S. Afr. J. wildl. Res. 7(2): 67-71 (1977)

OBSERVATIONS ON LACTATION AND MILK COMPOSITION OF THE GIRAFFE *GIRAFFA CAMELOPARDALIS*

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ABSTRACT. — Milk samples collected from giraffe *Giraffa camelopardalis* in the eastern Transvaal Lowveld of South Africa were analysed by conventional methods. Changes in the composition of the milk at different stages of the lactation cycle were noted. The prelactation secretion and milk of early lactation was considerably richer than the milk of established lactation in terms of total solids, fat, ash, and protein but not in lactose. Differences in minerals and trace elements were not significant. Giraffe milk is richer than bovine milk in terms of fat, total protein and ash content, but lactose is lower. The casein, lactalbumin and lactoglobulin fractions of the giraffe milk proteins are similar to those of bovine milk. Lactation in giraffe lasts for 12 to 13 months, and the milk yield is estimated at 2,5 to 10 litres per day.

INTRODUCTION

Hall-Martin, Skinner and van Dyk (1975) found that in the giraffe the time of conception is geared to optimum conditions for the adult female, and suggested that any selective disadvantage thereby exercised upon the young might be mitigated by a long lactation period. The quality and quantity of the milk would also be expected to influence calf survival. At that time only limited information was available on lactation and milk of captive giraffe (Greed 1961, Aschaffenburg, Gregory, Rowland and Thompson 1962, Ben Shaul 1962). This report describes the analysis of milk collected from wild giraffe at different stages of the lactation period and gives estimates of the duration of lactation and the milk yield.

MATERIALS AND METHODS

Material and data were collected from 26 female giraffe culled in the Timbavati Private Nature Reserve and its environs (24°24'S, 31°21'E) in the eastern Transvaal Lowveld, a savanna/woodland region of South Africa described in detail by Hall-Martin (1974). The animals were shot in the head early in the morning and the jugular vein immediately severed. Within minutes milk (or prelactation secretion) was collected by manual expression from the teats. When no further milk issued the udder was excised and the procedure repeated, this usually resulted in more milk being collected. The milk was frozen soon after collection. The mass of the excised udder was measured on a spring balance but no allowance was made for the mass of the milk removed. The age of the giraffe was determined (following Hall-Martin 1976), total body mass (following Hall-Martin, von La Chevallerie and Skinner 1977) and stage of gestation in pregnant cows assessed (following Skinner and Hall-Martin 1975).

Analysis of the milk from 12 females was carried out using conventional procedures (Horwitz 1970). Fat was measured by the Babcock method and total protein was determined by Kjeldahl analysis for nitrogen and multiplication by the factor 6,38. Casein and whey proteins were not measured in the present analysis, though small aliquots were prepared for examination by zone electrophoretic techniques (Osterhoff 1968). Total solids were determined by air drying over a water bath and then drying in an oven at 100°C until constant mass was reached. Ash was determined from samples incinerated overnight at 600°C. Lactose was estimated from the difference between T.S. and the sum of fat, protein and ash. Minerals were determined by atomic absorption spectrometry.

RESULTS

Udder mass and duration of lactation

The mammary gland is situated inguinally and has two pairs of teats, not one pair as quoted incorrectly by several authors (Shortridge 1934, Roberts 1951, Ansell 1960, Walker 1964). Udder size is shown in Table 1, the heaviest udder (7,26 kg) was that of a lactating female 14 years old, while the lightest (1,81 kg) was that of a pregnant non-lactating female, 10 years old. As could be expected inactive mammary glands have the lowest mass. Udder mass as a percentage of total body mass, and udder activity of 18 females at different stages of lactation and pregnancy is shown in Fig. 1. The decrease in size of the udder during early pregnancy and its rapid development during the last 50 days of gestation is apparent (Fig. 1).

From 26 postpubertal females for which the lactation status was recorded, it was found that all non-pregnant females were lactating, and pregnant females (n=4) lactated until day 150 of gestation (Fig. 1). Pre-lactation secretion was present in pregnant females as early as 231 days *pre-partum* (day 226 of gestation.) The udders of five females ranging from 131 days to 390 days of gestation were dry. Calves were seen suckling up to at least 10 months of age and milk was found in the stomach of a one-year old animal. The maximum length of lactation of a pregnant female (150 days) added to the mean *post-partum* reconception interval (242 days - Hall-Martin 1975) gives an estimate of the duration of lactation in wild giraffe of 392 days, or 12 to 13 months.

