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THE RELATIONSHIP OF UDDER MEASUREMENTS TO MILK YIELD IN SHEEP UNDER SEMI-ARID CONDITIONS

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ABSTRACT

The present study aimed to describe the main measurements of the udder and to establish their possible relationships with daily milk yield in two breeds of sheep (Ouled Djellal and Rembi). This study was carried out on a group of 113 multiparous ewes of the Ouled Djellal breed (n=65) and the Rembi breed (n=48); aged from two to five years, with udder clinically healthy, during the lactation period (February-May 2023), which allowed us to evaluate the udder traits on one hand. On the other hand, the assessment of milk yield and quality. The estimation of milk yield was carried out at (10 and 30 and 60) days: by the weighing lambs' method before and after suckling. The milk yield did not differ between Ouled Djellal and Rembi ewes until day 30 after lambing ($P>0.05$). The study showed that breed affected the morphological characteristics of the sheep's udder. Teat length, teat diameter, teat distance and udder width were affected by breed ($P<0.05$). In conclusion, the study provided us that the Ouled Djellal breed had a good daily milk yield and showed adequate udder morphology for milk-ability, which justifies the interest in the genetic analysis of ewes.

Keywords: Ewe; milk yield; semi-arid; udder morphology, measurements**.**

INTRODUCTION

In some countries, the production of ewe milk is of considerable importance, compared to that of cow milk (Houssou and Brik, 2021). The production of sheep milk during the first month of lactation is of great importance for animal breeding, especially because breastfeeding is the basis. Milk plays a vital role in both ensuring a strong start for lamb growth and provides essential protein as lambs transition to pasture-based diets. (Smith *et al.,* 2023). Sheep dairy products have high nutritional value, as they are rich in fats, proteins, vitamins, minerals, and ewe colostrum is also higher in basic nutrients (Wang *et al.,* 2023). It is difficult to measure milk yield accurately by manual milking in ewes (Ünal *et al.,* 2008). However, Benchohra *et al.* (2014) have reported correlations between milk yield and lamb growth. The method Weighing Before and After Feeding (WBAF) is the most frequently used method for estimating milk yield (Ünal *et al.,* 2008; Benchohra *et al.,* 2014; Benson *et al.,*

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1999). The use of the character of udder morphology is highly recommended to improve the morphology of the udder (Pourlis, 2020). Consequently, knowledge of morphological udder trait variability allowed the identification of the mammary trait most suitable for incorporation into selection programs for dairy sheep breed (Adamu *et al.,* 2024). Breeders and scientists were interested in morphological and functional characteristics of udder traits in order to allow an easy and uniform milking in dairy sheep husbandry. Thus, the morphology of the mammary gland is a key factor for the optimization of machine milking parameters of small ruminants (Rovai *et al.,* 2008). Several dairy sheep breeds have been studied concerning their udder morphology traits. Therefore, the relationship of udder traits with milk yield and their usefulness for genetic improvement in sheep have been focused (Ayadi *et al.,* 2014). The genetic potential for milk sheep is assessed by the growth rate of lambs before weaning. It's a key indicator of an animal's ability to efficiently convert feed into weight gain, impacting both productivity and profitability. Only a few studies have investigated udder traits in Algerian sheep. The present study aims to assess the relationship of udder traits with milk yield in sheep, and to characterize the genetic potential of ewe milk yield that has not yet been fully exploited under Algerian conditions.

MATERIALS AND METHODS

Description of the study area

The research was conducted in the two regions in the east of Algeria (Souk-Ahras and Skikda) located in the northeast of Algeria. Skikda and the northern part of the Souk-Ahras region are exposed to Mediterranean climatic influences. The Souk Ahras region is characterized by hot, dry summers with an average temperature of 33°C, peaking at 42°C, and cold, wet winters with an average temperature of 12°C. Rainfall averages 600 mm per year. Skikda is characterized by mild, wet winters and hot, dry summers. Specifically, the region experiences a rainy season from October to March and a dry season from April to September. The coastal areas receive significant rainfall, ranging from 700 to 1200 mm annually.

