Mammalian Biology
Zeitschrift für Säugetierkunde
www.elsevier.de/mambio

SHORT COMMUNICATION

Milk composition of a free-ranging white rhinoceros (*Ceratotherium simum*) during late lactation

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Received 19 December 2006; accepted 19 June 2007

Keywords: White rhinoceros; *Ceratotherium simum*; Milk; Protein; Fatty acid

The study of the detailed composition of milk is mainly limited to the few commercially exploited animals such as the cow (*Bos taurus*), sheep (*Ovis aries*), goat (*Capra hircus*), camel (*Camelus bactrianus*), water buffalo (*Buabalus bubalis*) and yak (*Bos grunniens*) (Jennes and Patton 1976; Oftedal 1984; Park and Haenlein 2004). For most other animals, the information is limited to the content of the major nutrients which are not studied in more detail (Landete-Castillejos et al. 2000; Gjøstein et al. 2004). Regarding the pachyderms, milk of the African elephant (*Loxodonta africana*) has been studied in great detail (McCullagh and Widdowson 1970; Osthoff et al. 2005) as well as the oligosaccharides of the milk of the Asian elephant (*Elephas maximus*) (Kunz et al. 1999; Uemura et al. 2006). Regarding the *Rhinocerotidae*, three studies have led to a good accumulation of data on the milk of the Indian rhinoceros (*Rhinoceros unicornis*) (Klos et al. 1972, 1974; Nath et al. 1993), while only the proximate composition has been reported for the milk of the white rhinoceros (*Ceratotherium simum*) (Wallach 1969; Mathews 1973) and proximate and mineral composition for the black rhinoceros (*Diceros bicornis*) (Gregory et al. 1965). The milk of these animals were characterized by a low total solids content of 81–168 g/kg, consisting of 2–19 g/kg fat, 2–120 g/kg protein and 55–84 g/kg lactose. The fatty acid composition of the milk fat of the Indian rhinoceros was characterized by a high content of capric acid, 180–360 g/kg, which is more than the 84 g/kg found in goat milk (Park and Haenlein 2006), and only surpassed by the milk of the elephant, which may contain 350–700 g/kg, depending on the state of lactation (McCullagh and Widdowson 1970; Osthoff et al. 2005). Since only fragmentary data is available on the milk composition of the white rhinoceros we took the opportunity to carry out a detailed analysis when milk of a free ranging animal was available.

Milk was obtained from a white rhinoceros cow of the Lutopi Game Ranch in the Mica district of Hoedspruit, South Africa in July 2006. This animal was free ranging, but feed was supplemented during the dry wintertime with lucern. The calf was approximately 16 months old, which is an age close to weaning (Smithers 1983). The mother animal had to be tranquilized to treat a wound and no milk-letting agent was administered.

The same basic procedures used by Osthoff et al. (2005) to analyse the milk of an African elephant (*Loxodonta africana*) regarding the fractionation, determination and electrophoresis of proteins, lipid determination and gas chromatography of fatty acids and carbohydrate analysis by HPLC. Minerals were analysed by ashing the milk and quantification by atomic absorption spectroscopy according to IDF Standards 154 (1992) and 156A (2000) (International Dairy Federation Standard 1992, 2000).

The proximate analysis of the milk of the white rhinoceros cow is shown in Table 1, the fatty acid composition of the fat fraction of these milk samples in Table 2, and mineral composition in Table 3. The NPN

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1616-5047/$ - see front matter
doi:10.1016/j.mambio.2007.06.005

Table 1. Proximate analysis (g/kg milk) of the milk of a white rhinoceros (*Ceratotherium simum*)

Nutrient	
Water	922.5
Fat	7.4
Fat-free dry matter	70.1
Protein	16.2
Casein	2.9
Whey	13.3
NPN	0.3
Lactose	75.5
Glucose	
Galactose	
Fucose	
Oligosaccharide	0.5

