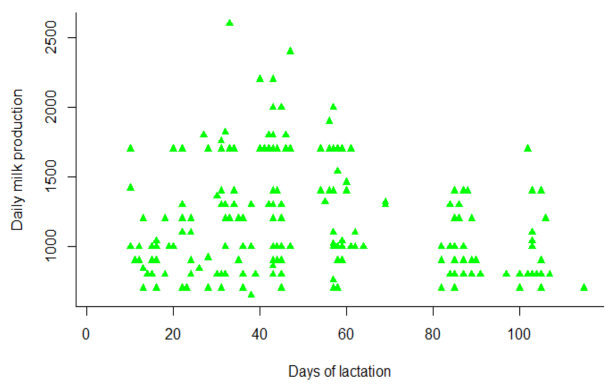

Figure 3 Observed daily milk yields (mL) along days of lactation

Mean values of UD were higher at mid lactation as compared to early lactation. The teat parameters TL, TD, TC, THG and DBT at early lactation stage were respectively 10.6 ± 0.4, 4.0 ± 0.3, 12.6 ± 0.5, 21.8 ± 0.7 and 10.1 ± 0.8 cm. The corresponding values at mid-lactation were 8.8 ± 0.6, 3.3 ± 0.2, 11.3 ± 0.8, 17.7 ± 0.9 and 8.4 ± 0.7 cm, respectively. Therefore, daily milk production decreased as lactation progress. This result is in consonance with the findings of Cappio-Borlino *et al.* (1997) who reported highest milk yield for ewes at early lactation.

The correlations between mammary morphology traits and DMP of local goat are shown in Table 5. Highly significant correlations between udder characteristics (between UV, UD and UC) were found. The DMP had positive ($P<0.01$; $P<0.05$) correlation with all the morphological parameters of the udder. The same trend was also observed for the teat parameters, except the THG, where the correlation was negative, but not significant.

This is in consonance with the findings of Das and Sidhu (1975) and James *et al.* (2009) who reported positive correlations between udder characteristics of goats.

The TL and TC were positively correlated in agreement with Fernandez *et al.* (1995) in Churra ewes. On the other hand, the TL was negatively correlated with THG, indicating that the larger TL, the smaller THG, which disagree with Peralta *et al.* (2001) in Chiapas ewes whose TL and THG were correlated positively.

The morphology of the udder showed substantial heterogeneity among the studied goats from the local population, within the same herd and under the same conditions. This confirms the lack of selection on dairy profile of this genetic group whose main production is the meat of suckled kid (Najari, 2005).

From the present study, udder shapes observed in local goats were different from those reported by Horak and Gerza (1969) and Montaldo and Martinez- Lozano (1993). Cylindrical shaped udder was the most frequent 43% followed by the bowl shaped udder (41%). Horal (1971) has earlier reported that round shaped udder predominated (72.6%) in Saanen goats. The observation that does with the normal two-teat condition were the most prevalent among others corroborates the findings of Odubote (1994), Ozoje (2002) and Amao *et al.* (2003). Odubote (1994) observed that the occurrence of supernumerary teats could be attributed to the presence of a recessive mutant allele which presents this characteristic feature in the homozygous state. The percentage of individuals with supernumerary teats was generally lower higher than the estimate initially reported by Odubote (1994), while lower higher than subsequent estimates by Ozoje (2002) and Amao *et al.* (2003). It is interesting to note that a third category of individuals with six teats was identified in the current study. The percentage of does with asymmetrical udder was however lower than previous estimate by Amao *et al.* (2003). The extra teats were considered to be congenital in nature (Adebayo and Chineke, 2011).