Data collection

The dairy production estimation was based on an assessment of 113 multiparous lactating ewes with healthy udders, Ouled Djellal (n=65) and Rembi (n=48) ewes, ages ranging from 2 to 5 years, in private farms in Souk-Ahras and Skikda, using an intensive breeding system. The diet was based on ad libitum green pasture and wheat straw. A concentrate feed supplement of 400-500 g/head/day was given for a total of 1 month, before and after lambing. One month before lambing, a stream of 400–500 g/female/day was distributed of the same concentrate feed. The lambs were weighed at birth, on day 10, on day 30, and on day 60.

For the characterization of some physicochemical parameters of raw milk, the samples were taken from these ewes. The samples were immediately transferred to the Hamada laboratory in Souk Ahras, and the analyses were carried out according to international standards and techniques (AFNOR). The density was measured using a thermo-lactodensimeter at 20 °C. If a thermo-lactodensimeter is used at a temperature other than 20 °C, a correction was applied using the following method: corrected density = density read + (milk temperature – 20 °C) * 0.2. Acidity was measured by the titrimetric method and expressed as a percentage of lactic acid.

Fat: Gerber acid-butyrometric method (AFNOR 2001) was used for the separation and reading of the milk fat. The principle of the technique is the dissolution of milk components, except fat, with

sulfuric acid under the influence of centrifugal force and with the addition of a small quantity of isoamyl alcohol (1 ml). The fat was separated into a clear and transparent layer.

Proteins: The dosage of proteins was determined according to Bradford (1976). The collected fractions were treated with a Coomassie blue solution and ortho-phosphoric acid that specifically bind to proteins. The technique is based on the dilution of the milk samples and the reading by the spectrophotometer at 595 nanometers. The results of the salt, lactose and freezing point were displayed directly on the MilkoScan FT 120. The estimation of (colostrum and milk) yield was carried out after lambing at 10, 30 and 60 days: by the weighing method before and after suckling, using an electronic scale (maximum 180 kg).

In dairy ewes, udder morphology is indeed a crucial functional trait, because it directly influences machine milking efficiency and, consequently, the animal's functional lifespan. A well-shaped udder with features like appropriate teat placement, size, and angle, and a good udder attachment, allows efficient and comfortable machine milking. Evaluation of udder morphology by direct measurements: linear measurements of udder (udder width, udder depth and cistern depth), as well as of teat length and teat angle, characterize the morphology of mammary according to El Bouyahiaoui *et al.* (2023). Subjective assessment of udder score and teat position (N) based on five scales, according to Pourlis (2020) and El Bouyahiaoui *et al.* (2023). Udder depth, udder attachment, and teat position are commonly used traits for the selection programs (Pourlis, 2020; Smith *et al.,* 2023; El Bouyahiaoui *et al.,* 2023; Adamu *et al.,* 2024).

Figure 1. Represents the measurement of udder cistern depth in the ewe.

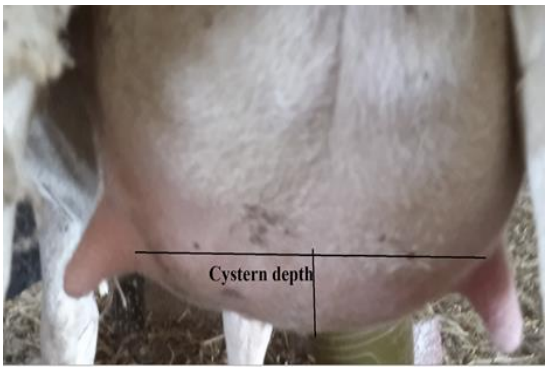

Figure 1: The measurement of udder cistern depth in the ewe

Statistical analysis

The descriptive analysis of the data was established using the SPSS version 20 tool. The effect of breed and the other factors were compared by a one-way ANOVA test. Pearson's correlation coefficients were performed to assess the association between the parameters studied. Regression analysis was used to study the effect of parity on milk yield at 10, 30, and 60 days. The best model that expresses the relationship between parity and milk yield was chosen based on R2 and significance

Y= b + b X + b X2 (quadratic model) at 10, 30 days of lactation
Y= b + b X + b X2 +b X 3 (cubic model) at 60 days of lactation

Ethical statement

The animals used in this study had their origin on semi-arid farms with a traditional management system. They were intended to produce milk and meat for human consumption. These animals were submitted to practice standardized and regulated by international guidelines for animal welfare (Terrestrial Animal Health Code 2018, section 7. Art 7.1) and national executive decree No. 95-363 of November 11, 1995 (Algeria).

