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Potential effect of the number and type of birth on udder, milk yield, milk composition, ovarian follicles, and certain blood parameters in Baladi goat

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Abstract

Background Multifetal births are the most significant economic characteristic in goats. Therefore, physiologically, exploring the influence of their birth frequency on genital function and milk production is vital. The present study was carried out to monitor the potential effect of the number and type of birth on udder, milk yield, milk composition, ovarian follicles, and certain blood parameters in dam's Baladi goats during the postpartum period. On the birth day, fifty Baladi goat dams were separated into five equal groups based on the number of births: (G1) female kids and (G2) male kids. In addition to gender, there are three categories: (G3) single kids, (G4) twin kids, and (G5) triple kids. All of the offspring looked to be in good health, moving about regularly, and displaying no symptoms of peripartum pregnancy problems.

Results The data revealed that the udder width of dams in G4 and G5 was significantly higher ($p < 0.033$) than G3, while the udder circumference was increased in the G5. Furthermore, no significant differences were observed in the udder measurements between G1 and G2. Gender of birth showed a significant higher in large follicle ≤ 5 mm ($p < 0.005$), medium follicle ($p < 0.004$), and small follicle ≥ 3 mm ($p < 0.004$) in the G2 compared to the G1. Also, the follicular population ($p < 0.042$) of the medium and the diameter follicle ($p < 0.038$) of the small ≥ 3 mm were significantly higher in the G5 compared to the G3. The Pearson correlation (r) was determined to increase the milk yield with an increase in udder length, udder width, and udder circumference. Also, there was a positive correlation among the udder length with protein, salt, solids not fat, and total solids. A negative correlation was found among udder width and udder circumference with fat, lactose, solids not fat, and total solids. There was a negative correlation between the ultrasonographic examination of ovarian follicles and milk yield.

Conclusions This study may provide valuable information regarding the association of udder parameters and ovarian population with milk yield and its composition as an indicator of milk production in goat dams based on gender and number of births.

Keywords Goat dams, Gender of kids, Number of kids, Milk yield, Milk composition

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Background

Over one billion goats have multiplied globally over the last four decades, with 90% in developing countries, with Asia and Africa having the largest numbers (Miller & Lu, 2019). Despite their common perception as inferior to other livestock, goats serve as an additional and crucial source of revenue for numerous resources in impoverished areas (Utaaker et al., 2021). Furthermore, goats have long been acknowledged as a valuable source of milk and meat (Boyazoglu et al., 2005). Goats emit less methane gas than other ruminants, making them better for the environment (Koluman et al., 2018).

Goat milk is widely acknowledged as a nutritious supplement for humans (dos Santos et al., 2023) and has long been utilized in newborn infant nutrition (Prosser, 2021). Many studies have found that goat milk provides a safer environment for the gut (Liu & Zhang, 2022). It has a high nutritional value and digestibility due to smaller fat globules and less lactose, which naturally homogenizes goat milk and provides a larger surface area of fat globules for better digestive action by lipases enzymes (Khalifa & Zakaria, 2019). Because goat milk has a distinct protein composition and less casein and lactose, it is advised for those with cow milk allergies, especially babies (Zakaria et al., 2023).

In goats, like in other ruminants, udder morphometric measurements can be used to predict milk production (D. Arcos-Álvarez et al., 2020a, 2020b); for example, an increase of one centimeter in ewe's udder length and circumference causes milk production to increase from 0.06 to 0.11 L (McKusick et al., 2001). Additionally, a lot of nutritional models depend on milk production and composition to calculate the right amount of nutrients and supplements to provide ruminants depending on their energy and dietary needs (Tedeschi & Fox, 2016; Tedeschi et al., 2010).

There is a major paucity and neglect of information concerning factors affecting udder parameters in goats and how these factors relate to milk production and composition, despite its effective contribution and widespread in most countries. Also, there is a scarcity of information correlated with follicular population and diameter in the Baladi goats, especially in the postpartum period. Therefore, this study was carried out to evaluate the possible influence of the number and type of birth on udder, milk yield, milk composition, ovarian follicles, and specific blood parameters in dam's Baladi goats throughout the postpartum period (Fig. 1).

