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SHORT NOTE

Milk yield and milk composition of Kalahari Red goat and the performance of their kids in the humid zone

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Additional keywords

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SUMMARY

Milk yield and milk composition of *Kalahari* red goat and the performance of their kids in the humid zone were studied. Data were collected from twenty six (26) *Kalahari* red goats over a period of 119 days. Stage of lactation was a significant source of variation for milk offtake ($p<0.001$), milk yield ($p<0.0001$) and not dams weight ($p>0.05$). Peak milk offtake was observed at weaning (42 weeks of lactation). Littersize had significantly ($p<0.05$) different weight with the single born kids being heavier than twin born kids. Litter size did not influence dam's weight, milk offtake and milk yield. Sex of kids significantly ($p<0.05$) affected dam's weight, milk yield and kids weight but had no effect on milk offtake. Kids that were single (11.98 kg) had higher weights than kids that were twins (8.8 kg). The change in kids' weight on weekly basis varied significantly ($p<0.05$). Kids' weight increased with the week of lactation ($p<0.05$) till the 12th week. Weight of kids was as high as 15.35 kg at the 17th week of lactation with the average of 10.44 kg. There was a significant difference in kids' sex ($p<0.05$) with male kids having higher weights (13.22 kg) when compared to the female kids (11.28 kg). The average milk components (%) were 5.16; 7.58; 4.99; 0.54; 81.15; 11.27 and 6.47 for protein, fat, lactose, ash, moisture, total solids, solid-not-fat and pH respectively. Correlation between milk yield and dams weight ($r= 0.31$) was significant and positive in Kalahari goats but negative correlations were observed between milk yield and kids' weight ($r= -0.45$) in this breed. Kids' weight was higher in estimating milk yield in Kalahari does with a coefficient of determination of 45%. Therefore, the lengthy lactation, high milk yield and quality milk component of Kalahari goats suggest that this goat breed could be adopted as a dairy animal in the humid zone of Nigeria. Great reliability can be achieved in the prediction of milk yield using kids' weight.

Rendimiento y composición láctea de la cabra Roja de Kalahari y rendimiento de sus cabritos en la zona húmeda

Palabras clave adicionales

Extracción leche.
Composición leche.
Cabra Roja del Kalahari.
Rendimiento cabritos.
Zona húmeda.

RESUMEN

Se estudió el rendimiento y composición de la leche, y producción de los cabritos de la cabra roja del Kalahari en la zona húmeda. Se recogieron datos de veintiséis (26) cabras Rojas de *Kalahari* durante un periodo de 119 días. La etapa de lactación fue una fuente significativa de variación para la extracción de leche ($p<0,001$), rendimiento de la leche ($p<0,0001$) y no para el peso de las hembras ($p>0,05$). El pico de lactación se registró al destete (42 semanas de lactancia). Según el tamaño de la camada ($p<0,05$) fue diferente el peso de los chivos, los de parto simple siendo fueron más pesados que los de parto doble. El tamaño de la camada no influyó en el peso de la hembra, extracción de leche y producción de leche. El sexo de los chivos afectó significativamente ($p<0,05$) el peso de la hembra, el rendimiento de leche y peso de los chivos, pero no tuvo efecto sobre la extracción de leche. Los chivos de parto simple (11,98 kg) tuvieron pesos superiores a los chivos de parto doble (8,8 kg). El cambio semanal del peso de los chivos no varió significativamente ($p<0,05$). El peso de los chivos aumentó con la semana de lactación ($p<0,05$) hasta la semana 12. El peso de los chivos alcanzó 15,35 kg en la 17ª semana de lactación con el promedio de 10,44 kg. Hubo una diferencia significativa según el sexo de los chivos ($p<0,05$) siendo mayor el peso de los machos (13,22 kg) que el de las hembras (11,28 kg). Los componentes lácteos promedio (%) fueron 5,16; 7,58; 4,99; 0,54; 81,15; 11,27 y 6,47 para proteína, grasa, lactosa, ceniza, humedad, sólidos totales, sólidos no grasos y pH respectivamente. La correlación entre el rendimiento lechero y el peso de las madres ($r= 0,31$) fue significativa y positiva en cabras de Kalahari, pero se observaron correlaciones negativas entre el rendimiento de la leche y el peso de los chivos ($r= -0.45$) en esta raza. El peso de los chivos fue superior para estimar el rendimiento lechero en cabras Kalahari con un coeficiente de determinación de 45%. Por lo tanto, la lactancia prolongada, el alto rendimiento lechero y la calidad de los componentes de la leche de cabras Kalahari son índices de que esta raza caprina puede ser adoptada como un animal lechero en la zona húmeda de Nigeria. Gran fiabilidad puede conseguirse en la predicción del rendimiento lechero a partir del peso de los chivos.

