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Changes in udder size and liveweight of West African Dwarf, Red Sokoto and Sahel goats during lactation and their phenotypic relationship with partial daily milk yield

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Abstract

Changes in udder size and liveweight (LWT) of ten West African Dwarf (WAD), three Red Sokoto (RS) and three Sahel goats during lactation and their phenotypic relationship with partial daily milk yield (PDM) were studied. Udder length (UL), udder width (UW), udder circumference (UC), udder volume (UV), distance between teats (DBT), teat height to ground (THG), teat length (TL), teat width (TW), teat circumference (TC) and LWT of does were determined weekly for 12 weeks of lactation commencing from 4 days post partum. There was increase in udder size arising from increases in all udder dimensions (except THG) of WAD from 1^{st} – 3^{rd} week of lactation and RS and Sahel from 1^{st} – 2^{nd} week of lactation when they peaked and thereafter declined up to 12 weeks of lactation. Partial daily milk yield followed the same pattern as the udder dimensions. Sahel does had the largest udder size with highest average PDM, except for TC which was largest in RS does. The WAD does had the smallest udder size with lowest average PDM. Largest size of udder was obtained on the day of peak milk yield. The correlation between udder dimensions, LWT and PDM were obtained with UL (r = 0.23), UW (r = 0.30), UC (r = 0.52), UV (r = 0.50), DBT (r = 0.57), THG (r = -0.32), TL (r = 0.09), TW (r = 0.226), TC (r = 0.36) and LWT (r = 0.50). Since, UW, UC, UV, DBT, TC and LWT of lactating goats showed significantly high correlation to average PDM, they could be good indicators of milk yield requiring further investigation as genetic markers.

Key words: *Udder size, liveweight, lactation, partial daily milk yield*

Introduction

Changes in udder size of goats during lactation have been attributed to extensive proliferation of cells in the mammary gland in early lactation (cell hyperplasia) and differentiation of mammary cells in which the tissue is made constant in declining lactation and reduced toward the end of lactation (cell hypertrophy) (Knight and Wilde, 1993; Dijkstra *et al.*, 1997). The pattern of changes in udder size of goats has been studied quantitatively for many years using descriptors such as wet weight, dry fat-free tissue (DFFT) and DNA content (Tucker, 1987). However, udder length (UL), udder width (UW), udder circumference (UC), udder volume (UV), distance between teats (DBT), teat height to ground (THG), teat length (TL), teat width (TW) and teat circumference (TC) are used in this study as reported by James (2000). Udder biometrics is related to milk yield in cattle (Singh *et al.*, 1993; Prajapati *et al.*, 1995), in sheep (Labussiere, 1988; Agbede *et al.*, 1997) and in goats (James and Osinowo, 2002; James *et al.*, 2002). Milk is an emulsion of fat in a watery solution of sugars and mineral salts with a protein in a colloidal suspension (O' Mahony and Peters, 1987). It is of great nutritional importance to both humans and livestock. It is synthesized and secreted by the epithelial cells lining the alveoli of the mammary gland. The synthesis is carried out by the removal of nutrients from the blood and transforming them into milk (Etgen and Reaves, 1978). The apposition of pairs of mammary glands forms an udder. Since the size of udder largely reflects milk secretion capacity while cell population is a crucial determinant of milk yield (Dijkstra *et al.*, 1997), hyper plastic growth of the mammary gland is of particular interest. The objective of this research is to study changes in udder size of WAD, RS and Sahel during lactation and determine their relationship with average PDM.

