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ANIMAL PRODUCTION

# Milk production and its relationship with milk composition, body and udder morphological traits in Bedouin goat reared under arid conditions

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**ABSTRACT.** This research aims to assess the performances of lactating Bedouin goat under arid conditions, focusing on the relationship of milk yield with body and udder morphology and growth traits. Fourteen goats and their kids were followed during early lactation (90 days *post-partum*). Mean daily milk yield was 0.56 kg. Milk fat, proteins, lactose, solids non-fat and minerals were respectively 34.9, 38.9, 48.8, 107 and 6.7 g $L^{-1}$. Mean kids' birth weight, adjusted body weight at 90 days of age and average daily gain were respectively 2 kg, 6.6 kg and 51.4 g $day^{-1}$. Daily milk yield was correlated with goats' body weight, withers height, rump height, udder width and udder circumference but not with linear udder score and growth performances. These results provide important data about the milk production of Bedouin goat emphasizing its correlation with body and udder morphological traits which can help to elaborate a specific breeding program for this breed.

**Keywords:** growth performances; milk yield; Sahara; udder.

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## Introduction

In the Sahara Desert, where the water and food resources are limited, Bedouin goat contributes strongly to the survival of sedentary and nomadic populations, by the consumption of its meat and milk known by its nutritional quality and therapeutic properties.

This breed exhibits an excellent adaptation to arid environment. Indeed, it has sweat gland which has a high secretory capacity to better dissipate the absorbed heat (Dmi'el, Robertshaw, & Choshniak, 1979) and has a lower water turnover and glomerular filtration rate which allow it to overcome water deprivation (Silanikove, 1984). Also when drinking a large amount of water, its spacious rumen releases it gradually to prevent hemolysis (Choshniak & Shkolnik, 1977). Bedouin goat has also low metabolic requirements and can reduce its energetic metabolism and digest low quality diet during food restriction periods (Silanikove, Tagari, & Shkolnik, 1993). Furthermore, Bedouin goat has higher concentration of caprine Pregnancy-Associated Glycoproteins, reflecting a strategy of adaptation for maintaining a pregnancy under arid conditions (Charallah, Amirat, Sulon, Khammar, & Beckers, 2009), and after kidding, it ensures the survival of its offspring by maintaining its milk production in such environment. In fact, Bedouin goat living in Negev desert and Eastern Sinai showed a high daily milk yield and was able to maintain its milk production unchanged after 2 days of dehydration (Maltz & Shkolnik, 1980; Shkolnik, Maltz, & Gordin, 1980). However, the performances of lactating Bedouin goat have not yet been fully studied, particularly body and udder morphological traits, which are important determinants of milk yield (Akpa et al., 2002; Akporhuarho, Orheruata, Otoikhian, & Igene, 2010; Peris, Caja, & Such, 1999), considered as a main factor affecting kids' growth performances.

Actually, Bedouin goat is conducted under uncontrolled conditions and milking and milk transformation are still limited to traditional practices, thus without being a subject of a development program, this breed presents a reduced profitability. Therefore, in this study we assess the performances of Bedouin goat during early lactation focusing on the relationship between milk yield and body and udder morphology to determine the most appropriate traits to introduce into breed improvement scheme.

# Material and methods

## Animals and management

The study was carried out at Beni-Abbes region, located in the southwest of Algeria (495 m altitude, 30°07' N, 2°10' W). The climate of this arid area is characterized by high temperatures (more than 44 °C in summer), rare precipitations (less than 30 mm year$^{-1}$) and poor vegetation.

Fourteen multiparous Bedouin goats were followed during the early lactation; eleven were 2 years old and three were between 6 and 8 years old. The buck was introduced for fertilization in fall and removed before kidding. In spring, goats gave birth to 16 kids, 7 males and 9 females, among them 12 singles and 2 twins. One female kid, from twin delivery, died at birth due to dystocia so it was omitted from the study.