RESULTS

Milk yield:

Table 1 shows the milk yield (from day ten after lambing until day 60).

Table 1: Shows the mean±SD of milk yield in OuledDjellal and Rembi ewes

Variables	Ouled-Djellal	Rembi	*P*
Milk yield at 10 day (kg)	0.35±0.05	0.29±0.07	0.067
Milk yield at day 30 (kg)	0.67±0.12	0.39±0.07	0.035
Milk yield at day 60 (kg)	1.12±0.53	0.81±0.48	0.007

The daily milk yield of the two sheep breeds increases by (0.35.and 0.29) kg/day at the tenth day of lactation for reach (1.12 and 0.86) kg/d on the 60th day respectively in OD and Rembi breeds (Table 1).

Figure 2 states the relationship between the milk yield at 10, 30 and 60 days after lambing and age. The estimated regression equation showed low to moderate coefficient of determination R2 = 17.9%. on day 10, R2= 37% and R2= 33.6 % on day 30 and day 60, respectively.

Regression equations of ewes in our study are:

MY D10= 5183,0 + 78,57 - 9,699^2

MY D30 = 259,2 + 224, - 27,57

MY D 60 = 4235-3514 + 1138 ^{2} - 112,0 y^3

Replace parity with milking intervals or duration of study (10, 20, 1 and 30 days)