Materials and Methods

Animals' management and experimental procedure

The study was conducted at the University of Agriculture, Abeokuta, South-Western Nigeria, located within the humid zone with a mean annual rainfall of 1037 mm. The annual mean temperature and humidity are 34.7^{0}C and 82% respectively. The altitude of the region is 76 *masl* and falls within latitudes 7^{0}5.5′ – 7^{0}8′N and longitudes 3^{0}11.2′ – 3^{0}2.5′E. A total of sixteen does was used for the study comprising ten WAD, three RS and three Sahel does weighing between 14 - 23 kg. The animals were managed semi-intensively. They were allowed to graze on mixed pasture comprising *Panicum maximum, Andropogon tectorum, Andropogon gayanus, hyperrhenia spp and Leucaena leucocephala* as browse plant for 6 – 8 hours daily, and were given 0.3 - 0.5 kg/day of 17 – 20% feed supplement consisting of wheat offal, dry brewer's grain, bone-meal and common salt. Animals were housed in cross-ventilated pens with slatted floors. They were given access to water *ad libitum* and were regularly de-wormed and treated against ectoparasites. The does were naturally mated and were checked 21 days later for non-return (conception). Following parturition, udder dimensions were measured weekly for 12 weeks commencing from 4 days *post partum* with a flexible canvas tape-rule as shown in Figure 1 and they were:

1. Udder length (UL): The distance between the base of udder attachment to the abdominal region and the point of teat protrusion from the udder.
2. Udder width (UW): The distance between the widest points of the udder.
3. Udder circumference (UC): The distance (perimeter) round the widest point of the udder.

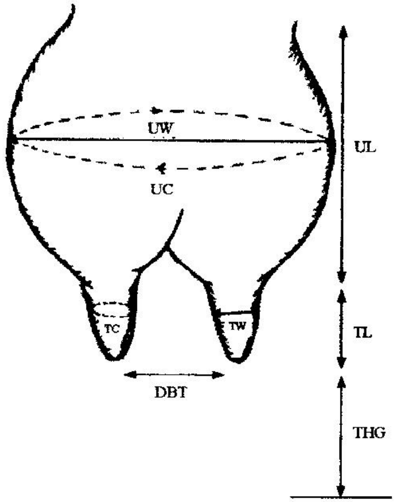

Figure 1 *Udder traits measurements in goats*

Key

UL	Udder length
THG	Teat height to ground
UW	Udder width
TL	Teat length
UC	Udder circumference
TW	Teat width
UV	Udder volume
TC	Teat circumference
DBT	Distance between teats

4. Udder volume (UV): This was derived using the formula:
   $UV = 4/3\pi r^3$

where $\pi = 22/7$
$r = (UL + UW)/4$.

5. Distance between teats (DBT): The distance between the tips.
6. Teat height from ground (THG): The distance between teat tips to the ground.
7. Teat length (TL): The distance between teat tip and base of attachment to the udder.
8. Teat width (TW): The distance between the widest points of the teats (middle).
9. Teat circumference (TC): The distance round the widest points of the teats.

Also, does were milked after udder dimensions were taken. The frequency of milking was weekly for 12 weeks commencing from 4 days *post partum*. On the evening of the day preceding milking, the kids were separated from their dams overnight (12 hours) and the does were milked by hand the following morning. The milk obtained was defined as the partial daily milk yield (PDM), which is a combination of milk off-take and 12-hour milk yield. The PDM (in ml and g) was measured by a calibrated cylinder and electronic weighing scale respectively. All measurements were taken in the morning on the days of data collection before animals were turned out to pasture. The liveweight of does were measured and monitored concurrently along side with udder size and milk yield measurements on the days of data collection. Partial daily milk yield per kilogramme liveweight of individual animal was also determined.

Data analysis

The data generated were analysed by the methods of least squares (Systat, 1993), using the model:

$Y_{ijk} = \mu + B_i + W_j + BW_{ij} + E_{ijk}$ where

Y_{ijk}=The value of the trait of interest

μ=The overall mean of the trait of interest

B_i=The fixed effect of the i^{th} breed (i = 1 - 3)

W_j=The fixed effect of j^{th} week of lactation (j =1 - 12)

BW_{ij}=The interaction between breed and week of lactation

E_{ijk} =Random error associated with each record (which is normally, independently and identically distributed with zero mean and variance .

Significant differences between means of data generated were determined using Duncan's Multiple Range Test (Gomez and Gomez, 1984).

Data adjustment

In order to obtain phenotypic relationship between the udder traits and average partial daily milk yield studied, data were adjusted using constant estimates generated from the least squares analysis. The adjustment equation is : $\alpha = \beta - b_i - w_j$ where

α =The adjusted udder trait/liveweight of does

Y =The unadjusted udder trait/liveweight of does

b_i =The adjustment factor for the effect of the i^{th} breed (i = 1-3)

w_j =The adjustment factor for the effect of the j^{th} week of lactation (j = 1 - 12).