Goats were maintained in a sheepfold at the research station of Beni-Abbes during the experimental period which lasted for the 13 first weeks *post-partum*. Goats were fed twice a day and the diet presented to them consisted mainly of a daily ration of 0.6 kg/goat of forage cereals and 0.6 kg/goat of barley (forage:concentrate ratio : 50:50) in addition to a supplementation of dates and *Aristida pungens* (desert plant commonly called Drinn) for the whole lactation period and fresh green alfalfa during the first days *post-partum*. Fresh water and mineral licks (Eurobloc Calseagrit Biotech, Calseaoligo) were always available. Kids were left with does and had free choice access to their mothers' diet.

## Milk yield recording

The measurement of milk production began after the 3$^{rd}$ day *post-partum* to allow kids consuming colostrum. The daily milk yield (DMY) was measured twice a week by the weigh-suckle-weigh method which showed similar results with the machine milking technique (Benson, Henry, & Cardellino, 1999). On the night preceding milk yield recording, kids were separated from goats at 20.00h. The next morning, at 08.00h, kids were weighed then allowed to suckle their dams for a period that did not exceed 20 min. Kids' body weight was recorded, then they were separated from their mothers again until 20.00h when the procedure was repeated. The difference between pre and post-suckling weights represented the amount of milk consumed by the kid. Residual milk remaining in the udder was hand-milked and measured. The DMY of the goat was estimated by adding the milk suckled by the kid at the two periods of recording to the residual milk.

## Milk sampling and analysis

Milk samples from each goat were collected weekly from the 4$^{th}$ day *post-partum*. The night before the milk sampling, kids were removed from their mothers. On the test day, the udder was cleaned and teats disinfected after the foremilk discharge. Milk samples were then collected into sterile plastic flasks and immediately transported in an icebox (4°C) to the milk quality laboratory where biochemical analyses were performed. Milk samples were analyzed for density, freezing point, fat, proteins, lactose, solids non-fat (SNF) and minerals by LactoStar apparatus (Funke Gerber, Germany) according to the combined thermo-optic method. The acidity analysis was performed by titration using 0.1 N sodium hydroxide and phenolphthalein as colored indicator.

## Body and udder morphological traits of lactating goats

The body weight of goats was recorded on the day of parturition then weekly. The assessment of the other body and udder morphological traits was performed once during the last week of the 2$^{nd}$ month. Body morphological traits measured were: trunk length, withers height, rump height, chest depth, chest width, rump width, chest perimeter, abdominal perimeter and ear length.

Udder morphology was assessed 11h after separation of goats from their kids by two methods: morphological measurements and subjective linear appraisals. Udder measurements consisted of: udder length from rear to fore attachment, udder width and udder circumference in the middle, udder depth from rear attachment to udder floor, citern depth from teat insertion to udder floor, teat length from insertion to tip, teat width and teat circumference in the middle, teats distance between the two teats attachments with udder, teat angle from the vertical in a rear view and teat-floor distance between the tip of teat and the ground. Udder morphology was scored with a nine-point linear scale (De la Fuente, Fernandez, & San Primitivo, 1996) which considers eight characteristics. Udder depth was scored by the evaluation of the udder floor position taking as a reference the hocks (1: deep udder close to the ground; 9: shallow udder close to the abdominal wall). Fore udder attachment ranges from loose with udder less extended forward (1) to strong with udder more extended forward (9). Rear udder attachment was assessed by the ratio between the rear attachment width and the udder depth (1: attachment width much smaller than the udder depth; 9: attachment width much larger than the udder depth). Udder cleft evaluates the strength of the median ligament by scoring the degree of separation of the two udder halves (1: pronounced; 9: none). Citern depth was assessed through the distance between teat insertion and the udder floor (1: high; 9: none). Teat size ranges from short and thick (1) to long and thin (9). Teat inclination varies from cranial (1) to caudal (9). Teat orientation was scored in relation to the medial ligament (1: divergent; 9: convergent). For udder depth, fore udder attachment, rear udder attachment and citern depth, the score 9 was the best while udder cleft, teat size, teat inclination and teat orientation have optimum intermediate scores. Udder texture, udder and teat shape and the presence of supernumerary teats were also recorded.

### Kids' growth performances

Kids were weighed at birth then twice a week. Calculated traits were adjusted live body weight (ABW, kg) at 30 days (ABW30), 60 days (ABW60) and 90 days of age (ABW90), as well as average daily weight gain (ADG, g/day) from birth to 30 days (ADG0-30), between 30 and 60 days (ADG30-60), between 60 and 90 days (ADG60-90), from birth to 90 days (ADG0-90) and between 30 and 90 days (ADG30-90).