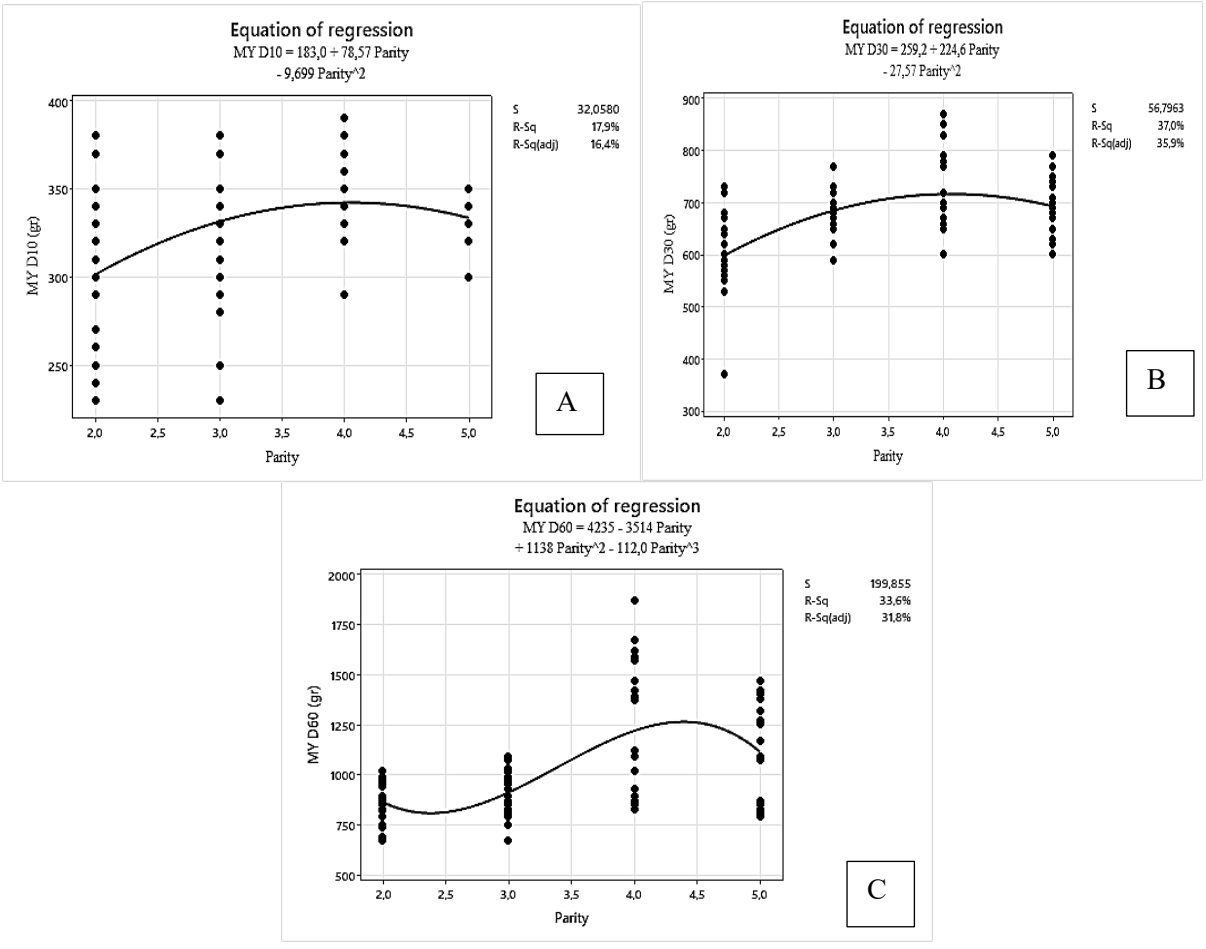

Figure 2: Relationship between the milk yield (MY) and milking intervals or duration of study on day 10 (A), day 30 (B) and day 60 (C) of lactation.

Table 2: Shows the mean ±SD of physicochemical analyses in ewe's milk

Parameters	Total	Ouled-Djellal	Rembi	*P*
Density (gr/mL)	1.031±0.20	1.029±2.21	1.033±0.31	0.035
Acidity (°D)	19.7±0.85	21.7±1.61	16.9±0.28	0.042
Fat %	7.14 ±2.01	7.25±1.85	6.91±2.08	0.074
Proteins %	6.26±0.83	5.89±0.55	7.69±1.38	0.025
Dry matter %	21.88±9.76	23.62±8.52	20.39±5.21	0.044
Salt %	0.734±0.05	0.761±0.07	0.703±0.02	0.032
Lactose	4.65±0.34	5.23±0.47	4.37±0.31	0.081
Conductivity	4.21±0.48	4.49±0.39	4.09±0.51	0.124
pH	6.79±0.49	6.76±0.40	6.85±0.28	0.070
Freezing point (°C)	-0.66±1.32	-0.62±1.64	-0.69±1.02	0.043

The density of milk is linked to its richness in dry matter; where it was estimated at 1.029 vs. 1.033 in Ouled Djellal and Rembi ewes, respectively. Regarding the fat content, we recorded content of 7.25% for Ouled Djellal milk and 6.91% for Rembi milk. The mean values of the total proteins of the studied milk in Ouled Djellal and Rembi were 5.89 and 7.69%. The values of the conductivity vary between 4.09 and 4.45. The measured pH values give averages ranging from 6.76 for milk from Ouled Djellal to 6.85 for milk from Rembi (P>0.05

Udder characteristics:

Table 3 shows the mean ±SD of udder measurements in Ouled Djellal and Rembi ewes during lactation periods

Table 3: Shows the mean ± SD of udder measurements in Ouled Djellal and Rembi ewes during lactation periods

Variables	**Ouled Djellal**	**Rembi**	***P***
	Mean± SD	**Mean± SD**	
Udder width (cm)	11.91±2.27	9.95±1.22	0.043
Udder depth (cm)	15.95±2.56	12.52±1.31	0.002
Cistern depth (cm)	4.45±1.25	3.15±1.25	0.003
Udder Score	2.87±1.12	2.54±2.10	0.114
Teat length (cm)	4.73±1.26	3.17±1.01	0.032
Teat width (cm)	2.22±0.48	1.92±0.26	0.025
Teat distance (cm)	10.71±2.27	9.85±1.22	0.042
Teat position	3.75±1.15	3.04±1.02	0.074
Teat angle (α)	44±10.24	50±9.25	0.154

The size of the Ouled Djellal and Rembi sheep's udder, respectively (119.1 x 149.5 versus 99.5 x 115.2 mm) can be considered intermediate size. The average depth of the udder is significantly affected by breed (P<0.01), estimated at 159.5 mm for Ouled Djellal ewes and 125.2 mm for Rembi ewes. The teats' position (N) is set a little forward on a scale of 5 in Ouled Djellal and Rembi, respectively (N: 3.75 and 3.34).