Material and methods

Ethics and consent to participate section

This study was carried out on a private farm in the Aswan governorate, Aswan, Egypt, which is located at 24° 5′ 20″ N latitude and 32° 53′ 59″ E longitude on the eastern bank of the Nile River. It is located about 900 km south of Egypt, during the autumn of 2023. The animals were used in the study after obtaining informed consent from all owners to use them. This study was conducted in accordance with institutional and national guidelines for the care and use of animals, which were followed according to the World Organization for Animal Health (WOAH) standards. The ethics approval from an Institutional Review Board (IRB) has been granted by the Research Ethics Committee of the Faculty of Agriculture at Assiut University; Reference No: 03-2024-0008.

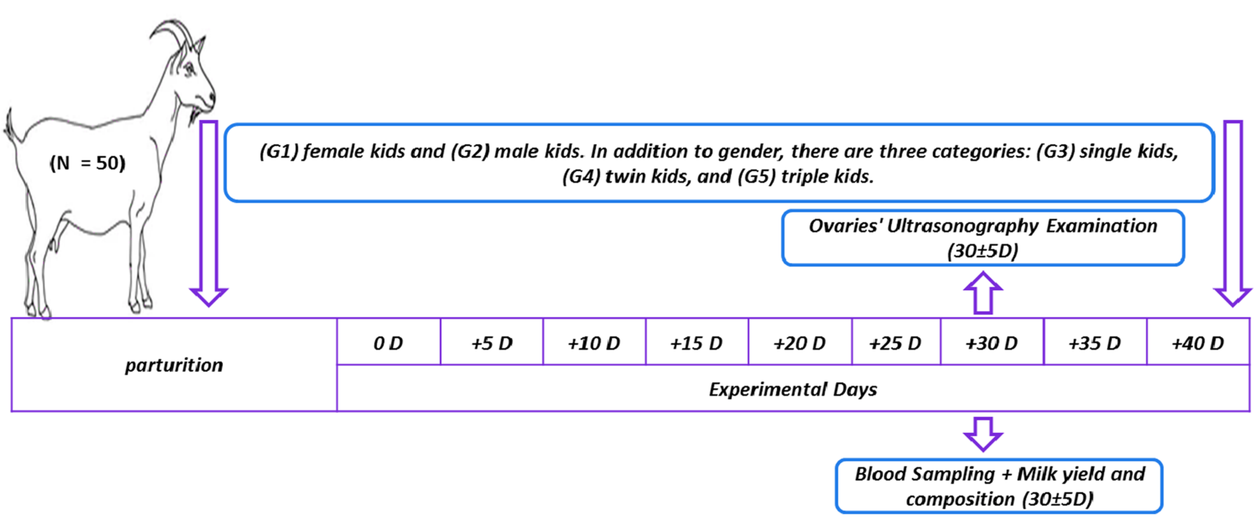

Fig. 1 Schematic diagram of the experimental protocol: (G1) female kids and (G2) male kids. In addition to gender, there are three categories: (G3) single kids, (G4) twin kids, and (G5) triple kids

Experimental animals

The current investigation comprised fifty dam's Baladi goats aged 2.5–3 years and weighing 25 ± 1.7 kg (mean SD) and showed signs of health and vitality, which appeared to be clinically valid. The animals were allowed to graze around the farm during the daylight hours, and they spent the night in a semi-open farm barn. Goats received a daily farm meal regulated by the National Research Council (NRC; 1985). The chemical composition of the experimental feedstuff is described in Table 1.

Experimental design

Every one of the goat dams was naturally inseminated, with normal clinical indications; birth occurred normally, with each mother waiting for the placenta to emerge and recognizing the goat kids. Goat kids were allowed to sucking their dam's udder teat during the period of study. The animals were separated into five groups (10 animal/each) based on the number of births: (G1) female kids and (G2) male kids. In addition to gender, there are three categories: (G3) single kids, (G4) twin kids, and (G5) triple kids. All of the offspring looked to be in good health, moving about regularly and displaying no symptoms of peripartum pregnancy problems.

Udder measurements

The external udder measurements were performed at the same day of ovaries' ultrasonography examination before morning milking for each goat as described by (Merkhan et al., 2011). The following udder measurements (cm) were recorded: udder length (UL), udder width (UW), udder circumference (UC), teat diameter (TD), and teat length (TL) on both sides (Right and left) by using flexible fiberglass tape and a digital caliper.