### Statistical analysis

Results are expressed as means ± SEM. Statistical analyses were realized with GraphPad Prism (version 5.00 for Windows, GraphPad Software, San Diego California USA). All variables were tested for normal distribution using Shapiro-Wilk test and for homogeneity of variances by Levene's test. Student's t-test was used to determine the statistical difference between two means. The statistical difference between more than two groups was evaluated using Kruskal-Wallis test and Dunn's multiple comparison test as post hoc. Correlation analyses were performed using Spearman test. Probability was considered significant at 5 % level ($p \leq 0.05$).

## Results

### Milk yield and composition

The daily yield and chemical composition of Bedouin goat's milk are summarized in Table 1 and their evolution during early lactation is shown in Fig. 1 and 2.

During early lactation, the mean of DMY was 0.56 ± 0.06 kg and the individual values varied between 0.10 and 1.36 kg. Daily milk production increased from the 1$^{st}$ to the 6$^{th}$ week *post-partum*, which corresponds to the peak of lactation (0.71 ± 0.09 kg), and then it decreased significantly (0.31 ± 0.07 kg) until the 13$^{th}$ week ($p < 0.01$). Older goats, 6 to 8 years old, produced 43.5 % more milk than 2 years old goats (0.85 ± 0.60 vs 0.48 ± 0.37 kg). Moreover, goats giving birth to twins produced 25.9 % more milk than those kidding singles (0.72 ± 0.20 vs 0.53 ± 0.06 kg).

Mean rates of fat, proteins, lactose and SNF were respectively 34.9 ± 1.8, 38.9 ± 0.6, 48.8 ± 0.8 and 107.1 ± 1.5 g $L^{-1}$. The concentration of fat dropped by 54.8 % from the 1$^{st}$ (66.5 ± 15.4 g $L^{-1}$) to the 3$^{rd}$ week *post-partum* (30.0 ± 1.7 g $L^{-1}$), then stabilized for the rest of early lactation period. Proteins, lactose and SNF rates were the highest in the 1$^{st}$ week *post-partum* (44.7 ± 4.0, 55.9 ± 4.9 and 122.1 ± 10.0 g $L^{-1}$ respectively). They decreased through the 1$^{st}$ month of lactation before stabilizing in the two next months. The average concentration of minerals remained relatively stable throughout early lactation; it ranged between 5.9 and 7.6 g $L^{-1}$ with a mean of 6.7 ± 0.2 g $L^{-1}$.

Mean rates of physicochemical properties were 18.8 ± 0.7 °D for acidity, 1037.2 ± 0.6 mg $L^{-1}$ for density and -0.521 ± 0.003 °C for freezing point. Their highest rates were also recorded in the 1$^{st}$ week of lactation.

**Table 1.** Daily yield and composition of Bedouin goat's milk during early lactation.

| | Mean ± SEM | | | | Min | Max |
|---|---|---|---|---|---|---|
| | Week 1-4 | Week 5-8 | Week 9-12 | Whole early lactation | | |
| DMY (kg) | 0.60[a] ± 0.05 | 0.63[a] ± 0.07 | 0.42[b] ± 0.07 | 0.56 ± 0.06 | 0.10 | 1.36 |
| Fat (g $L^{-1}$) | 39.6[a] ± 2.9 | 31.7 ± 1.6 | 30.3[b] ± 1.4 | 34.9 ± 1.8 | 15.5 | 142.1 |
| Proteins (g $L^{-1}$) | 40.5[a] ± 0.8 | 37.9[b] ± 0.7 | 38.1 ± 0.7 | 38.9 ± 0.6 | 28.7 | 57.7 |
| Lactose (g $L^{-1}$) | 50.7[a] ± 1.0 | 47.5[b] ± 0.9 | 47.7 ± 0.9 | 48.8 ± 0.8 | 36.4 | 72.4 |
| SNF (g $L^{-1}$) | 111.0[a] ± 2.1 | 104.5[b] ± 1.7 | 104.9 ± 1.6 | 107.1 ± 1.5 | 82.9 | 156.6 |
| Minerals (g $L^{-1}$) | 6.4 ± 0.3 | 6.8 ± 0.2 | 6.9 ± 0.3 | 6.7 ± 0.2 | 4.4 | 11.5 |
| Acidity (°D) | 20.2 ± 0.9 | 18.0 ± 1.0 | 17.9 ± 0.7 | 18.8 ± 0.7 | 10.0 | 32.0 |
| Density (mg $L^{-1}$) | 1038.2 ± 0.9 | 1036.5 ± 0.7 | 1036.9 ± 0.7 | 1037.2 ± 0.6 | 1025.7 | 1056.5 |
| Freezing point (-°C) | 0.524 ± 0.005 | 0.515 ± 0.007 | 0.519 ± 0.007 | 0.521 ± 0.003 | 0.629 | 0.444 |