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INTRODUCTION

Indigenous goats in Nigeria are mainly kept for meat production with their milk rarely used for human consumption (Apata and Adewumi, 2011; Adewumi *et al.*, 2012). However, there is a growing awareness of the importance of goats as a source of milk for man (Malau-Aduli *et al.*, 2004). In some tropical and temperate countries, the Jonica, Payoya, Moxoto, Murciano-Granadina and few other breeds are used for milk production (Laudadio and Tufarelli, 2010; Delgado-Pertinez *et al.*, 2009; Queiroga *et al.*, 2009; Fernandez *et al.*, 2013). Although, there is an affinity for milk products in the country; the dairy industry still remains rural and traditional with Fulani pastoralists controlling more than 95 percent of the national herd. The increasing demand for milk and its product in Nigeria has made it imperative to look at ways of increasing milk production (Malau-Aduli *et al.*, 2004; Ahamefule *et al.*, 2007) and goat milk is of interest due to variation in yield and composition from breed to breed. The variation in milk composition affects product yield and quantity (Assan, 2014). Among the breeds of goat, the West African Dwarf (WAD) and Red Sokoto are common goat breeds in Nigeria that could be milked for household consumption. However, there are some breeds although are not indigenous, but with outstanding qualities of large carcass size, excellent mothering abilities and also they produce large amount of milk. The Kalahari Red goat is known to be hardy, less susceptible to diseases with fully pigmented coat to endure heat and strong sunshine and produces sufficient milk for twins and triplets (Jordan, 2015). Therefore, there is need to evaluate the milking potential and nutritional value of Kalahari red goat milk which is an imported breed and to identify traits that are simple to measure and correlate with milk yield so as to select kids that may be used for future dairy program.

MATERIALS AND METHODS

Experimental site

The research was conducted at the Institute of Food Security, Environmental Resources and Agricultural Research Farm (IFSERAR), Animal Product and Processing Laboratory of the Federal University of Agriculture Abeokuta (FUNAAB), which falls within the rainforest region with a typical hot and humid climate. The region is 76 m above sea level, lies at latitude 7°13 49.4''N and longitude 3°26 11.98''E. The climate is humid with mean annual precipitation, temperature and relative humidity of 1,112.11 mm, 34°C and 80% respectively.

Experimental animals and management

A total of 26 lactating does of Kalahari red goats weighing 43 to 45 kg, age 1 to 2 years and in their second parity were imported from South Africa and used for this study. The does were raised in a standard pen and were maintained under a semi-intensive system. They were allowed to graze and supplemented with concentrate. The concentrate was composed of wheat offal, soya, palm kernel cake, groundnut cake and maize. Extra concentrate was offered during milking to the animals. Routine health care practices such as vaccination, medication, ecto-practice control and deworming were also regularly carried out. Fresh water was provided *ad libitum*.

Data collection and material

Weight of does and kids were taken weekly. Milk yield was determined from the first week of lactation till the 17th week of lactation (119 days). The milk yield was measured using a measuring cylinder. On the day of yield determination, kids were separated from their dams for a period of 3 hours. Animals were hand-milked twice daily, with the first milking as the off take and then the second after a 3 hours interval. The daily milk yield was determined by multiplying the yield after the 3 hours interval by eight (8). The kids were left with their dams until weaning at 42 days of age. Milk samples were taken to determine the milk composition which was analyzed in triplicate. Samples were kept in a freezer at -10°C until required for analysis.