Table 1 Chemical composition of the experimental diets

Nutrients	As feed basis %	As dry matter basis %
DM	91.12	100
Moisture	8.97	–
CP	15.69	16.2
NDF	32.31	35.8
ADF	12.09	13.4
HCell	20.21	22.4
Cell	9.2	10.2
Lig	2.88	3.2
Ash	7.39	8.2
NFC	31.40	34.8
EE	2.44	2.7
TDN_{1x}	62.20	68.93
DE (M cal/kg)	2.83	3.14
ME (Mcal/kg)	2.45	2.72
NEL_{3x} (Mcal/kg DM)	1.42	1.57

DM Dry matter, *CP* crude protein, *NDF* neutral detergent fiber, *ADF* acid detergent fiber, *HCell* hemicellulose, *Lig* lignin, *NFC* non-fiber carbohydrate, *EE* ether extract, TDN_1x total digestible nutrients, *DE* digested energy, *ME* metabolizable energy, NEL_3x net energy of lactation

Milk yield and composition

The daily milk yield (kg/day; DMY) of ewes was determined according to Darwin Arcos-Álvarez et al. (2020a, 2020b) by hand-milking at the same day of performing udder measurements. The kids were separated from their mothers at 8:00 p.m. On the next morning, the goats were hand-milked at 8:00 a.m. and the quantity of milk was recorded. Chemical analysis for milk samples was performed to determine fat %, protein %, salts %, lactose %, solids not fat %, and total solids % by Milk-Scan apparatus according to Shaban et al. (2022).

Ovaries' ultrasonography examination

Total number of ovarian follicles (TNF), large follicles diameter ≤ 5 mm (LGFD ≤ 5), number of large follicles (NLGF), medium follicles diameter from 3 to 5 mm (MEFD 3–5), number of medium follicles (NMEF), small follicles diameter from 3 to 5 mm (SNFD ≥ 3), and number of small follicles (NSMF) were monitored after 30 ± 5 day of parturition. Following the monitoring of all metrics on both ovaries, the overall mean of the ovarian activity measurements was determined. Every dam was measured and mapped separately (Ginther et al., 1997; Hashem et al., 2020). The uterine and ovarian images were frozen on the monitor, and the maximum diameters of the structures were measured using a real-time ultrasonography, B-mode, diagnostic scanner equipped with a trans-rectal 5/7.5 MHz linear array transducer (Hitachi, EUB-405B, Japan). Every investigation was carried out by a single manager to avoid individual variance.

Blood sampling

A total of 50 (10 animals × 5 groups) blood samples were collected from each animal's jugular vein during an ultrasound evaluation of the ovaries and measurements of the udder following parturition. The serum samples were then separated by centrifuging blood samples at 3000 × g for 15 min, collected, and kept at -20 °C until further examination. The serum's evaluation includes the total protein using particular kits manufactured by Spinreact Company, Spain (Young, 1997a, 1997b). However, a serum albumin test was utilized by a kit manufactured by Spectrum Company (Tietz, 1995). Also, globulin levels were calculated mathematically by subtracting albumin values from the total serum protein values. Serum cholesterol level was determined as described by Thomas

(1961). For assessing the concentrations of glucose, sodium fluoride-coated collecting tubes were employed. Glucose and urea were measured by utilizing laboratory kits provided by the Diamond Chemical Company, Germany (Tietz, 1995). With assay kits provided by Spectrum Chemical Company, Egypt, the levels of aspartate transaminase (AST) and alanine transaminase (ALT) were detected following the protocol with Young (Young, 1997a, 1997b).

Statistical analysis

These studies reported their findings as the mean and standard error of the mean (SEM). All statistical analyses on the data were performed using SPSS Inc., version 20. The Kolmogorov–Smirnov test was used to determine the data's normal distribution. The ultrasonography examination of the ovaries, urine measures, blood collection, milk production, and composition were compared across groups using one-way ANOVA with Duncan's post-hoc test. Simultaneously, Pearson's correlation (95%) was used to calculate the connection between ovaries and udder ultrasonography examinations of milk supply and composition.