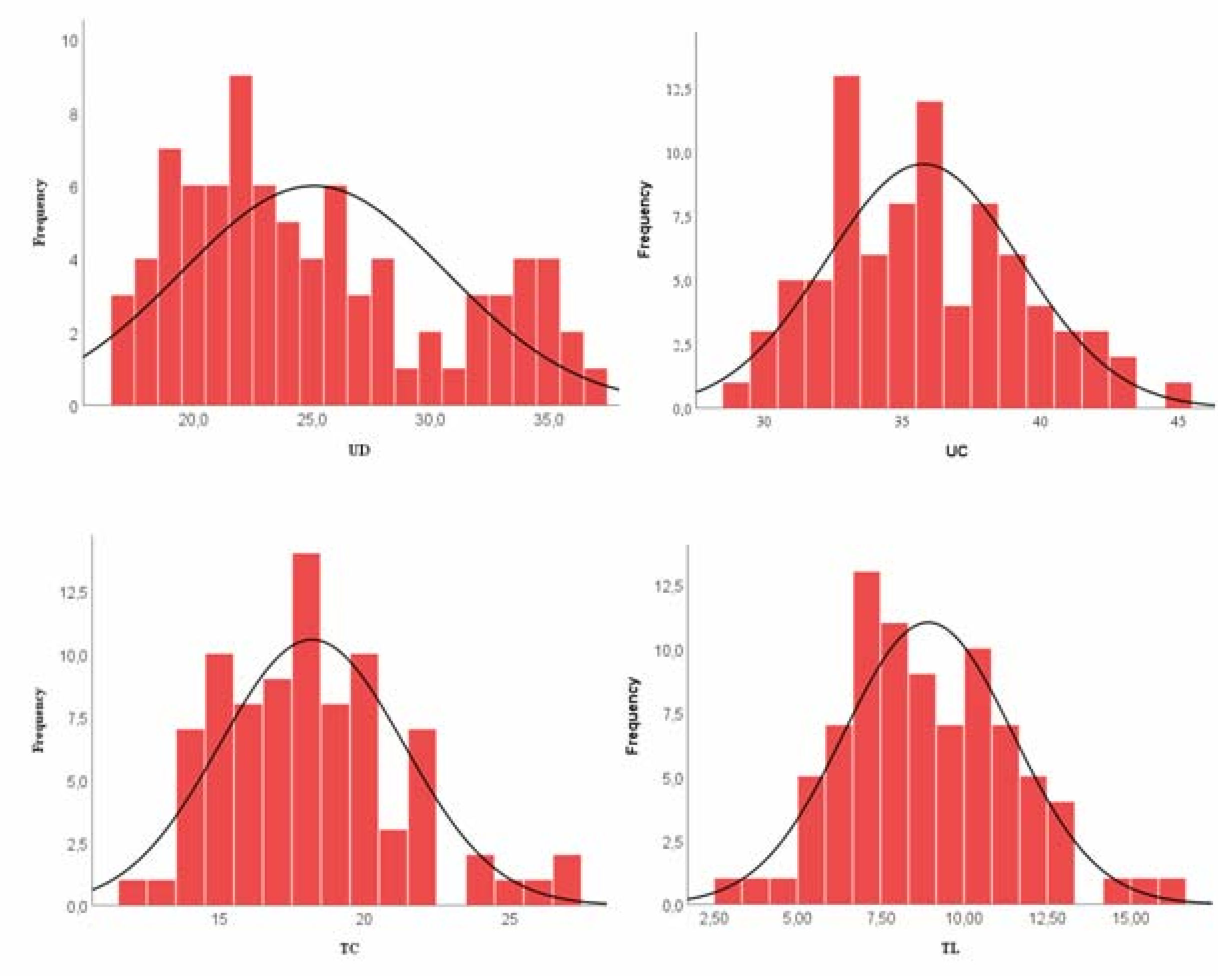

Figure 4 Distribution of observed frequencies and fit of a Gaussian kernel for some of the udder morphological traits, UD: udder depth; UC: udder circumference; TC: teat circumference and TL: teat length

Table 2 Test of significance from ANOVA analyses and coefficient of determination (R^2) of a model including non-genetic factors on daily milk production and mammary gland in local goat

Sources of variation	ddl	DMP	TD	TL	TC	DBT	UD	THG	UC	UV
Parity	1	S	S	NS	S	NS	S	NS	S	HS
Litter size	1	HS	S	S	S	S	S	S	HS	HS
Lactation stage	1	S	S	HS	S	S	S	S	S	S
R^2	-	0.81	0.69	0.80	0.68	0.72	0.71	0.68	0.80	0.84

DMP: daily milk production; TD: teat diameter; TL: teat length; TC: teat circumference; DBT: distance between teats; UD: udder depth; THG: udder height; UC: udder circumference and UV: udder volume.

Similar results have been reported in most breeds and local population raised under arid environments (Alexandre *et al.* 1999).

The mean udder depth value in our goats was higher than that reported in Omanabadi goats (8.13±0.32cm (Deokar *et al.* 2006). Kashyap *et al.* (2014) reported that a good udder of goats is characterized by developed and symmetrical halves. It must be horizontal or parallel to the ground. The halves should not be hanged and the teats should be well developed, regular and well-spaced.