Results and Discussion

The results of the present study revealed that the udder dimensions of does except THG increased from 1^{st} - 3^{rd} week (in case of WAD) and 1^{st} – 2^{nd} week (in case of RS and Sahel) when they peaked and thereafter declined till the 12^{th} week of lactation (Tables 1 – 3). This observation is in consonance with the findings of Knight and Wilde (1993) who reported a continual increase in population of milk secreting cells in the mammary gland in early lactation which leads to general increase in udder size arising from increase in the udder dimensions. The increase which is for lactopoiesis definitely leads to the increase in udder size. Dijkstra *et al.* (1997) attributed this mammary cell increases to endocrine activities associated with lactation that stimulate extensive cell proliferation in the mammary gland. However, the rapid decrease in udder size except THG after 3^{rd} week of lactation in WAD, and after 2^{nd} week in RS and Sahel up to 12^{th} week of lactation could be attributed to regression of mammary tissues after peak udder size was attained as reported by Agbede *et al.* (1997) in goats. The observed pattern of changes in THG (Table 2) was expected because increases or decreases in other udder and teat dimensions definitely leads to decreases or increases in THG respectively. This explains why inverse relationships exist between THG and other udder and teat dimensions measured. The observation corroborates the finding of Amao (1999). The present study also showed that the liveweight of does decreased from parturition up to 4th week of lactation in WAD and RS and 2nd week in Sahel does and increased thereafter till 12th week of lactation (Table 4). This trend is a normal one because lactating does loose weight for some periods and stabilize for some weeks after parturition. This weight loss could be hinged on parturition and lactation stress experienced by does. This observation calls for proper and adequate nutrition of lactating does during this period in order to replace lost body reserves and prepare the does for the next reproductive cycle. Tables 1 – 4 show that Sahel does had the largest udder dimensions (a reflective of largest udder size) with the highest average PDM, except for TC which was largest in RS does. The WAD does had the smallest udder size with lowest PDM (Tables 1 – 4). The finding is in consonance with the observation of Akpa *et al.* (1998) and Amao (1999) who reported significant influence of breed on udder size of WAD and RS goats. James (2000) asserted that heavier breeds possess larger udder size with higher average PDM than the lighter ones. The average PDM of 118 ml/day (122.9 g/day) obtained for WAD was lower than average milk yield of 300 g/day reported by Akinsoyinu *et al.* (1977). In RS does, a lower average PDM of 125 ml/day (148.2 g/day) was obtained vis-à-vis average milk yield of 468.6 g/day and 545.0 g/day reported by Akinsoyinu *et al.* (1982) and Ehoche and Buvanendran (1983) respectively. However, in Sahel does, a lower average PDM of 150.9 ml/day (156.1 g/day) was obtained as against 468.6 g/day and 545.0 g/day reported on Red Sokoto by the authors respectively. Based on the above scenario, WAD does produced the least average PDM but with regards to average PDM per kilogramme liveweight, WAD does significantly ($P < 0.001$) produced the highest average PDM of 8.4 ml per day while RS and Sahel does produced 8.2 and 7.2 ml per day respectively (Table 4). However, the lower milk yield of does obtained in this study vis-à-vis that reported by other authors is because, the PDM measured is a combination of milk off-take and 12-hour milk yield while 24-hour milk yield was measured by other authors cited. In essence, the method reduces nutritional stress experienced by kids during 24-hour separation from their dams before milking and provides additional quantity of milk for dairy farmer as against little quantity obtained as milk off-take. In addition, the disparity in the milk yield of does could be due to breed differences as reported by Devendra and Mcleroy (1982). It may also be hinged partly on different management systems adopted, different milking frequencies, different ages and liveweight of does used and partly to differences in milk extraction methods or estimation during the experimental period. While some authors used oxytocin prior to milking, others estimated milk yield using kid weight differences before and after suckling. Average PDM across the breeds increased correspondingly with increase in udder size up to the attainment of peak udder size and thereafter declined up to 12th week of lactation. Since milk yield of goats followed the same pattern of changes in udder size during lactation, in effect, it shows that larger udder size reflects higher milk yield. The finding supports the observation of Gall (1980), Anderson *et al.* (1981) and Dijkstra *et al.* (1997) who reported that udder size of goats has a direct relationship with milk yield. Therefore, milk yield could be possibly predetermined based on udder size of does. Table 5 shows that there was significant positive correlation between udder dimensions (except THG) which determines udder size and average PDM. This finding corroborates the report of Das and Sidhu (1975) who reported positive correlation between udder size and milk yield of goats. This suggests that udder size of lactating does could be a good indicator of milk yield requiring further investigation as genetic markers.