Analysis of milk component

Milk samples were thawed and shaken before determining the proximate composition following the procedure of AOAC (2005). Fat was determined by the Rose-Gottlieb method. Protein (N x 6.38) was determined with Markham's semi-microkjedahl apparatus. Lactose constituent of milk sample was estimated as follows:

Lactose= snf- (% protein + % ash)

Analytical procedure of milk pH

The pH of the milk was determined by using a digital pH meter. The pH meter was standardized with standard buffer solutions prior to use.

Statistical analysis

Data obtained were analyzed using analysis of variance (ANOVA) and significant means were separated using Duncan's Multiple Range Tests of SAS (2003). Pearson's correlation coefficients among doe weights, milk offtake, milk yield and kids weight were estimated using correlation procedure to establish relationships.

RESULTS AND DISCUSSION

Effect of stage of lactation on doe's weight, milk offtake, milk yield and the weight of kids of Kalahari Red goats

The result of doe's weight, milk off-take, milk yield and the weight of kids of Kalahari goat as affected by stage of lactation are presented in **table I**. Stage of lactation effect was a significant source of variation for milk offtake ($p<0.003$), milk yield ($p<0.001$) and kids' weight ($p<0.001$). In a study to evaluate milk yield of Damascus does raised under Sudan condition, it was observed that different stages of lactation affected their milk yield (Mahmoud *et al.*, 2014). The significant stage of lactation effect may have practical implications in determining optimal feeding management to maximize total lactation yield and milk composition (Assan, 2014; Adewumi *et al.*, 2006).

Table I. Effect of stage of lactation on doe's weight, milk offtake, milk yield and weight of kid of Kalahari **Red goat** (Efecto de la etapa de lactación sobre el peso de la cabra, extracción de leche, rendimiento lechero y peso del chivo de las cabras Rojas del Kalahari).

Stage of lactation	Doe's weight (kg)	Offtake (mL)	Milk yield (mL)	Kids weight (kg)
1	47.90	209.50^{ab}	2252.00^{a}	4.50^{h}
2	46.65	202.75^{ab}	1808.00^{b}	5.41^{gh}
3	45.69	121.09^{b}	1297.45^{c}	6.90^{fgh}
4	45.02	132.75^{ab}	1240.67^{cd}	7.72^{efg}
5	44.43	123.33^{ab}	1012.00^{cde}	8.73^{def}
6	53.59	220.75^{ab}	849.25^{defg}	8.80^{def}
7	44.28	339.00^{a}	836.67^{defg}	9.87^{cdef}
8	44.25	195.62^{ab}	971.69^{cdef}	10.02^{cde}
9	43.97	255.36^{ab}	870.29^{defg}	10.94^{bcd}
10	43.03	101.47^{b}	732.27^{efgh}	12.07^{ab}
11	43.36	70.31^{b}	607.50^{efgh}	12.21^{bc}
12	44.51	73.00^{b}	531.43^{fgh}	11.58^{bcd}
13	44.42	49.09^{b}	492.36^{gh}	13.28^{ab}
14	45.67	107.83^{b}	546.67^{fgh}	11.94^{bc}
15	44.44	97.40^{b}	443.20^{gh}	12.88^{abc}
16	43.93	49.33^{b}	568.00^{fgh}	15.33^{a}
17	44.65	40.00^{b}	352.00^{h}	15.35^{a}
Mean	44.65	195.21	1077.19	10.44
SEM	0.49	21.19	48.98	0.24
P-value	0.98	0.00	0.00	0.00
Litter size				
Single	43.40	159.60^{a}	750.22	11.98^{a}
Twins	45.53	134.58^{b}	978.20	8.88^{b}
SEM	0.42	20.03	50.76	0.34
P-value	0.23	0.05	0.75	0.04
Sex				
Female single	43.60^{b}	149.92	717.22^{b}	11.28^{b}
Female twins	43.02^{b}	131.52	822.48^{ab}	9.34^{c}
Mixed sex	47.54^{a}	146.31	1056.90^{a}	8.81^{c}
Male single	42.33^{b}	176.54	807.96^{ab}	13.22^{a}
Male twins	37.78^{c}	62.22	808.00^{ab}	8.27^{c}
SEM	0.50	18.02	52.61	0.31
P-value	0.00	0.58	0.01	0.00