Results

Udder' measurements

The udder examination of the gender and number of births is presented in Tables 2 and 3. The data revealed that no significant differences were observed in the udder parameters for the goat dams that produced male kids compared to those that produced female kids (Table 2). However, the udder width of the goat dams that produced triple and twin kids was significantly higher ($p<0.033$) than that produced single kid. Also, udder circumference was increased ($p<0.053$) in the goat dams produced triple than in those produced single (Table 3).

Milk yield and composition

The milk yield and milk composition for the gender and number of births in the Baladi goats are presented in Tables 4 and 5. The data revealed that no significant differences were observed in the milk yield (kg/day) or composition in the goat dams that produced male kids than in those that produced female kids (Table 4). However, there were significant differences in the milk yield (kg/day) $p<0.05$ of the dams that produced single, twin, and triple kids. Regarding milk composition the goat dams that produced single kid were significantly higher in fat

Table 2 Udder measurements of the dams produced male and female kids in the Baladi goats

Udder measurements (cm)		Gender of birth		SEM	*p*-value
Variable	Description	Male	Female		
UL	Udder length	10.95	11.13	0.63	0.853
UW	Udder width	11.70	11.85	0.47	0.829
UC	Udder circumference	27.53	27.73	0.12	0.904
RTL	Right teat length	1.90	1.97	0.16	0.775
LTL	Left teat length	1.86	1.90	0.17	0.877
RTD	Right teat diameter	1.28	1.37	0.10	0.556
LTD	teat diameter	1.22	1.29	0.08	0.595

UL udder length, *UW* udder width, *UC* udder circumference, *RTD* right teat diameter, *LTL* left teat length, *RTD* right teat diameter, *LTL* left teat length

Table 4 Milk yield and composition of the dams produced male and female kids in the Baladi goats

Milk yield and composition	Gender of birth		SEM	*p*-value
	Male	Male		
Milk yield (kg/day)	0.49	0.50	0.05	0.798
Fat %	3.53	3.4	0.05	0.190
Protein %	3.21	3.17	0.07	0.697
Salts %	0.72	0.71	0.01	0.271
Lactose %	4.82	4.79	0.05	0.558
solids not fat %	8.78	8.69	0.12	0.607
Total solids %	12.31	12.16	0.18	0.556

Table 3 Udder measurements of the dams produced single, twin, and triple kids in the Baladi goats

Udder measurements (cm)		Number of births			SEM	*p*-value
Variable	Description	Single	Twin	Triple		
UL	Udder length	11.10	11.00	10.90	0.56	0.969
UW	Udder width	11.80^{b}	13.35^{a}	13.88^{a}	0.48	0.033
UC	Udder circumference	27.63^{b}	30.78^{ab}	31.68^{a}	1.08	0.053
RTL	Right teat length	2.03	1.85	1.75	0.19	0.636
LTL	Left teat length	1.90	1.73	1.63	0.18	0.601
RTD	Right teat diameter	1.35	1.39	1.43	0.10	0.853
LTD	teat diameter	1.29	1.33	1.36	0.09	0.843

[a and b] Means with different superscripts in the same row are significantly different (p < 0.05) and (P < 0.01). *UL* udder length, *UW* udder width, *UC* udder circumference, *RTD* right teat diameter, *LTL* left teat length, *RTD* right teat diameter, *LTL* left teat length

Table 5 Milk yield and composition of the dams produced single, twin, and triple kids in the Baladi goats

Milk yield and composition	Number of births			SEM	*p*-value
	Single	Twin	Triple		
Milk yield (kg/day)	0.34^{a}	0.49^{b}	0.54^{b}	0.06	0.042
Fat %	3.45^{a}	3.13^{b}	3.03^{b}	0.05	0.002
Protein %	3.20	3.01	2.94	0.07	0.070
Salts %	0.72	0.70	0.70	0.01	0.104
Lactose %	4.79^{a}	4.59^{b}	4.53^{b}	0.03	0.001
Solids not fat %	8.71^{a}	8.30^{b}	8.16^{b}	0.11	0.017
Total solids %	12.16^{a}	11.43^{b}	11.19^{b}	0.15	0.007

[a and b] Means with different superscripts in the same row are significantly different ($p < 0.05$) and ($p < 0.01$)

($p < 0.002$), lactose ($p < 0.001$), solids not fat ($p < 0.017$), and total solids ($p < 0.007$) than the goat dams that produced triple and twin kids, while there were no significant differences in the percentage of protein ($p < 0.070$) and salts ($p < 0.104$) among groups (Table 5).