Table 1 *Least squares means showing the effects of breed and week of lactation on udder length, udder width, and udder circumference of West African Dwarf, Red Sokoto and Sahel goats*

Week of lactation	West African Dwarf (n = 10) Udder traits (cm)			Red Sokoto (n = 3) Udder traits (cm)			Sahel (n = 3) Udder traits (cm)		
	*UL	UW	UC	UL	UW	UC	UL	UW	UC
1	11.5^{b}	10.5^{b}	29.7^{c}	15.5^{a}	11.7^{b}	35.3^{b}	18.2^{ab}	12.8^{b}	39.5^{b}
2	11.8^{ab}	11.0^{a}	30.1^{b}	15.9^{a}	12.0^{a}	36.4^{a}	18.7^{a}	13.4^{a}	40.2^{a}
3	12.1^{a}	11.3^{a}	30.5^{a}	13.9^{b}	10.1^{c}	33.0^{c}	18.1^{b}	11.1^{c}	36.8^{c}
4	9.3^{c}	8.3^{c}	27.7^{d}	13.3^{c}	9.5^{d}	31.4^{d}	17.6^{c}	10.8^{c}	34.8^{d}
5	9.0^{cd}	8.3^{c}	27.3^{e}	13.0^{cd}	9.2^{e}	30.1^{e}	17.3^{cd}	10.4^{e}	31.7^{e}
6	8.9^{d}	8.1^{cd}	27.0^{f}	12.8^{de}	8.7^{f}	29.0^{f}	16.9^{de}	10.4^{e}	31.7^{e}
7	8.8^{d}	8.0^{de}	26.7^{fg}	12.7^{de}	8.6^{f}	28.9^{g}	16.6^{de}	10.1^{f}	31.0^{f}
8	8.7^{d}	7.9^{de}	26.6^{gh}	12.5^{e}	8.5^{f}	28.3^{gh}	16.3^{ef}	9.9^{fg}	30.9^{f}
9	8.7^{d}	7.8^{e}	26.4^{hi}	12.5^{e}	8.2^{g}	27.9^{h}	16.0^{fg}	9.7^{gh}	30.6^{fg}
10	8.7^{d}	7.8^{e}	26.2^{ij}	12.5^{e}	8.1^{g}	27.2^{i}	15.9^{fg}	9.6^{hi}	30.5^{fg}
11	8.7^{d}	7.8^{e}	26.1^{ij}	12.5^{e}	8.0^{g}	27.1^{i}	15.6^{fg}	9.5^{hi}	30.2^{g}
12	8.7^{d}	7.8^{e}	26.1^{j}	12.5^{e}	8.0^{g}	26.8^{i}	15.2^{g}	9.4^{i}	30.0^{g}
Means ± SE	9.6 $\pm 0.06^{3}$	8.7 $\pm 0.04^{3}$	27.5 $\pm 0.10^{3}$	13.3 $\pm 0.12^{2}$	9.2 $\pm 0.06^{2}$	30.1 $\pm 0.19^{2}$	16.9 $\pm 0.12^{1}$	10.6 $\pm 2.04^{1}$	33.2 $\pm 0.19^{1}$

*See Materials and Methods for key to codes

a-j Means in the same column within each breed having different superscripts differ significantly ($P < 0.05$)

1-3 Means in different columns across breeds having different superscripts differ significantly ($P < 0.05$)

Table 2 *Least squares means showing the effects of breed and week of lactation on udder volume, distance between teats and teat height to ground of West African Dwarf, Red Sokoto and Sahel goats*