DMY, daily milk yield; SNF, solids nonfat; °D, Dornic degree. [a,b] Means within the same row followed by a different lowercase letter indicate a significant difference between months ($p < 0.05$).

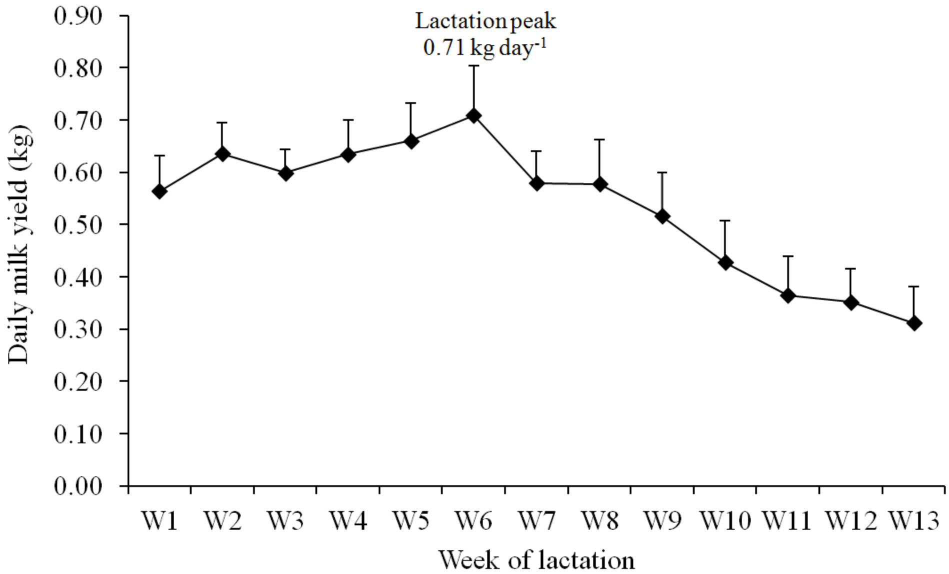


**Figure 1.** Average daily milk yield evolution during early lactation in Bedouin goat.

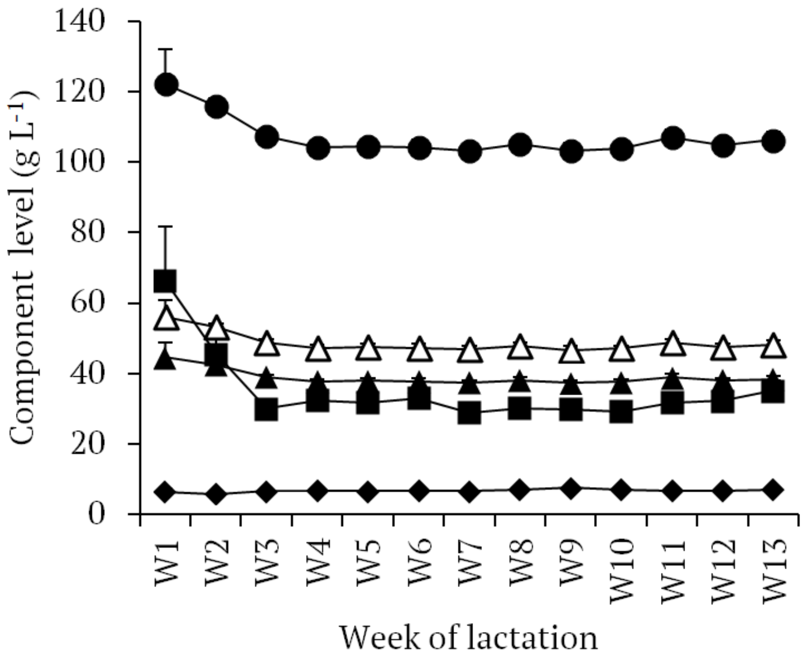


**Figure 2.** The evolution of milk components during early lactation in Bedouin goat. -■-: fat, -▲-: proteins, -Δ-: lactose, -•-: solids nonfat, -♦-: minerals.

### Body and udder morphological traits of lactating goats

Characteristics of body and udder morphology of lactating goats and their correlations with milk yield are summarized in Table 2. Mean goats' body weight was 23.2 ± 1.5 kg on the day of parturition. It decreased significantly ($p < 0.01$) to 20.5 ± 1.4 kg during early lactation, which corresponded to a loss of 11.6 % of initial body weight. Most of the goats had a globular udder with a funnel or bottle teat shape. Non globular udders and cylindrical shaped teats were less frequent (three and two goats respectively). Except two goats, the others presented a soft udder texture. Supernumerary teats were present in five goats.

The mean DMY was significantly correlated with goats' body weight ($p < 0.01$), withers height, rump height, udder width and udder circumference ($p < 0.05$). The correlation between DMY and linear udder score was not significant ($p > 0.05$).

Results of correlation between udder measurements and linear udder traits are shown in Table 3. The higher correlation coefficient was found between teat size and teat circumference ($r = -0.92$, $p < 0.001$). Fore udder attachment was significantly correlated with teats distance and teat angle ($p < 0.05$) and citern depth score was significantly correlated with teat width ($p < 0.01$) and teat circumference ($p < 0.001$). Teat inclination was significantly correlated positively with udder and citern depths and negatively correlated with teats distance and teat angle ($p < 0.05$). Teat orientation was also significantly correlated with teats distance ($p < 0.05$). Correlations between udder and citern depths and their scores were not significant ($p > 0.05$) despite the relatively high correlation coefficients (-0.50 and 0.54 respectively).