A summary of the correlations among traits is shown in Table 4. Results showed a positive correlation between udder characteristics of ewes. Correlations among all teat and udder traits were positive; these correlations were significant ($p < 0.001$), ranging from (r =0.38** to (r =0.700**). Strong positive and significant correlation was recorded between udder width and udder depth (r =0.67**), while moderate correlation was observed between udder width and cistern depth (r =0.41**).

Table 4: The correlation between the milk yield and udder measurements in Ouled-Djellal and Rembi ewes

Variables	Milk quantity	Udder width (cm)	Udder depth (cm)	Cistern depth (cm)	Udder Score	Teat length (cm)	Teat with (cm)	Teat distance (cm)	Teat position	Teat angle (α)
Milk quantity	1									
Udder width (cm	0.04	1								
Udder depth (cm)	0.21*	0.67**	1							
Cistern depth (cm)	0.82*	0.41**	0.39**	1						
Udder Score (cm)	0.42**	0.52**	0.66**	0.43**	1					
Teat length (cm)	0.35**	0.55**	0.70**	0.42**	0.90**	1				
Teat with (cm)	0.77**	0.38**	0.45**	0.34**	0.82**	0.78**	1			
Teat distance (cm)	0.37**	0.38**	0.47**	0.37*	0.54	-0.57*	-0.55*	1		
Teat position	0.11	0.00	0.01	-0.01	0.34	0.24	0.43**	0.47*	1	
Teat angle (α)	0.71**	-0.24	-0.28	-0.30	-0.04*	-0.04*	-0.34**	0.0	-0.45**	1

*Significant at P<005; ** Significant at P<0.01

DISCUSSION

The peak of milk production average during the first month of lactation was reached on the 30th day of breastfeeding. No significant difference was noted in milk production between the two breeds on day 10 (P>0.05). However, dairy production was significantly influenced by birth on day 30 (P<0.05) and on day 60 (P<0.01). The results obtained in the present study are much weaker. The dairy production of these ewes is close to Rembi breed, which produces from 0.5 kg per day in Algeria, conducted under extensive breeding conditions in Tiaret province (Benchohra *et al.,* 2014).

Regression analysis indicates a significant relationship between ewe's parity and milk yield, with milk yield generally increasing with parity number up to 5. Similarly, Casoli *et al.* (1989) reported that parity had a significant effect on total milk yield according to this formula $y=2.1409-0.012x+0.00002x2$.

These results of density (1039 and 1033) in the Rembi and OD breeds are lower than findings reported by Yabrir *et al.* (2013). In addition, some physicochemical characteristics of milk were affected by breed (P<0.05). Regarding the physical characteristics of milk, Rembi had significantly (P<0.05) higher milk density than the Ouled Djellal and weak freezing point (-0.69 vs. -0.62 °C) (P<0.05). The milk acidity of ewes showed that it was more acidic in Ouled Djellal (21.7 °D), compared to that of Rembi ewes (16.9 °D). The acidity content may be explained by the type of sheep's diet. According to the FAO (1995), ewe's milk should have an acidity between 22-25°D. According to

Houssou *et al.* (2023), the increase in acidity is an indicator of keeping quality of milk and can only result from a consequent development of the lactic flora influenced by the effect of the increase in temperature, as well as the milk storage time. The peak of milk yield average during the first month of lactation was reached on the 30th day of breastfeeding. No significant difference was noted in milk yield between the two breeds at birth and before day 30 ($P>0.05$). Whereas the analysis of variance showed that the Ouled Djellal ewe had a higher milk yield beyond day 30 ($P<0.05$). The results obtained in the present study are much weaker. The milk yield of Correct these ewes is close to Rembi breed, which produces from 0.5 kg per day in Algeria, conducted under extensive breeding conditions in Tiaret province, as evidenced by Benchohra *et al.* (2014).