Week of lactation	West African Dwarf (n = 10) Udder traits (cm)			Red Sokoto (n = 3) Udder traits (cm)			Sahel (n = 3) Udder traits (cm)		
	*UV	DBT	THG	UV	DBT	THG	UV	DBT	THG
1	705.5^{c}	10.3^{b}	16.3^{g}	1344.8^{b}	10.6^{b}	25.7^{g}	1958.4^{b}	11.9^{b}	30.1^{g}
2	782.3^{b}	10.5^{ab}	15.9^{fg}	1451.5^{a}	11.1^{a}	25.1^{g}	2153.8^{a}	12.4^{a}	28.1^{i}
3	835.3^{a}	10.7^{a}	15.7^{f}	912.6^{c}	9.0^{c}	27.4^{f}	1636.2^{c}	9.5^{c}	29.3^{h}
4	361.4^{d}	8.4^{c}	18.2^{e}	785.2^{d}	8.7^{d}	28.4^{e}	1510.5^{c}	8.8^{d}	31.2^{f}
5	339.6^{de}	8.1^{d}	18.5^{de}	727.0^{e}	8.6^{d}	29.4^{d}	1391.9^{e}	8.8^{d}	31.1^{f}
6	321.4^{def}	8.0^{de}	18.7^{d}	656.1^{f}	8.3^{e}	29.8^{c}	1337.1^{f}	8.6^{de}	31.6^{e}
7	309.4^{ef}	7.9^{de}	19.0^{d}	638.8^{f}	8.3^{e}	30.4^{b}	1242.0^{g}	8.5^{ef}	31.8^{de}
8	298.7^{ef}	7.8^{e}	19.7^{c}	613.0^{fg}	8.3^{e}	30.4^{b}	1186.7^{h}	8.5^{ef}	31.9^{d}
9	291.5^{e}	7.8^{e}	20.0^{bc}	79.7^{gh}	8.3^{e}	30.6^{ab}	1107.2^{i}	8.3^{fg}	32.1^{c}
10	291.0^{f}	7.8^{e}	20.4^{ab}	570.9^{gh}	8.3^{e}	30.7^{ab}	1086.1^{ij}	8.2^{g}	32.7^{b}
11	290.4^{f}	7.8^{e}	20.6^{a}	562.9^{gh}	8.3^{e}	30.8^{a}	1041.7^{j}	8.2^{g}	32.8^{ab}
12	293.6^{f}	7.8^{e}	20.7^{a}	559.9^{h}	8.3^{e}	30.8^{a}	984.3^{k}	8.2^{g}	33.0^{a}
Means ± SE	426.8 ± 8.70^{3}	8.6 ± 0.04^{3}	18.6 ± 0.07^{3}	783.5 ± 15.90^{2}	8.9 ± 0.06^{2}	29.1 ± 0.13^{2}	1386.3 ± 15.90^{1}	9.2 ± 0.06^{1}	31.3 ± 0.13^{1}

*See Materials and Methods for key to codes

$^{a-j}$Means in the same column within each breed having different superscripts differ significantly ($P < 0.05$)

$^{1-3}$Means in different columns across breeds having different superscripts differ significantly ($P < 0.05$)

Table 3 *Least squares means showing the effects of breed and week of lactation on teat length, teat width and teat circumference of West African Dwarf, Red Sokoto and Sahel goats*