**Table 2.** Body and udder morphological traits of Bedouin goat during early lactation and their correlations with milk yield.

| Traits | Mean ± SEM | Min | Max | Correlations with milk yield |
|---|---|---|---|---|
| Body measurements | | | | |
| Body weight (kg) | 20.5 ± 1.4 | 14 | 39.5 | 0.75** |
| Trunk length (cm) | 61.1 ± 1.3 | 56.5 | 69.0 | 0.34 |
| Withers height (cm) | 64.2 ± 0.9 | 59.0 | 70.0 | 0.64* |
| Rump height (cm) | 66.3 ± 1.2 | 61.0 | 73.0 | 0.68* |
| Chest depth (cm) | 26.9 ± 0.5 | 24.0 | 30.0 | 0.31 |
| Chest width (cm) | 8.1 ± 0.2 | 7.3 | 9.0 | 0.52 |
| Rump width (cm) | 8.6 ± 0.4 | 7.4 | 12.1 | 0.51 |
| Chest perimeter (cm) | 67.7 ± 0.9 | 64.3 | 75.0 | 0.54 |
| Abdominal perimeter (cm) | 76.6 ± 1.9 | 65.5 | 89.0 | 0.18 |
| Ear length (cm) | 14.4 ± 0.5 | 12.2 | 16.5 | 0.06 |
| Udder measurements | | | | |
| Udder length (cm) | 20.6 ± 2.2 | 14.0 | 40.8 | 0.29 |
| Udder width (cm) | 6.3 ± 0.3 | 4.7 | 8.7 | 0.70* |
| Udder circumference (cm) | 26.1 ± 0.8 | 22.5 | 32.0 | 0.66* |
| Udder depth (cm) | 12.9 ± 1.1 | 9.5 | 22.5 | 0.18 |
| Citern depth (cm) | 2.0 ± 0.5 | 0.8 | 6.0 | 0.18 |
| Teat length (cm) | 2.5 ± 0.2 | 2.0 | 4.5 | -0.48 |
| Teat width (cm) | 0.7 ± 0.1 | 0.4 | 1.6 | 0.03 |
| Teat circumference (cm) | 3.4 ± 0.3 | 2.4 | 6.2 | 0.10 |
| Teats distance (cm) | 5.7 ± 0.5 | 2.5 | 8.5 | 0.09 |
| Teat angle (°) | 46.8 ± 2.2 | 35.0 | 55.0 | 0.20 |
| Teat-floor distance (cm) | 32.2 ± 2.4 | 12.0 | 39.5 | 0.04 |
| Linear udder traits (score) | | | | |
| Udder depth | 8.6 ± 0.4 | 5.0 | 9.0 | -0.50 |
| Fore udder attachment | 2.5 ± 0.5 | 1.0 | 5.0 | 0.37 |
| Rear udder attachment | 5.2 ± 0.5 | 3.0 | 9.0 | 0.21 |
| Udder cleft | 5.0 ± 0.3 | 3.0 | 7.0 | -0.12 |
| Citern depth | 5.0 ± 0.7 | 2.0 | 9.0 | 0.30 |
| Teat size | 6.1 ± 0.7 | 3.0 | 9.0 | -0.03 |
| Teat inclination | 4.7 ± 0.3 | 3.0 | 6.0 | -0.03 |
| Teat orientation | 3.5 ± 0.5 | 1.0 | 7.0 | -0.05 |