Ultrasonographic examination of ovarian follicles

Ultrasonographic data on the follicular population, the diameter for the gender, and number of births in the Baladi goats are presented in Tables 6 and 7. The total number of ovarian follicles was higher ($p < 0.024$) in the dams that produced male kids than in those that produced female kids. Furthermore, the gender of the birth was highly significant for dams that produced male kids in the large follicles diameter ≤ 5 mm ($p < 0.005$), number of medium follicles ($p < 0.004$), and small follicles diameter ≥ 3 mm ($p < 0.005$) than in those that produced female kids (Table 6). Table 7 shows that goat dams producing twins and triples kids were significantly higher ($p < 0.035$) in the total number of ovarian follicles and medium follicles diameter from 3 to 5 mm than dams producing single kids. Also, the follicular population ($p < 0.042$) of the medium follicles and the diameter ($p < 0.038$) of the small follicles ≥ 3 mm were significantly higher in the goat dams that produced triple kids than others.

Table 6 Follicular population and diameter of the dams that produced male and female kids in the Baladi goats

Variable	Description	Gender of kids		SEM	*p*-value
		Male	Female		
TNF	Total number of ovarian follicles	4.00*	2.50	0.29	0.024
LGFD ≤ 5	Large follicles diameter ≤ 5 mm	5.25**	4.85	0.06	0.005
NLGF	Number of large follicles	1.75	1.50	0.29	0.670
MEFD(3–5)	Medium follicles diameter from 3 to 5 mm	4.00	3.80	0.21	0.488
NMEF	Number of medium follicles	2.75**	1.25	0.25	0.004
SNFD ≥ 3	Small follicles diameter from 3 to 5 mm	2.43**	1.90	0.07	0.004
NSMF	Number of small follicles	1.75	2.00	0.58	0.750

*Means in the same row differ significantly ($p \leq 0.05$); **Means in the same row differ significantly ($p \leq 0.001$). *TNF* Total number of ovarian follicles, *LGFD ≤ 5* large follicles diameter ≤ 5 mm, *NLGF* number of large follicles, *MEFD* medium follicles diameter from 3 to 5 mm, *NMEF* number of medium follicles, *SNFD ≥ 3* small follicles diameter from 3 to 5 mm, *NSMF* number of small follicles

Table 7 Follicular population and diameter of the dams produced single, twin, and triple kids in the Baladi goats

Variable	Description	Number of births			SEM	*p*-value
		Single	Twin	Triple		
TNF	Total number of ovarian follicles	2.33^{b}	4.33^{a}	4.00^{a}	0.33	0.035
LGFD ≤ 5 mm	Large follicles diameter ≤ 5 mm	5.20	5.25	5.13	0.09	0.731
NLGF	Number of large follicles	1.67	1.67	1.67	0.33	0.966
MEFD(3-5 mm)	Medium follicles diameter from 3 to 5 mm	3.67^{b}	4.13^{a}	4.15^{a}	0.12	0.035
NMEF	Number of medium follicles	1.67^{b}	3.00^{ab}	3.67^{a}	0.58	0.042
SNFD ≥ 3 mm	Small follicles diameter from 3 to 5 mm	2.17^{b}	2.50^{b}	4.57^{a}	0.12	0.038
NSMF	Number of small follicles	1.33	2.00	2.67	0.58	0.171

[a and b] Means with different superscripts in the same row are significantly different ($p < 0.05$) and ($p < 0.01$). *TNF* Total number of ovarian follicles, *LGFD ≤ 5* large follicles diameter ≤ 5 mm, *NLGF* number of large follicles, *MEFD* medium follicles diameter from 3 to 5 mm, *NMEF* number of medium follicles, *SNFD ≥ 3* small follicles diameter from 3 to 5 mm, *NSMF* number of small follicles

Table 8 Blood biochemical of the dams that produced male and female kids in the Baladi goats

Blood biochemical	Gender of birth		SEM	*p*-value
	Male	Female		
Total protein (mg/dl)	6.99	6.37	0.35	0.194
Albumin (mg/dl)	3.22	3.21	0.06	0.996
Globulin (mg/dl)	3.58**	2.62	0.24	0.008
Cholesterol (mg/dl)	110.84	104.74	1.78	0.226
Glucose (mg/dl)	41.35	52.96**	0.46	0.001
Aspartate transaminase (mg/dl)	37.62*	30.53	3.60	0.013
Alanine transaminase (mg/dl)	19.92**	17.42	0.41	0.004
Urea (mg/dl)	22.30	21.37	0.26	0.194