^{abcdefgh} Means with different superscript are significantly different at $p<0.05$.

The value of milk yield from Kalahari does in this study was higher than those of the tropical breeds (Adewumi *et al.*, 2012; Agbede *et al.*, 1997; Akpa *et al.*, 2001). This might partly be due to breed, size of does and differences in method of extraction by these authors. While some authors used oxytoxin prior to milking, others estimated milk yield using kids' weight differences before and after suckling. Moreover, there was difficulty in extracting milk. However, with an average yield of 863.26 ml, this breed surpassed the average daily milk of West African Dwarf does with a yield of 93.11, 146.6 and 53.86 mL (Agbede *et al.*, 1997; James *et al.*, 2005; Adewumi *et al.*, 2012 respectively). It was also higher than Jakhrana (770 ml) and Marwari (500 ml) (Agnrhotri and Rajkumar, 2007) in India. The pattern of daily milk yields significantly rising to maximum within two weeks and decreasing thereafter till the end of lactation has been reported by James and Osinowo (2004) and Ehoche and Buvanendran (1983) in the Red Sokoto goat. The highest milk yield (2252.00 ml) was recorded in week one of lactation which started declining, reaching as low as 352.00 ml in week 17 of lactation in the present study. The average daily milk yield was 1077.19 ml. Later occurring peaks have however, been reported by Badamana (1989) where peak yield occurred at week 6 in Kenyan goats and by Akinsoyinu *et al.* (1977) working with the West African Dwarf goats whose peak occurred from week 4 to 6. Variation on these milk yield peaks could be attributed to year of kidding, season, parity, feeding

management, method of milk yield determination and environment. The difference may be as a result of increase and decrease in milk secreting cells at the onset and progression of lactation respectively and could also be due to increase requirement of milk by the kids as they advance in age. Milk offtake was affected by the week of lactation ($p<0.05$) with the average milk offtake at 195.21 mL. Peak milk offtake and milk yield were observed at the beginning (7 days) and at weaning (42 days) of lactation. Milk offtake was highest at the 7th week (255.3 ml) and lowest at 17th week (40.00 ml) of lactation. However, milk offtake oscillated as the week of lactation advanced and did not follow a particular trend. Doe's weight changes remained relatively constant throughout the lactation period as established by James (2000) but this is not in agreement with the findings of Cooper *et al.* (1994) and Zygoyiannis (1994).

Effect of litter size and kids' sex on doe's weight, milk offtake, milk yield and kids' weight

Litter size effect was significant ($p<0.05$) on body weight with the single born kids being heavier than twin born kids **(table I)**. Litter size did not influence dam's weight, milk offtake and milk yield. The mean weight (kg) of kids that was single was 11.98 kg and that of twins was 8.88 kg. This shows that the kids that were single had the highest growth or superior weights than kids that were twins. This may be due to the availability of more milk for the kids that were single. Kids weight increased significantly ($p<0.05$) as lactation advanced. Weight of kids was as high as 15.35 kg at the 17th week of lactation with the average at 10.44 kg. Sex of kids born significantly ($p<0.05$) affected dam's weight, milk yield and kids weight but it had no effect on milk offtake with the dams of mixed sex kids being heavier (47.54 kg) and high producing (1056.90 mL) **(table I)**. However, the weight of mixed sex kids was least (8.81 kg).