* Significant correlation ($p < 0.05$); ** Very significant correlation ($p < 0.01$).

**Table 3.** Correlation Coefficients between udder measurements and linear udder traits.

| | UDS | FUA | RUA | UC | CDS | TS | TI | TO |
|---|---|---|---|---|---|---|---|---|
| UL | -0.50 | -0.15 | -0.30 | -0.33 | 0.14 | -0.16 | 0.52 | 0.20 |
| UW | -0.40 | -0.23 | -0.06 | -0.03 | -0.04 | 0.15 | 0.09 | -0.10 |
| UC | -0.40 | 0.23 | -0.05 | -0.25 | 0.13 | -0.11 | -0.20 | 0.14 |
| UD | -0.50 | -0.28 | -0.32 | -0.20 | 0.35 | -0.29 | 0.61* | 0.15 |
| CD | -0.51 | -0.06 | 0.13 | -0.02 | 0.54 | -0.36 | 0.62* | 0.09 |
| TL | 0.31 | -0.10 | 0.01 | 0.09 | 0.16 | 0.36 | -0.04 | 0.50 |
| TW | -0.16 | 0.11 | -0.19 | -0.03 | 0.79** | -0.83 | 0.14 | 0.16 |
| TC | -0.30 | 0.18 | -0.09 | -0.07 | 0.88*** | -0.92*** | 0.22 | 0.31 |
| TD | 0.40 | 0.64* | -0.29 | -0.11 | -0.27 | 0.21 | -0.62* | 0.37* |
| TA | 0.30 | 0.66* | -0.20 | -0.20 | -0.35 | 0.40 | -0.63* | -0.46 |
| TF | 0.40 | 0.12 | -0.34 | 0.33 | 0.08 | -0.02 | -0.33 | -0.07 |

UL, udder length; UW, udder width; UC, udder circumference; UD, udder depth; CD, citern depth; TL, teat length; TW, teat width; TC, teat circumference; TD, teats distance; TA, teat angle; TF, teat-floor distance; UDS, udder depth score; FUA, fore udder attachment; RUA, rear udder attachment; UC, udder cleft; CDS, citern depth score; TS, teat size; TI, teat inclination; TO, teat orientation. * Significant correlation ($p < 0.05$); ** Very significant correlation ($p < 0.01$); *** Highly significant correlation ($p < 0.001$).