*Means in the same row differ significantly ($p \leq 0.05$); **Means in the same row differ significantly ($p \leq 0.001$)

Table 9 Blood biochemical of the dams produced single, twin, and triple kids in the Baladi goats

Blood biochemical	Number of births			SEM	*p*-value
	Single	Twin	Triple		
Total protein (mg/dl)	6.88	6.52	7.08	0.11	0.408
Albumin (mg/dl)	3.11	3.58	3.21	0.12	0.385
Globulin	3.76[a]	2.94[b]	3.90[a]	0.09	0.008
Cholesterol (mg/dl)	115.14[a]	107.01[b]	100.30[c]	1.46	0.008
Glucose (mg/dl)	44.48	49.75	51.75	3.32	0.430
Aspartate transaminase (mg/dl)	33.06	37.59	36.80	5.22	0.559
Alanine transaminase (mg/dl)	19.63[a]	19.45[a]	16.40[b]	0.32	0.005
Urea (mg/dl)	21.90	21.93	20.80	0.17	0.379

[a and b] Means with different superscripts in the same row are significantly different ($p < 0.05$) and ($p < 0.01$)

Blood biochemical

The blood biochemicals of the gender and number of goat dam's kids are presented in Tables 8 and 9. For the protein-related parameters (mg/dl), there were no significant changes in the total protein and albumin of the gender of birth between groups. While the albumin was higher ($p < 0.08$) in the dams that produced male kids than in those that produced female kids, However, there were no significant changes in the energy-related parameters (glucose and cholesterol, mg/dl). However, the liver function enzymes (ALT and AST) were significantly higher in the dams that produced male kids in comparison to those in the dams that produced female kids (Table 8). Additionally, there were no significant changes in the total protein, and albumin of the dams that produced single, twin, or triple kids. But for the energy-related parameters (mg/dl), the cholesterol concentrations were higher ($p < 0.008$) in the dams that produced single in comparison to those in the dams that produced twin kids (Table 9).

Correlation among udder measurements, milk yield, and milk composition

The correlation among udder measurements, milk yield, and milk composition is presented in Table 10. A large variation in udder length, udder width, udder circumference, and right and left teat diameter was observed with milk yield (kg/day) ranging from 0.739 to 0.974 Pearson correlations (r). Also, the udder length also widely ranged with protein% ($r = 0.774$), salt% ($r = 0.779$), solids not fat% ($r = 0.684$), and total solids% ($r = 0.628$). A negative correlation was found among udder width and udder circumference with fat ($r = 0.311$ and $r = 0.226$), lactose ($r = 0.325$ and $r = 0.285$), solids not fat% ($r = 0.132$ and $r = 0.107$), and total solids not fat% ($r = 0.207$ and $r = 0.173$). The teat diameter and milk composition were not correlated with milk yield ($p > 0.05$), but were correlated with teat length.

Correlation among ultrasonographic examination of ovarian follicles, milk yield, and milk composition

Correlation among ultrasonographic examination of ovarian follicles, milk yield, and milk composition is presented in Table 11. A negative correlation was found between ultrasonographic examination of ovarian follicles and milk yield (kg/day) with $r = -0.312$, -0.387, -0.545, and -0.104 for TNF, LGFD ≥ 5, NMEF, and SNFD ≤ 3, respectively, while there was a moderate correlation in the NLGF and MEFD(3–5) with $r = 0.035$, and 0.039. However, the ovarian follicles were not correlated ($p > 0.05$) with mostly milk composition ($p > 0.05$), except positive correlation was found in the LGFD ≥ 5 and fate% ($r = 0.553$), lactose% ($r = 538$), and total solids% ($r = 0.499$). Also, a negative correlation was found between NSFD and milk composition ($p > 0.05$).