Kids' weight at birth was high due to the heavy size of the Kalahari red goats with kids gaining as high as 0.4 to 1.0kg weekly. Peart (1982) concluded that when nutrition is low or restricted during the late stages of gestation, birth weight of kids and dam's milk yield in the first lactation weeks are reduced. Hence, the high performance of these kids was probably due to the higher yields of milk and milk components. Kids that were males (13.22 kg) had superior body weights than their female (11.28 kg) counterparts this may be as a result of the male aggression when suckling, effect of male hormone in the growth or perhaps the breed (Bemji *et al.,* 2006). Although, non-significant, higher litter size gave rise to a higher level of milk production, the non-significant difference obtained between the two dam groups may be explained by the assertion of previous studies that rather than number born, it is the number of kids suckled by the dam that determines the milk yield (Linzell and Peaker, 1971). Linzell and Peaker (1971); Ehoche and Buvanandran (1983); Montaldo *et al.* (1995) attributed no physiological relevance to the increased milk production from dams with twins but to frequency of suckling. This differed from reports on Red *Sokoto* and lactating goats (Akpa *et al.,* 2001; Wahome *et al.,* 1995) reared under intensive management system where there was less stress for pregnant and lactating does carrying twins, hence body reserve to mobilize for milk following kidding when compared with the single litter does was high.

Table II. Pearson's correlation among doe's weight, milk offtake, milk yield and kid's weight (Correlaciones de Pearson entre el peso de la cabra, extracción de leche, rendimiento lechero y peso del chivo).

Variables	Doe's weight	Milk offtake	Milk yield	Kids weight
Dam's wt	1.0000	0.0873	0.3103	-0.1339
		0.2617	<0.0001	0.0844
Milk offtake		1.0000	0.2801	-0.0792
			0.0002	0.3088
Milk yield			1.0000	-0.4519
				<0.0001
Kids Wt				1.0000

Correlation among doe's milk offtake, milk yield, weight, and kids' weight of Kalahari Red goats

Correlation between milk yield and dams weight ($r = 0.31$) was moderate, significant and positive in Kalahari goats but negative correlations between milk yield and kids weight ($r = -0.46$) in this breed at 119 days **(table II)**. Observations made in the present study showed that there was a positive and significant relationship between the dam's weight and milk yield which is in agreement with Ehoche and Buvanendran (1983) and Prasad *et al.* (1994). It was indicated further by Gall (1980) that increased body weight favours milk yield if it is due to scale, while it reduces milk yield if it is due to fat and muscle mass. Cooper *et al.* (1994) who worked with indigenous Malawi's goats reported positive but insignificant relationship between doe's weight and yield. The negative phenotypic correlation between kids weight and milk yield clearly showed a particular trend. This was because as the kids increasingly depend on forage intake, less milk is suckled. However, kids' weight and milk yield were negatively correlated which is contrary to the findings of Malik *et al.* (1980) that kids' weight and milk yield were positively related and in turn affects kid survival rate. Insignificant relationship between doe's weight and milk offtake corroborates the findings of Bemji (2003) and further stated that this may be attributed to level of milk production which was sufficient to rear kids. It is indicative from the positive and significant correlation between milk offtake and milk yield that higher milk offtake will invariably increase milk yield.

Estimation of milk yield through linear regression equations

The results of stepwise multiple regressions to determine the contribution of doe's weight, milk offtake, weight of kid to milk yield is presented in **table III**. The result showed that kids' weight was superior to dam's weight in estimating milk yield in Kalahari does. It gave a coefficient of determination of 20%.

Table III. Stepwise linear regression equations among dam's weight, milk offtake, milk yield and kid's weight (pooled) (Ecuaciones de regresión lineal entre el peso de la cabra, extracción de leche, rendimiento lechero y peso de los chivos (combinado).