TABLE 1. *Udder size in pregnant and non-pregnant giraffe.*

Status	n	Mean mass of udder (kg) ± S.E.	Range (kg)
Pregnant, lactating	4	3,68 ± 0,23	3,17 - 4,31
Pregnant (<400 days) not lactating *	6	2,24 ± 0,12	1,81 - 2,72
Near term (454 days) pre-lactation secretion	1	6,80	—
Early *post-partum*	1	7,26	—
Non-pregnant, lactating	5	4,99 ± 0,28	4,54 - 5,90

* Pre-lactation secretion in two animals.

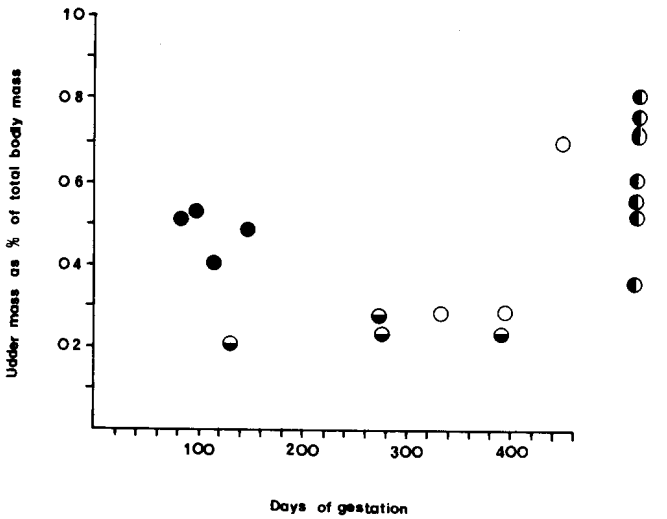

FIG. 1. Udder mass as a percentage of total body mass in giraffe at different stages of pregnancy and lactation. Pregnant and lactating (●); pregnant but not lactating (◒); pre-lactation secretion (o); non-pregnant but lactating (◐).

Gross composition and variation of the milk

The chemical analyses of 12 samples of giraffe milk from different stages of lactation are shown in Table 2. As it is well known that the *pre-partum* secretion and colostrum differ in composition from milk of established lactation (Ling, Kon and Porter 1961) the composition of these are shown separately. Pre-lactation secretion was cream coloured and varied in consistency from a jelly-like substance when first present to a less viscous fluid closer to term while milk was white. Samples 4 and 5 have been referred to as early milk rather than colostrum as it is not known precisely when parturition occurred. However, evidence from the degree of uterine involution, presence of cotyledons and condition of ovaries indicated that the females had recently calved. The remaining samples have been arranged in order of the relative udder size (udder mass as % of total body mass) as udder size decreases with time, at least during early pregnancy (Fig. 1). It is assumed that there is little individual variation in udder size and that none of these females had lost their calves.

The data in Table 2 indicate an increase in fat, protein, total solids and ash in the prelactation secretion close to term which declines following parturition. Lactose is high in the pre-lactation jelly secretion, falls in the later pre-lactation liquid secretions, rises again during early lactation, remaining fairly constant for a while and then declines towards the end of lactation. The composition of early milk was found to be significantly different from milk of established lactation ($P<0,01$ - $P<0,02$) when compared using Students-t test (Simpson, Roe and Lewontin 1960), except for lactose which did not differ significantly. However, samples are small and in these calculations the very high protein value of no. 11 (Table 2) when included, made the difference in protein values only just not significant at the 5% level of probability. When comparing the first three samples from the early part of established lactation (nos. 6, 7 and 8) with the samples from late lactation it seems clear that there is a fall to minimum values of fat, protein, and total solids followed by a recovery in later lactation, though this cannot be statistically substantiated due to the small sample size. There is little apparent trend in the values for ash except for high values following parturition and in sample 12.

The pattern of migration of the casein, lactalbumin and lactoglobulin fractions of the milk proteins in starch gel were examined and found to be very similar to those obtained for bovine milk.

TABLE 2. *The major constituents of giraffe milk from the Eastern Transvaal Lowveld.*

Sample No.	Gestation days		Composition in g per 100 g				
			Fat	Protein (N x 6,38)	Total Solids	Ash	Lactose (by difference)
Pre-lactation secretion (jelly)							
1	409		11,5	3,9	19,9	0,8	3,7
Pre-lactation secretion (fluid)							
2	405		15,6	10,4	28,8	0,7	2,1
3	414		17,8	15,4	34,6	1,0	0,4
		Mean	16,7	12,9	31,7	0,8	1,2
Early lactation							
4	—		12,8	10,4	25,6	1,4	1,0
5	—		17,5	16,3	38,8	1,2	3,8
		Mean	15,1	13,3	32,2	1,3	2,4
Established lactation							
6	—		7,5	3,6	18,6	0,9	6,6
7	—		3,4	4,2	12,3	0,7	4,0
8	—		3,6	4,1	12,5	0,8	4,0
9	98		10,0	4,2	18,0	0,9	2,9
10	116		10,8	9,8	22,5	0,8	1,1
11	—		5,5	13,4	19,9	0,7	0,3
12	—		9,5	4,8	17,1	1,2	2,4
		Mean	7,2	6,3	17,3	0,9	3,0
		±S.E.	1,1	1,4	1,4	0,06	0,8