Discussion

One of the most important first steps in putting methods into practice to enhance small ruminant dairy performance is accurately predicting milk output (Angeles-Hernandez et al., 2022). The milk yield and composition of Baladi goat were described in many previous studies and have been summarized by many researchers (Gaddour et al., 2013; Khalifa & Zakaria, 2019). But literature data about factors affecting goat milk yield and composition are limited and not sufficient. There are many factors affecting milk yield and composition in dairy animals as the breed, stage of lactation, management, parity, feeding, geographical location, and production system (Zakaria & Mohamed, 2021). But there is very little information about the effect of gender and number of births on milk yield and composition in goat. So, our study monitored

Table 10 Descriptive statistics of correlation among udder measurements, milk yield, and milk composition

item		Udder length (UL)	Udder width (UW)	Udder circumference (UC)	Right teat length (RTL)	Left teat length (LTL)	Right teat diameter (RTD)	Left teat diameter (LTD)
Milk yield (kg/day)	Pearson correlation	0.739**	0.974**	0.942**	0.513	0.513	0.863**	0.806**
	Sig	0.006	0.0001	0.0001	0.088	0.088	0.001	0.002
Fat %	Pearson correlation	0.536	− 0.311	− 0.266	0.721**	0.734**	0.277	0.258
	Sig	0.072	0.325	0.404	0.008	0.007	0.384	0.419
Protein %	Pearson correlation	0.774**	0.013	0.025	0.850**	0.864**	0.556	0.491
	Sig	0.003	0.967	0.938	0.001	0.001	0.061	0.105
Salts %	Pearson correlation	0.779**	0.04	0.091	0.829**	0.859**	0.624	0.598
	Sig	0.003	0.901	0.778	0.001	0.001	0.053	0.051
Lactose %	Pearson correlation	0.529	− 0.325	− 0.285	0.697*	0.713**	0.273	0.244
	Sig	0.077	0.303	0.368	0.012	0.009	0.390	0.444
Solids not fat %	Pearson correlation	0.684*	− 0.132	− 0.107	0.801**	0.817**	0.447	0.397
	Sig	0.014	0.683	0.742	0.002	0.001	0.145	0.201
Total solids %	Pearson correlation	0.628*	− 0.207	− 0.173	0.774**	0.789**	0.38	0.342
	Sig	0.029	0.519	0.591	0.003	0.002	0.223	0.276

* Means in the same row differ significantly ($p \leq 0.05$); **Means in the same row differ significantly ($p \leq 0.001$)

Table 11 Correlation among ultrasonographic examination of ovarian follicles, milk yield, and milk composition

item		TNF	LGFD ≤ 5	NLGF	MEFD(3–5)	NMEF	SNFD ≥ 3	NSFD
Milk yield (kg/day)	Pearson correlation	− 0.312	− 0.387	0.035	0.039	− 0.545*	− 0.104	0.036
	Sig	0.222	0.125	0.894	0.883	0.024	0.69	0.892
Fat %	Pearson correlation	0.039	0.553*	0.253	0.388	0.339	0.202	− 0.240–
	Sig	0.881	0.021	0.328	0.124	0.183	0.436	0.354
Protein %	Pearson correlation	− 0.018–	0.379	0.338	0.345	0.086	0.163	− 0.203
	Sig	0.946	0.133	0.184	0.175	0.744	0.533	0.434
Salts %	Pearson correlation	− 0.172	0.444	0.226	0.291	0.214	0.161	− 0.355
	Sig	0.51	0.074	0.383	0.258	0.408	0.537	0.162
Lactose %	Pearson correlation	0.058	0.538*	0.303	0.331	0.263	0.189	− 0.247
	Sig	0.824	0.026	0.238	0.195	0.308	0.467	0.338
SNF %	Pearson correlation	− 0.002	0.458	0.317	0.343	0.174	0.186	− 0.226
	Sig	0.994	0.064	0.215	0.177	0.504	0.474	0.383
Total solids %	Pearson correlation	0.014	0.499*	0.279	0.366	0.236	0.239	− 0.213
	Sig	0.958	0.042	0.279	0.149	0.363	0.355	0.412