**Table 4.** Early growth performances of Bedouin kids and their correlations with milk yield.

| Growth traits | Mean ± SEM | Min | Max | Correlations with milk yield[1] |
|---|---|---|---|---|
| BW (kg) | 2.0 ± 0.1 | 1.2 | 2.6 | -0.06 |
| ABW30 (kg) | 3.9 ± 0.3 | 2.2 | 5.3 | 0.38 |
| ABW60 (kg) | 5.4 ± 0.4 | 3.5 | 7.5 | 0.10 |
| ABW90 (kg) | 6.6 ± 0.5 | 4.1 | 9.2 | 0.01 |
| ADG0-30 (g day$^{-1}$) | 65.1 ± 7.2 | 18.3 | 102.3 | 0.42 |
| ADG30-60 (g day$^{-1}$) | 51.1 ± 4.5 | 30.1 | 86.2 | 0.35 |
| ADG60-90 (g day$^{-1}$) | 42.4 ± 6.2 | 20.4 | 91.9 | 0.36 |
| ADG0-90 (g day$^{-1}$) | 51.4 ± 5.0 | 29.1 | 74.1 | 0.23 |
| ADG30-90 (g day$^{-1}$) | 46.5 ± 4.5 | 30.1 | 74.3 | 0.32 |

BW, birth weight; ABW30, adjusted live body weight at 30 days of age; ABW60, adjusted live body weight at 60 days; ABW90, adjusted live body weight at 90 days; ADG0-30, average daily weight gain from birth to 30 days; ADG30-60, average daily weight gain from 30 to 60 days; ADG60-90, average daily weight gain from 60 to 90 days; ADG0-90, average daily weight gain from birth to 90 days; ADG30-90, average daily weight gain from 30 to 90 days. [1] All correlations of growth performances with milk yield were not significant ($p > 0.05$).

### Kids' growth performances

Bedouin kids' performances and their correlations with milk yield are given in Table 4. The mean kids' birth weight (BW) was 2 ± 0.1 kg. They grew at a rate of 51.4 g day$^{-1}$ during early lactation to reach a final weight of 6.6 kg at the 90$^{th}$ day. The highest growth rate was recorded for ADG0-30 followed by ADG30-60 and then ADG60-90 but no significant difference was noted between these traits ($p > 0.05$).

Neither goats' body weight ($r = 0.38$), nor DMY ($r = 0.07$) were significantly correlated with mean kids' body weight ($p > 0.05$). Body weights adjusted to different typical ages as well as ADG were also not significantly correlated with DMY ($p > 0.05$).

## Discussion

The average DMY of Bedouin goat was comparable to those of Nigerian Red Sokoto goat (Malau-Aduli, Eduvie, Lakpini, & Malau-Aduli, 2003) and Egyptian Zaraibi and Shami goats (Alsheikh, 2013). However, it was much lower than the value of 1.5 kg found by Maltz and Shkolnik (1980) in the same breed living in the Negev desert and lower than the value of 0.70 kg reported in black Moroccan goat (Hossaini-Hilali, Benlamlih, & Dahlborn, 1993). This difference can be attributed to environmental factors, since for the three studies the temperature did not exceed 30°C, while it was much higher in the present study where we tried to keep the goats under climatic and nutritional conditions that are the closest to their natural environment.

The effect of goat's age and litter size on DMY was in line with those of several authors (Goonewardene, Okinea, Patrick, & Scheer, 1999; Ilahi et al., 1999; Silva et al., 2013). Goat's age effect can be explained by the fact that younger females, which did not achieve their development, including that of the mammary gland, must cover their nutritional needs of growth, in addition to those of maintenance and lactation (Carvalho, Freitas, Valente, & Azevedo, 2001). The effect of litter size on DMY can be attributed to the quantity of hormones preparing the udder to lactation phase which differs from females carrying multiples to those carrying singles (Haldar et al., 2013), thus affecting the milk production after delivery.

Previous study on the same breed showed a lower proteins and lactose rates and a higher fat rate (Shkolnik et al., 1980). The low fat concentration that we found is due to the fact that most of the time the goats, especially those with low production potential, retained their milk during milking and preserve it for their kids; so samples were taken only from the citernal milk, not from the alveolar milk which has a higher fat content. This observation suggests a behavioral adaptation mechanism. The decrease of fat, proteins and lactose, observed during the 1st month of lactation is due to the dilution effect caused by the increase of milk yield during that time.