It is well recognized that udder depth has an intermediate optimum given that deep udders are needed to hold large amounts of milk but are also associated with higher risks of mastitis (Kappes *et al.* 2020 in cattle; Margatho *et al.* 2020 in goats). This ought to be taken into account when selecting for improved milk production using udder depth as indirect predictor of milk yield.

The teat length in the current study was longer compared to Osmanabadi (7.74±0.35 cm) and Jamunapari (8.5±1.5 cm) goats (Hassan *et al.* 2010).

Table 3 Effect of parity number and litter size at birth on daily milk production, udder and teat morphology in local goat population

Variables[1]	Parity		Litter size	
	Primiparous	Multiparous	Simple	Double
DMP	1380±90.72[b]	1670.28±60.72[a]	1312±60.1[b]	1732.26±71.00[a]
TD	3.13±0.30[b]	4.18±0.14[a]	3.27±0.24[b]	4.42±0.22[a]
TL	9.18±0.59[a]	9.48±0.35[a]	9.26±0.44[b]	9.59±0.39[a]
TC	10.29±0.80[b]	13.32±0.45[a]	11.20±0.78[b]	13.40±0.64[a]
DBT	8.11±0.78[a]	10.14±0.66[a]	8.30±0.70[b]	10.38±0.62[a]
UD	11.78±0.53[b]	14.16±0.49[a]	12.52±0.60[b]	14.76±0.49[a]
THG	20.74±0.98[a]	18.52±0.84[a]	19.81±0.70[a]	18.69±0.93[b]
UC	28.24±1.12[b]	35.12±0.50[a]	30.09±1.20[b]	35.40±0.89[a]
UV	1500.54±75.00[b]	1735.06±47.00[a]	1213.87±76.00[b]	1634.05±62.19[a]

DMP: daily milk production; TD: teat diameter; TL: teat length; TC: teat circumference; DBT: distance between teats; UD: udder depth; THG: udder height; UC: udder circumference and UV: udder volume.
The means within the same column with at least one common letter, do not have significant difference (P>0.01).

Table 4 Effect of lactation stage on daily milk production, udder and teat morphology in local goat population

Variables[1]	Early-lactation	Mid-lactation
DMP	1735.16±30.40[a]	1536.14±84.12[b]
TD	4.02±0.27[b]	3.28±0.17[a]
TL	10.58±0.35[a]	8.77±0.57[b]
TC	12.62±0.51[a]	11.29±0.80[b]
DBT	10.12±0.78[a]	8.44±0.66[b]
UD	11.77±0.60[a]	13.69±0.80[b]
THG	21.80±0.73[a]	17.69±0.90[b]
UC	31.34±1.01[a]	33.34±1.21[b]
UV	1720.76±36.47[a]	1600.54±54.24[b]

DMP: daily milk production; TD: teat diameter; TL: teat length; TC: teat circumference; DBT: distance between teats; UD: udder depth; THG: udder height; UC: udder circumference and UV: udder volume.
The means within the same column with at least one common letter, do not have significant difference (P>0.01).

Table 5 Correlation coefficient between mammary gland morphology and daily milk production

Variables	UV	UD	UC	TL	DBT	TD	TC	THG
DMP	0.734**	0.715**	0.740**	0.756**	0.332[ns]	0.634*	0.620*	-0.269[ns]
UV		0.764**	0.800**	0.330[ns]	0.341[ns]	0.666*	0.657*	-0.445*
UD			0.842**	0.0173[ns]	0.647*	0.332[ns]	0.297[ns]	-0.053[ns]
UC				0.043[ns]	0.630*	0.492*	0.493*	-0.266[ns]
TL					-0.261[ns]	0.670*	0.733**	-0.480*
DBT						0.115[ns]	0.083[ns]	-0.057[ns]
TD							0.972**	-0.609*
TC								-0.678*

DMP: daily milk production; UV: udder volume; UD: udder depth; UC: udder circumference; TL: teat length; DBT: distance between teats; TD: teat diameter; TC: teat circumference and THG: udder height.
** (P<0.01) and * (P<0.05).
NS: non significant.

Furthermore, the distance between two teats was longer in Osmanabadi goats (5.66±0.36 cm), but the teat diameter was less than in Osmanabadi goats (11.16±0.66 cm) as reported by Deokar *et al.* (2006). Kashyap *et al.* (2014) recommended selecting females with vertically implanted teats that are uniform and well-spaced. Very small teats are difficult to milk effectively with an increased risk of trauma and injury during milking for the animal and for the milker. In addition, animals with too large teats should be avoided since they make suckling almost impossible for the kids.