Week of lactation	West African Dwarf (n = 10) Udder traits (cm)			Red Sokoto (n = 3) Udder traits (cm)			Sahel (n = 3) Udder traits (cm)		
	TL*	TW	TC	TL	TW	TC	TL	TW	TC
1	2.2^{b}	1.3^{bc}	3.8^{bc}	4.7^{b}	2.8^{b}	9.0^{b}	5.0^{b}	3.0^{b}	8.7^{b}
2	2.3^{ab}	1.3^{ab}	3.9^{ab}	5.0^{a}	3.1^{a}	9.6^{a}	5.3^{a}	3.2^{a}	9.0^{a}
3	2.4^{a}	1.4^{a}	3.9^{a}	4.2^{c}	2.8^{b}	8.5^{c}	4.8^{bc}	2.8^{c}	7.9^{c}
4	2.2^{c}	1.2^{c}	3.6^{cd}	4.0^{cd}	2.6^{c}	7.4^{d}	4.7^{c}	2.5^{de}	6.7^{d}
5	2.1^{cd}	1.1^{cd}	3.5^{de}	3.9^{de}	2.5^{cd}	6.9^{e}	4.7^{c}	2.4^{e}	6.0^{e}
6	2.1^{cd}	1.1^{cd}	3.5^{de}	3.8^{def}	2.4^{d}	6.5^{f}	4.7^{c}	2.5^{de}	6.1^{e}
7	2.0^{d}	1.1^{cd}	3.5^{e}	3.8^{def}	2.2^{e}	6.4^{g}	4.7^{c}	2.2^{f}	6.0^{e}
8	2.0^{d}	1.1^{cd}	3.4^{e}	3.8^{def}	2.1^{ef}	6.3^{g}	4.7^{c}	2.2^{f}	5.9^{f}
9	2.0^{d}	1.1^{d}	3.4^{e}	3.7^{f}	2.0^{fg}	6.0^{h}	4.6^{d}	2.2^{f}	5.7^{f}
10	2.0^{d}	1.1^{d}	3.4^{e}	3.6^{f}	1.9^{gh}	5.8^{i}	4.6^{d}	2.1^{f}	5.7^{fg}
11	2.0^{d}	1.1^{d}	3.4^{e}	3.6^{f}	1.8^{hi}	4.8^{ij}	4.5^{e}	2.1^{f}	5.6^{g}
12	2.0^{d}	1.1^{d}	3.4^{e}	3.6^{f}	1.7^{i}	5.6^{j}	4.5^{e}	2.1^{f}	5.6^{g}
Means ± SE	2.1 $\pm 0.03^{3}$	1.2 $\pm 0.02^{3}$	3.6 $\pm 0.04^{3}$	4.0 $\pm 0.05^{2}$	2.3 $\pm 0.03^{2}$	6.9 $\pm 0.07^{2}$	4.7 $\pm 0.05^{1}$	2.4 $\pm 0.03^{1}$	6.6 $\pm 0.07^{1}$

*See Materials and Methods for key to codes

$^{a-i}$Means in the same column within each breed having different superscripts differ significantly ($P < 0.05$)

$^{1-3}$Means in different columns across breeds having different superscripts differ significantly ($P < 0.05$)

Table 4 *Least squares means showing the effects of breed and week of lactation on liveweight, partial daily milk yield and partial daily milk yield per kilogramme liveweight of West African Dwarf, Red Sokoto and Sahel goats*