TABLE 3. *Mineral and trace element constituents of giraffe milk from the Eastern Transvaal Lowveld.*

Sample No.	Minerals in mg per Kg					Trace elements in μg per Kg			
	Ca	Mg	K	Na	P	Fe	Mn	Cn	Zn
Early Milk									
5	800	60	1340	310	990	80	200	280	5700
Established lactation									
6	700	50	1020	300	1060	200	200	360	4900
7	800	60	1020	380	1100	1800	200	320	5300
8	700	50	390	240	1080	4400	200	480	6400
9	30	40	990	250	550	40	200	240	4400
10	800	50	1290	300	920	1600	200	200	6000
11	700	50	1220	340	850	800	200	240	6500
12	1000	60	420	830	1600	2000	200	640	7200
Mean	691,2	52,5	961,2	386,7	1018,7	1365,0	200,0	345,0	5800,0
±S.E.	101,0	2,5	103,3	67,9	104,6	518,9	0,0	52,5	320,0

Minerals and trace elements

Table 3 shows the mineral and trace element composition of milk from eight females (identified by the same numbers as in Table 2) at different stages of lactation. No clear trends could be discerned (as seen in the ash composition of the samples). The level of potassium in the early milk was however higher than that of later milk.

Milk yield

The maximum volume of milk obtained from a single milking of a female in established lactation was 2250 ml. Most samples varied between 100-800 ml while the volumes of pre-lactation secretion collected were less than 100 ml. The time elapsed from last suckling to death was not known nor could the amount of milk present in the udder after milking be determined.

DISCUSSION

Duration of lactation

The lower mass of the udder in the four pregnant lactating females *cf.* non-pregnant lactating females (Table 1) is a further confirmation that conception occurred late in the lactation cycle. The low udder mass of the non-lactating female at 131 days gestation (Fig. 1) could possibly be ascribed to a lost calf, in which case lactation might have ended earlier than normal as found in some other mammals (Grimsdell 1973, Smuts 1976). The estimate of the duration of lactation viz. 12 to 13 months is in agreement with observations on captive giraffe (Aschaffenburg *et al.* 1962, Dagg 1971) while Mason (1973) recorded a wild calf still suckling at 10 months.

Collection and analysis

As the milk samples were collected at unknown times after suckling, from udders which might not have been completely emptied, and under field conditions where, for example, the possibility of lactose breakdown due to bacterial activity existed, the results of the analyses might, to some extent be unrepresentative of the true composition of giraffe milk. However, the clear trends in the major constituents from milk at different stages of lactation, and the general similarity of milk of the same category indicate that the samples probably were representative of the milk in the udders despite these possible deficiencies which, however, might explain the apparently anomalous relationships among the salts and ions as indicated in some samples (e.g. low ash and low lactose in sample 11, Table 2) and the large variations in some constituents.

The method used for determining total protein is subject to some error, because the non-protein nitrogen is also expressed as protein when using this method (Jenness and Sloan 1970). The nitrogen content of milk proteins has been precisely determined for *inter alia* the bovine *Bos taurus,* goat *Capra hircus* and human *Homo sapiens.* Non-protein nitrogen amounts to about 5% and 17% of the total nitrogen in the milk of bovines and humans respectively, however, in the case of giraffe milk it is only of minor importance as Aschaffenburg *et al.* (1962) found only 0,023 g per 100 g non-protein nitrogen in the sample they analysed, and this amounted to only 0,4% of the total proteins.

The estimation of lactose by difference is also subject to error and according to Jenness and Sloan (1970) it is likely to err on the high side of the actual value for several reasons, the most important of which is the loss of organic salts, such as citrate in the determination of ash. Thus ash, as expressed here, represents the mass of the mineral residue and does not precisely represent the quantity of salts in the milk.