Effect of parity number was significant for all traits except the TL, the DBT and the THG. Present results agree with the findings of Capote *et al.* (2006). Deokar *et al.* (2006) indicated that the effects of parity, age of dam, and year of kidding are the most important sources of variation of udder parameters. We observed an increase in UV as parity progresses as reported by Akporhuarho *et al.* (2010). This may be due to the full growth and the active phase of mammary system with the progression of parity. Nevertheless, Amao *et al.* (2003) concluded that parity number has no significant effect on the morphology of the udder.

We detected that THG decreased with the increasing of litter size. Deokar *et al.* (2006) also observed that the THG and the UV were affected by litter size. However, this tendency could be due to the functional mammary system at later stage of life. The increase in DMP for double births compared to single births was more marked as lactation advanced. It may be related to the degree of suckling stimulus and duration and to the ability of multiple kids to completely empty the udder, especially during early lactation. The effect of litter size on DMP can be attributed to the concentration of lactogenesis hormones, which differs from females carrying multiples to those carrying singles (Haldar *et al.* 2013).

The udder and teat parameters decreased significantly throughout lactation. In addition, the teats became shorter, flabby, and empty. This is mainly due to the drop in the amount of milk stored in the cisternal cavities, leading to flabbier teats compared to earlier stages of lactation. This suggests less efficient transfer of milk from the alveoli to the cistern between milkings, since milk secretion is reduced at the end of lactation (Siddik *et al.* 2005).

In Churra (Fernandez *et al.* 1995) and Chios (Papachristoforou and Mavrogenis, 1981), a reduction in the UD has been reported as lactation period increases. An udder length decrease has been reported in the sheep breeds such as Churra (Purroy *et al.* 1982), Manchega (Gallego *et al.* 1983) and Latxa (Arranz *et al.* 1989). In the present study, UC gradually increased as lactation advanced, a trend also reported in Lacaune ewes which depicted a maximum teat insertion value at day 105 post-lambing. However, no differences for this trait were reported by Rovai, (2001), Purroy *et al.* (1982), Gallego *et al.* (1983) and Arranz *et al.* (1989).

Similar to our results, Siddik *et al.* (2005) showed a positive correlation between udder traits (UD, TC) and DMP. Ghosh and Prasad (1998) reported that the udder length and UC are positively correlated with milk yield. Additionally, Capote *et al.* (2006) reported a positive correlation between milk production and UD when the goats were milked once a day and a negative relationship when the goats were milked twice a day. The high correlation between DMP and each of goats' udder volume and udder circumference emphasizes the importance of these traits both in predicting the milk production in local goats and as selection markers for future improvement of its production under arid conditions. The negative correlation between DMP and THG could be caused by the fact that udders of goats with high milk production were more pendulous. Udder volume was significantly correlated ($P<0.05$) with the UD and UC. The UD had a positive and significant correlation with the UC. The THG also was negatively correlated with most of udder parameters. This agrees with the result reported by Peris *et al.* (1999) who concluded that UV was inversely proportional to the distance from the teat to the floor. Nonetheless, all the traits values observed in this study were superiors to those reported in Chiapas ewes (Peralta *et al.* 2001).

Such a low milk production of local goat corresponds to low energetic needs, which could be considered as a strategy of adaptation to the difficult environmental conditions. In this regard, low milk production can be considered as a specific mechanism for adaptation to the restrictive and irregular environment (Amao *et al.* 2003). Despite the low level of production on average, some high-performance goats were observed, which can constitute a selection nucleus to produce a specialized herd able to take the advantage of the intensive conditions and produce high milk yields.

CONCLUSION

In conclusion, the local goat population showed high morphological variability of udder and teats, indicating the possibility of selection for this criterion, in the objectives to improve caprine milk production or to contribute in the kids growth by additive suckled milk. The main udder characteristics and variability seem common to unselected caprine breeds adapted to arid and desertic environments. In fact, all caprine local genetic resources have reduced dairy performances and udder shapes illustrating the indigene livestock adaptation to harsh conditions. The local goat had medium size teats, indicating adequate udder morphology for machine-milking. Some udder morphology traits had a positive correlation with daily milk and can be adopted for genetic selection in the breeding programs of local goat population under arid conditions. Some environmental factors such as lactation stage and age of the doe affect the mammary morphology and this will have to be taken into account when designing the optimal time of recording for these traits. Results complete this local genetic resource characterization and contribute to its sustainable management and performances improvement, nevertheless. Further research is required to complete the biological profile of this population in order to contribute to the modernization of the sector.

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