Regression type	Predictive equations	Estimate multiple r	R^2 (%)
Linear $Y=A+BX$	$Y=-68.3248\ X_1 \pm 1535.0253$	0.4500	0.2043***
Multiple i.Two variables $Y=A+B_1X_1+C_2X_2$	$Y=-58.5520\ X_1 + 26.1664\ X_2 + 322.5131$	0.5300	0.2678***
ii.Three variables $Y=A+B_1X_1+C_2X_2+D_3X_3$	$-56.3594\ X_1 \pm 24.3369\ X_2 \pm 0.5471\ X_3 \pm 297.0178$	0.5800	0.3189***

Y = Milk yield; X_1= Kids weight; X_2 = Dam's weight; X_3 = Milk offtake; A,B,C,D are constants.

The high coefficient of determination indicated that great reliability can be achieved in the prediction of milk yield using kids' weight in Kalahari goat. However, the prediction was enhanced with the use of all parameters considered in this study. The significant correlation between milk yield and dam's weight in goat is in agreement with our earlier findings (Adewumi *et al.,* 2012). This author attributed increased milk yield to dam's weight suggesting that kids' weight in addition to milk offtake and dams weight could be used to identify high producing Kalahari does.

Milk composition

The average milk components (%) were 5.16; 7.58; 4.99; 0.54; 81.15; 11.27 and 6.47 for protein, fat, lactose, ash, moisture, total solids, solid-not-fat and pH respectively **(table IV)**. The protein (5.16%) content reported in this present study was lower than to that of Sahelian goats (5.56%) (Ibeawuchi *et al.,* 2005) and the Mexican Rambouillet ewes (5.21%) (Ochoa-Cordero *et al.,* 2002). The mean fat (7.58%) was higher than the 5.23% reported in Granadina goats in Spain (Ceballos *et al.,* 2009) but comparable to reported value of 7.61% in *Sahel* goats (Ibeawuchi *et al.,* 2005). The lactose content was comparable to the reported values of 4.75% and 4.9% for Swedish Landrace and Boer respectively (Hosberg, 2011; Mestawet *et al.,* 2012). The total solids mean value of 18.84% was higher than that of the West African Dwarf (18.30%) and Red Sokoto (15.85%) goat milk (Mba *et al.,* 1975). The present total solids value was much higher than the values of 16.60% reported for Saanen (Pilla *et al.,* 1980) and Alpine goat milk (Varna and Chawia, 1984). Overall mean of solid-not-fat was also higher than the reported values of 4.60% for Red Sokoto and 4.17% for the West African Dwarf goat milk (Mba *et al.,* 1975). This implies that Kalahari Red goat milk will yield more products per litre of milk during cheese and butter production. The ash (0.54%) representing the mineral content of the milk was lower compared to 0.78% of Indian goats (Quresh *et al.,* 1981). The pH value of 6.47% is comparable to values reported by (Agnihotri *et al.,* 2002). Joshi and Vedanayakan (1967) reported that the lower the solid-not-fat content in goat milk, the lower the buffering capacity resulting in poor keeping quality of goat milk.

Table IV. Least square means of milk components of Kalahari red goats (Medias mínimo cuadráticas de los componentes de la leche de cabra roja de Kalahari).

Component (%)	Mean	S.E	Min	Max
Protein	5.16	0.03	3.50	6.89
Total solids	18.84	0.59	18.01	19.99
Fat	7.58	0.22	7.14	7.84
Solid-not-fat	11.27	0.56	10.23	12.15
Ash	0.54	0.01	0.53	0.56
pH	6.47	0.03	6.40	6.50
Lactose	4.99	0.55	3.98	5.88
Moisture	81.15	0.59	80.12	81.99

S.E.: Standard error; Min: minimum; Max: maximum.

CONCLUSION

The results obtained from this study demonstrated the milk production potential of Kalahari red goats. Kalahari red goats have an adequate lactation length and are high producing with milk components of good quality. Week of lactation, milk offtake and kids' weight significantly influenced milk yield of Kalahari red goats. Great reliability could be achieved in estimating milk yield using parameters like doe's weight, milk offtake and kids' weight.

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