Week of lactation	West African Dwarf (n = 10) Live weight (kg)	Partial daily milk yield (PDM)			Red Sokoto (n = 3) Live weight (kg)	Partial daily milk yield (PDM)			Sahel (n = 3) Live weight (kg)	Partial daily milk yield (PDM)		
	*LWT	ml	g	PDM/ LWT	LWT	ml	g	PDM/ LWT	LWT	ml	g	PDM/ LWT
1	14.1	179.4^{b}	186.4^{b}	13.1^{a}	19.0	226.0^{b}	238.4^{b}	11.9^{ab}	21.7	246.7^{b}	256.5^{b}	11.4^{ab}
2	14.3	185.5^{ab}	192.6^{ab}	13.2^{a}	17.2	234.7^{a}	247.3^{a}	13.6^{a}	20.2	256.0^{a}	265.7^{a}	12.7^{a}
3	14.0	190.8^{c}	197.8^{c}	14.0^{a}	16.7	198.0^{c}	195.2^{c}	11.2^{b}	20.6	198.0^{c}	205.3^{c}	9.6^{c}
4	13.8	151.4^{d}	156.9^{d}	11.2^{b}	16.4	168.7^{d}	175.0^{d}	10.3^{b}	20.7	165.0^{d}	171.3^{d}	8.0^{cd}
5	14.0	131.3^{e}	135.9^{e}	9.5^{c}	16.7	150.0^{e}	155.5^{e}	9.0^{bc}	20.9	153.0^{e}	158.4^{e}	7.3^{de}
6	14.3	115.6^{e}	119.6^{e}	8.2^{de}	16.7	135.3^{f}	140.2^{f}	8.1^{cd}	21.2	144.0^{f}	149.0^{f}	6.8^{de}
7	14.5	106.9^{f}	110.5^{f}	7.5^{e}	17.2	125.3^{g}	129.7^{g}	7.3^{cde}	21.2	125.0^{g}	129.1^{g}	5.9^{efg}
8	14.8	91.0^{g}	94.4^{g}	6.2^{f}	17.6	118.7^{g}	122.7^{g}	6.8^{def}	21.4	115.0^{g}	118.6^{g}	5.4^{efg}
9	15.0	79.5^{h}	82.1^{h}	5.3^{fg}	17.9	105.7^{h}	109.2^{h}	5.9^{efg}	21.6	109.3^{fg}	112.9^{fg}	5.1^{fg}
10	15.3	71.7^{i}	73.9^{i}	4.7^{g}	18.1	95.7^{i}	95.7^{i}	5.1^{fg}	21.6	104.2^{hi}	107.0^{hi}	4.8^{g}
11	15.5	64.0^{j}	65.9^{j}	4.2^{h}	18.4	86.7^{ij}	89.4^{ij}	4.7^{g}	21.8	98.7^{ij}	101.4^{ij}	4.5^{g}
12	15.8	57.3^{k}	58.9^{k}	3.7^{h}	18.6	78.0^{j}	80.4^{j}	4.2^{g}	22.0	95.3^{j}	97.9^{j}	4.3^{g}
Means ± SE	14.6 ± 0.20^{3}	118.7 ± 1.12^{3}	122.9 ± 0.95^{3}	8.4 ± 0.09^{3}	17.5 ± 0.36^{2}	142.5 ± 2.04^{2}	148.2 ± 1.74^{2}	8.2 ± 0.17^{2}	21.2 ± 0.36^{1}	150.9 ± 2.04^{1}	156.1 ± 1.74^{1}	7.2 ± 0.17^{1}

*Liveweight of does

$^{a-k}$Means in the same column within each breed having different superscripts differ significantly ($P < 0.05$)

$^{1-3}$Means in different columns across breeds having different superscripts differ significantly ($P < 0.05$)

Table 5 *Phenotypic correlations between udder dimensions and partial daily milk yield of goats*

	UL	UW	UC	UV	DBT	THG	TL	TW	TC	PDM
UW[1]	0.42^{***}									
UC	0.36^{***}	0.30^{**}								
UV	0.65^{***}	0.60^{***}	0.78^{***}							
DBT	0.44^{***}	0.52^{***}	0.45^{***}	0.57^{***}						
THG	-0.49^{***}	-0.03	-0.30^{**}	-0.30^{**}	-0.22					
TL	0.01	0.51^{***}	0.33	0.41	0.20	0.16				
TW	0.07	0.30^{**}	0.68^{**}	0.54^{***}	0.26	0.03	0.61^{***}			
TC	0.05	0.16	0.85^{***}	0.60^{***}	0.19	-0.11	0.44	0.79^{***}		
PDM	0.23	0.30^{**}	0.52^{***}	0.50^{***}	0.57^{***}	-0.32^{***}	0.09	0.23	0.36^{***}	
LWT	0.19	0.11	0.24^{*}	0.14^{***}	0.28^{**}	0.02	0.19	0.15	0.11	0.50^{***}

$^{*}P < 0.05$, $^{**}P < 0.01$ and $^{***}P < 0.001$

[1]See materials and methods for key to codes

Conclusion

- Sahel does had the largest udder dimensions with highest average PDM while WAD does had the smallest with the lowest average PDM.
- Sahel does had the largest liveweight while WAD does had the least.
- WAD does produced the highest average PDM per killogramme liveweight than the other two breeds.
- The larger the udder dimensions (a reflective of udder size), the higher the average PDM produced by the three breeds.
- UW, UC, UV, DBT, TC and liveweight of does were positively and significantly correlated to average PDM thus indicating that they could be selected for predicting indirect response to milk production if genetic basis is established.

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