*Means in the same row differ significantly ($p \leq 0.05$); **Means in the same row differ significantly ($p \leq 0.001$)

the effect of gender and number of births on udder measurements, milk yield, milk composition, ovarian follicles, and blood biochemical parameters in the dam's Baladi goat during the postpartum period. The data reported in Table 2 pointed out that gender of birth has non-significant effect ($p > 0.05$) on udder measurements, while the number of births has significant ($p < 0.05$) effect on udder measurements as the udder size increased with the increase in number of births. Also the number of births significantly ($p < 0.05$) affects milk yield and the data reported in Table 5 pointed out that milk yield increased with the increase in number of births, while milk solids as fat, protein lactose, and solid not fat decreased. Gender of birth did not significantly affect milk yield and composition as reported in Table 4. The positive relationship between number of kids and milk production may be due to prolactin stimulation of the udder which depends on the intensity of the suckling stimulus in response to the number of kids. It is more likely that the relationship between milk yield and number of kids is for the most part dependent on the extent of prepartum development of the mammary gland where prolactin plays a major role (Assan 2020).

In the presented study, the milk yield was positively and significantly correlated with udder length, udder width, udder circumference, and teat diameter. Udder measurement is a crucial component of dairy breeds' milk capacity since it has a notable and powerful impact on milk yield (Jaayid et al., 2011). The most significant factor in more than 22% of the variation in the West African dwarf goat's partial daily milk output was udder circumference (Benji & Osinowu, 2009).

The positive correlations between milk production and composition, with $r = 0.890$ to 0.986, suggest that all of these measures assess the goats' milking capabilities. As a result, selection to improve any of these features may benefit the others as well (Merkhan & Alkass, 2011).

Also, in this study a negative correlation was found among udder width and udder circumference with fat, lactose, solids not fat, and total solids not fat. likewise, there was a correlation between the size of the udder and the chemical composition of goat milk; an increase in udder size is counterbalanced by a decrease in milk fat (Cedden et al., 2008), protein, and solids(McKusick, 2000).

Interestingly, there was no correlation between milk production and estrus when it was studied visually twice a day (Harrison et al., 1990; Van Eerdenburg et al., 2002), which prompted to study the follicular population and diameter in dam's goat during the expected period of estrus after postpartum. A negative correlation was found between ultrasonographic examination of ovarian follicles and milk yield for TNF, LGFD ≥ 5, NMEF, and SNFD ≤ 3. Milk production correlated with the duration of estrus, as well as estrogen and the width of the pre-ovulatory follicles (Lopez et al., 2004), and it was concluded that estradiol concentrations at estrus and the duration and intensity of estrus are inversely affected by the level of milk production.

Conclusion

This study monitored udder parameters in Baladi goats in the postpartum period and demonstrated their strong correlation with milk yield and composition. It also showed the number and diameter of ovarian follicles in the expected period of ovulation while studying the effect of sex and the number of births. These results are useful in predicting milk production. This study may provide valuable information regarding the association of udder parameters and ovarian population with milk yield and its composition as an indicator of milk production in goat dams based on gender and number of births. In order to assess a model for genetic improvement in goat milk production, future research should concentrate on monitoring the udder and follicle size factors in the post-calving period.

Abbreviations

UL	Udder length
UW	Udder width
UC	Udder circumference
RTD	Right teat diameter
LTL	Left teat length
RTD	Right teat diameter
LTL	Left teat length
TNF	Total number of ovarian follicles
LGFD ≤ 5	Large follicles diameter ≤ 5 mm
NLGF	Number of large follicles
MEFD	Medium follicles diameter from 3 to 5 mm
NMEF	Number of medium follicles
SNFD ≥ 3	Small follicles diameter from 3 to 5 mm
NSMF	Number of small follicles

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Author contributions
MEA, HAH, RHM, and AMZ prepared the conception and design of the study, performed data curation, blood sampling, and interpretation of data, statistically analyzed the data, and drafted the manuscript. AMZ, RHM, AHM, and AER conducted the field study and ultrasonographic examination. AM conducted the semen evaluation. All authors have read and approved the final manuscript.

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Availability of data and materials
All data are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The authors confirm that the ethical policies of the journal, as noted on the journal's author guidelines page, have been adhered to. This study was conducted in accordance with Institutional and National Guidelines for the care and use of animals were followed according to the World Organisation for Animal Health (WOAH) standards. The ethics approval from either an Institutional Review Board (IRB) has been granted by the Research Ethics Committee of the Faculty of Agriculture at Assiut University; Reference No: 03-2024-0008.

Consent for publication
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Competing interests
The authors declare no competing interests.

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