The observed averages for fat contents are close to results obtained by other authors, Yabrir *et al.* (2013), who found an acidity of (6.83 %) in Ouled Djellal and (5.35 %) in Rembi. This is considered high fat levels compared to those recorded in Iraq, 5.65 % reported by Mustafa *et al.* (2023). Grigorescu *et al.* (2023) had shown that sheep dietary manipulations can increase the unsaturated fatty acid profile of milk, while decreasing the levels of saturated fatty acids. Djeddi *et al.* (2024) reported that Bovine, Caprine, Camelin and Human milks are characterized by a lower fat content than that of sheep.

The mean values of the total proteins of the studied milk in Ouled Djellal and Rembi were 5.89 and 7.69%, respectively, which is higher than the findings obtained (4.70 and 5.41 %) for the same breeds in Algeria by Yabrir *et al.* (2013) and Mustafa *et al.* (2023) in Iraq with (4.40 %). We recorded the dry extract values, which varied between 23.62% and 20.39%, respectively, for the Ouled Djellal ewes' milk and Rembi studied. The later are higher than 16.95% and 16.47% of the same breeds in Algeria) studied by Yabrir *et al.* (2013). The dry matter confirms the high nutritional quality of the milk (Houssou *et al.,* 2023). It is noted that the total dry extract content depends on several factors, such as the quality of the water and its quantity available to the animals (Gonzalo *et al.,* 2005). The values of the conductivity varied between 4.09 and 4.45, which are within the standards 3.8-5.2 (FAO, 1995). The electrical conductivity of milk is an excellent potential for the detection of mastitis (Houssou *et al.,* 2023). The measured pH values give averages ranging from 6.76 for milk from Ouled Djellal to 6.85 for milk from Rembi ($P>0.05$). These results are closer to the standard stated by the literature FAO (1995). The variation in pH is probably due to the type of food because the pH depends on the nature of the ingested food by the animal and the availability of water (Houssou *et al.* 2023). According to Yabrir *et al.* (2013), several factors influence the variation in the pH of sheep's milk, including the presence of mastitis, the stage of lactation, which decreases towards the end of the cycle, the variation in temperature, season and age of the ewes. Variations in milk pH can result from an infection of the animal's udder (Kandee *et al.,* 2019).

The factors influencing the milk composition are multiple; differences may be genetic. Yabrir *et al.* (2013) found that breed had a significant effect on milk composition. Abd Allah *et al.* (2011) found that breed had a significant effect only on fat and Solid-non-fat (SNF) when comparing Rahmani and Chios Egyptian ewes. However, Mierlita *et al.* (2011) reported that the breed of ewe had no significant effect on protein, fat and dry extract contents for Spanca and Turcana Romanian ewes. Also, Tsiplakou *et al.* (2008) did not find any effect of breed on fat, protein and lactose concentration of the four sheep breeds (Awassi, Lacaune,

Friesland and Chios) kept under the same management in Greece.
According to many authors (Benchohra et al., 2014; El Bouyahiaoui et al., 2023), the sheep's milk yield is affected by several factors, of which we can mention those related to the female body score, age, breed, stage of lactation, udder health, diet, method of milking, season and other factors. The shape and size of the udder and teat characteristics are important determinants of milk yield and ease of milking or milking ability of dairy animals and the health of the animal, especially of the udder, are important factors in milk yield (El-Gendy *et al.*, 2014). Pulina *et al.* (2006) reported that an appropriate nutritional ration is essential for producing high-quality sheep milk with desirable fat and protein levels. It also underscores the importance of monitoring milk composition to assess the nutritional balance and health status of the animals.