The significant decrease of goats' body weight observed during the early lactation was expected, since after parturition the appetite of goats decreases, so it becomes very difficult to satisfy their high energy requirements of lactation. This weight decreasing was previously reported in Nigerian Red Sokoto goat (Djibrillou, Pandey, Gouro, & Verhulst, 1998), local Burundian goat and ewe (Mbayahaga, Mandiki, Bister, & Paquay, 1998) and Sudanese Nubian goat (Gubartalla, Abu Nikhaila, & EL Khidir, 2002).

The studied goats had a small udder with a floor well above the hocks level which was not favorable to high milk production but reflected the adaptation of the mammary conformation of Bedouin goat to desert rangelands, with a predominance of shrubs increasing the risk of injury and contamination of deeper udders close to the ground. However, an udder floor at the same level of hocks or slightly above is more adapted for high-yielding goats maintaining under intensive management system, as reported in Saanen and Alpine goats (Manfredi, Piacere, Lahaye, & Ducrocq, 2001) and Fiurinà goat (Cornale et al., 2014).

The udder suspensory system was of a medium strength; the median ligament was well marked, the ratio between rear attachment width and udder depth was balanced but the fore attachment was loose. Assessment of teats characteristics did not show a form entirely favorable to milking. Usually, the teats inclination was vertical or slightly cranial which was desirable, but divergent orientation was predominant, well-shaped teats with a medium size and cylindrical form were rare and supernumerary teats were frequent. Udders with lower citern depth tended to have thicker teats, and wide udders with deeper citerns tended to have vertical teats rather than cranial ones.

The significant correlation between the mean DMY and each of goats' body weight, withers height, rump height, udder width and udder circumference emphasizes the importance of these traits both in predicting the milk yield in Bedouin goat and as selection markers for future improvement of its production. On the other hand, subjective linear udder appraisals were not significantly correlated with milk yield; thus objective udder measurements were more appropriate for assessing milk production in this breed. Moreover, despite the ease of application of linear udder score method, it requires a trained technician, so it cannot be adopted by breeders as a routine method.

The correlation of DMY with udder width and circumference was in line with results of Mavrogenis, Papachristoforou, Lysandrides, and Roushias (1989), Amao, Osinowo, Onwuka, Abiola, and Dipeolu (2003) and Keskin, Kor, Karaca, and Mirtagioglu (2005) in Damascus, West African Dwarf and Akkesi goats and results of Emediato, Siqueira, Stradiotto, Maestá, and Fernandes (2008) and Kominakis, Papavasiliou, and Rogdakis (2009) in Bergamasca and Frizarta ewes.

Bedouin kids' BW was similar to that reported by Shkolnik et al. (1980) for the same breed (1.82 kg). Our result was also in line with that of Morand-Fehr (1981) who reported that the BW represents, in most cases, 1/15 of the body weight of an adult goat. Growth rate recorded in the same breed (Shkolnik et al., 1980) was more than double of that obtained in our study. This can be explained by a difference in environmental factors such as climatic conditions and nutritional diet during reproduction, gestation and lactation periods (Berhane & Eik, 2006; Kharrat & Bocquier, 2010; Tedonkeng et al., 2006). The ADG0-30, considered mainly as an indicator of milk production potential, was the highest compared to ADG30-60, ADG60-90 and ADG30-90 which reflect the growth potential of the offspring (Ben Hamouda & Othmane, 2011). In fact, kids grew faster during the 1st month of life when their alimentation depended almost exclusively on the suckled milk.

The non-significant correlations between goats' and kids' body weight and between DMY and kids' performances agrees with the results of Kharrat and Bocquier (2010) who showed that weight gain of Baladi kids was related neither to mothers' body condition at kidding, nor to the milk production during suckling, but it was related to the last after weaning.

## Conclusion

The results of the present study on the performances of lactating Bedouin goat under arid conditions showed low milk yield and shallow mammary gland adapted to pasturing in desert rangelands, but not favorable to high production. Milk yield was positively correlated with body weight, withers height, rump height, udder width and udder circumference. These traits may represent a group of suitable selection markers to elaborate the appropriate breeding program to improve the production potential of this breed. In the future, a large scale study on performances of Bedouin goats grazing on natural pastures, and on the genetic, nutritional and environmental factors which affect them, must be conducted.

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