Milk composition

The early milk was found to be much richer than the colostrum analysed by Ben Shaul (1962). She also analysed milk after the first 10 days and found that the fat, protein and ash content were lower while the value for carbohydrates was higher. Unfortunately she gives no indication of how many samples were analysed, or whether the values she presents are mean values. It is well known that colostrum or early milk is richer than milk of established lactation in bovines, and that the pre-lactation secretion is even richer than the colostrum (in terms of those constituents normally high in colostrum i.e. total solids, fat, non-fatty solids, and ash as discussed by Ling *et al.* 1961). In this respect the

giraffe is similar to the bovine and the eland *Taurotragus oryx* (Treus and Kravchenko 1968, van Zyl and Wehmeyer 1970) though it is difficult to explain why total solids were found to be lower in the jelly than in the fluids (Table 2, no. 1,2,3). Once the colostrol stage is past, in cattle, lactation follows fairly well-defined trends with fat, non-fatty solids, protein and casein falling to low values during early lactation and thereafter increasing (Ling *et al.* 1961). In this respect too, the apparent trend is the same in sheep *Ovis aries* (Corbett 1968), Dall sheep *Ovis dalli* (Cook, Pearson, Simmons and Baker 1970), cervids (Arman, Kay, Goodall and Sharman 1974), eland (Treus and Kravchenko 1968) and giraffe.

The mean values of the seven samples of established lactation are treated as fairly representative of giraffe milk for purposes of discussion. These data differ from that of Aschaffenburg *et al.* (1962) mainly in that values are lower than those found in their sample from a captive giraffe. When compared with bovine milk the main features are that the fat, total protein and ash content of giraffe milk is higher while, on average, lactose is lower. When compared with eland milk (Posselt 1963, Treus and Kravchenko 1968, Van Zyl and Wehmeyer 1970) the giraffe milk has a lower percentage of all major components. The ash content of giraffe milk is generally lower than that in the milks of the other domestic species listed by Ling *et al.* (1961), and of red deer *Cervus elaphus* (Arman *et al.* 1974). The mean values for mineral components in wild giraffe milk are also lower than the values found by Aschaffenburg *et al.* (1962), though their phosporus, potassium and iron values fall within the range of the wild giraffe. By comparison, the mineral content of the milk of red deer (Arman *et al.* 1974) is generally higher, with the exception of sodium and some individual values of potassium.

For those major trace elements which were measured (Table 3) it was found that giraffe milk had higher concentrations of iron and zinc while the manganese and copper values were close to the higher end of the range found in bovine milk (Ling *et al. 1961).*

Paper electrophoresis studies of the soluble protein fraction of giraffe milk showed it to be of a complex nature with both globulins and albumins present (Aschaffenburg *et al.* 1962). The present work confirmed their findings. However, as only a small subsample was examined the effect of globulins on total solids could not be ascertained.

The difference in composition of giraffe milk could not be explained on the basis of seasonal nutritional deficiencies. Only one sample (no. 11 in Table 2) was collected in the dry season (19th July) and had a particularly low lactose content and high protein. Whether this was due to a seasonal effect of diet or a diseased udder could not be determined. Abnormally low lactose and high protein values are indicative of mastitic infections in dairy cattle (Ling *et al.* 1961). Sample 3, (Table 2) also showed these characteristics. Age of the females was also not obviously related to milk composition, the youngest female (no. 5) was 7 years old and the two oldest (nos. 9 & 12) were both 11 years old. There are, however, indications of individual differences such as in an animal 9 years old (no. 9, Table 3) which was particularly low in most minerals and trace elements.

The estimated 600 ml udder contents of a captive giraffe on the 150th day of lactation (Aschaffenburg *et al.* 1962) falls well within the range of volumes collected during the present study. If it can be assumed that giraffe provide 500 - 2000 ml of milk per suckling bout, which the available data suggests is likely, then, because giraffe (in captivity) suckle about once every 5 hours (Dagg 1970), the yield of milk per 24 hour period might fall in the range of 2,5 to 10 litres. However the method of collection did not allow the ejection of milk from the alveoli and small milk ducts through the milk ejection reflex. The milk obtained probably, therefore, gives an underestimate of the udder contents. The closest living relatives of the giraffids are the cervids, with whom a common ancestor is shared (Colbert 1961). It is interesting therefore to note that the only cervid which approaches the giraffe in body mass, the elk (Europe) or moose (America) *Alces alces* produces milk yields of 2 to 6 litres per day (Yazan and Knorre 1964). In the much smaller red deer, Bubenik (1965) estimated milk yields of 3 to 4,5 litres per day.

ACKNOWLEDGEMENTS

We are grateful to the owners of the Timbavati and Sandringham Private Nature Reserves for allowing us to collect material for this study. One of us, A.J. H-M is also indebted to the University of Pretoria and the Council for Scientific and Industrial Research of South Africa for financial support. We also wish to thank the Nature Conservation Division of the Transvaal for funding aspects of this work through the Mammal Research Institute. We thank Mr. M.C. Laker and Prof D.R. Osterhoff for technical assistance with the milk analyses.

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Received 10 January 1977
Revised 4 April 1977