The average depth of the udder is significantly affected by breed ($P<0.01$), these records are slightly lower than the founds of El Bouyahiaoui *et al.* (2023) in Tazegzawt (175.56 mm). The size of the Ouled Djellal and Rembi sheep's teats is 47.3 x 22.2 versus 31.7 x 19.2 mm respectively. We note that the dimensions obtained are close to those recorded by El Bouyahiaoui *et al.* (2023) in Tazegzawt breed (31,48 x 22 mm); Labussière *et al.* (1981) in the Lacaune breed (32.5 x 15.2 mm). According to El Bouyahiaoui *et al.* (2023), these dimensions were probably due to the replacement of milk, with other words of these breeds adapted to mechanical milking.

The teats' position (N) findings are similar to the Tazegzawt breed (N: 3.30) (El Bouyahiaoui *et al.,* 2023), Churra breed (N: 3.64) (Fernández *et al.,* 1995), but higher than other breeds, such as the Manchega (N: 2.21) and the Lacaune (N: 2.48) (Rovai *et al.,* 2008). The morphological characteristics of the teats in Ouled Djellal were higher ($P<0.05$). Furthermore, Rembi breed was characterized by a very small udder depth and cistern depth ($P<0.01$), the same observations for milk yield were higher in Ouled Djellal breed on the 30th day.

Correlation was recorded between the udder width and udder depth, and also between udder width and cistern depth. These results agreed with the findings of correlation results reported by Tsiplakou *et al.* (2008). Ayadi *et al.* (2014) reported positive and significant correlations between milk yield and udder volume, and between udder volume and udder depth. This study disagrees with the negative phenotypic relationship between udder depth and milk yield reported in dairy sheep (Marshall *et al.,* 2024). Conversely, negative correlations were obtained between teat insertion angle and teat diameter and between teat diameter and distance between teats, the importance of these traits both in predicting the milk yield in local ewes and as selection markers for future improvement of their production under arid conditions.

CONCLUSION

In conclusion, the ewe's milk has shown that there are significant variations in production and some physicochemical composition of milk depending on the breed in Algeria (Ouled Djellal and Rembi). In addition, the ewe population showed high morphological variability of udder and teats, indicating the possibility of selection for this criterion, in the objectives to improve ewe's milk yield or to contribute to the lamb's growth by additive suckled milk. Similarly, the udder of Ouled Djellal ewes was significantly more developed than Rembi ewes. The udders of the Ouled Djellal ewes were assessed to be suitable for machine milking, based on their size and shape.

Conflict of interest
The authors declare that they have no potential conflict of interest.

Author contributions
The authors contributed equally to the research.

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علاقة مقاييس الضرع بمحصول اللبن فى الأغنام تحت الظروف الشبه جافة

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استهدفت الدراسة الحالية وصف القياسات الرئيسية للضرع وإقامة علاقاتها المحتملة مع إنتاج الحليب اليومي في سلالتين من الأغنام (أولاد جلال ورمبي). أجريت هذه الدراسة على مجموعة من ١١٣ نعجة متعددة الولادات من سلالة أولاد جلال (ن = ٦٥) وسلالة رمبي (ن = ٤٨)؛ تتراوح أعمارها بين سنتين وخمس سنوات مع ضرع سليم سريريًا، خلال فترة الرضاعة (فبراير - مايو ٢٠٢٣)، مما سمح لنا بتقييم سمات الضرع من ناحية, ومن ناحية أخرى، تقييم إنتاج الحليب وجودته. تم تقدير إنتاج الحليب عند ١٠ و٣٠ و٦٠ يومًا: بطريقة وزن الحملان قبل وبعد الرضاعة. لا يختلف إنتاج الحليب بين نعجة أولاد جلال ورمبي حتى اليوم الثلاثين بعد الولادة. أظهرت الدراسة أن السلالة تؤثر على الخصائص المورفولوجية لضرع الأغنام. وتأثر طول الحلمة، وقطرها، ومسافتها، وعرضها بالسلالة. وفي الختام، خلصت الدراسة إلى أن سلالة أولاد جلال تتمتع بإنتاج يومي جيد من الحليب، وأن شكل ضرعها مناسب لكفاءة إنتاج الحليب، مما يبرر الاهتمام بالتحليل الوراثي للنعاج.

الكلمات المفتاحية: النعاج ؛ الحليب ؛ الإنتاج ؛ شبه القاحلة ؛ الضرع