Table 2. Fatty acid composition (g/kg milk fat) of the milk of a white rhinoceros (*Ceratotherium simum*)

FAME (g/kg milk fat)		
Common name	Abbreviation	
Caprylic	C8:0	29.7
Capric	C10:0	255.2
Lauric	C12:0	165.2
Myristic	C14:0	95.7
Pentadecylic	C15:0	3.5
Palmitic	C16:0	157.5
Palmitoleic	C16:1c9	11.6
Margaric	C17:0	4.6
Stearic acid	C18:0	88.6
Oleic	C18:1c9	85.6
Linoleic	C18:2c9,12 ($n-6$)	37.1
Arachidic	C20:0	4.0
α-Linolenic	C18:3c9,12,15 ($n-3$)	24.8
Nervonic	C24:1c15	7.6
Saturated fatty acids		803.7
Monounsaturated fatty acids		104.8
Polyunsaturated fatty acids		61.9
Omega-3 fatty acids		24.8
Omega-6 fatty acids		37.1

ND: not detected, although reported in milk of other animals.

Table 3. Mineral composition (mg/kg milk) of the milk of a white rhinoceros (*Ceratotherium simum*)

Mineral	
Ca	608.01
P	272.89
K	60.80
Mg	76.90
Na	177.04
Cu	0.41
Fe	0.93
Zn	7.33
Mn	0.18
Pb	0.05
Cr	0.01
Cd	0.002
Al	1.91

of 0.3 g/kg made up 10.6% of the total nitrogen (Table 1). The total protein content of the white rhinoceros milk was 16.2 g/kg, consisting of 2.9 g/kg whey proteins and 13.3 g/kg casein. The whey to casein ratio is therefore 1:4.7. The protein content is comparable with the 19 g/kg protein reported for an Indian rhinoceros at 15 months lactation (Klos et al. 1974), 11.8 g/kg for a white rhinoceros at 18 months lactation and 14 g/kg for a black rhinoceros of unknown lactation time. At earlier stages of lactation Klos et al. (1972) reported 120 g/kg protein in colostrums which decreased to 17.5 g/kg after 12 weeks of lactation in the Indian Rhinoceros, while Mathews has reported 73.4 g/kg protein in the colostrums of a white rhinoceros. Nath et al. (1993) also reported a higher protein content of 76 g/kg in the milk of an Indian rhinoceros in early, i.e. 30–44 days, lactation. At this stage the milk proteins were divided into 1.39 g/kg casein and 1.00 g/kg whey proteins, giving a whey to casein ratio of 1:1.4. This is lower than the 1:4.7 in the current report, however, it is known from studies in other single stomach animals, such as the pig, that the casein content increases over the lactation time (Csapó et al. 1996).

The protein bands observed in the electrophoretograms of the white rhinoceros milk (Fig. 1) showed a similar sequence of migration as the proteins from cow's milk, but at different distances. It also resembles the electorphoresis pattern of Indian rhinoceros milk by Nath et al. (1993). The close resemblance of migratory pattern of the α-caseins *Cs* (*Cs* as abbreviation for *Ceratotherium simum*), of the white rhinoceros milk, with that of the bovine milk would suggest similar charges and molecular sizes. The β-caseins *Cs* migrated slower, indicating a less negative charge, while the, γ- and κ-caseins *Cs* migrated distances closer to those of the cow's milk. Only two low-molecular-weight whey protein bands are clearly visible, probably the equivalents of α-lactalbumin and β-lactoglobulin, which is an indication of late lactation milk, where high amounts of immunoglobulins are absent.

While the milk protein content of the white rhinoceros milk was comparable with that of the other rhinoceros types that have been studied to date, the fat content seems to be unique (Table 1). The fat content was found to be 7.4 g/kg milk, which is comparable with 6 g/kg reported by Wallach (1969), but much lower than the 20 g/kg in Indian rhinoceros milk at 15 month lactation (Klos et al. 1974). At earlier stages of lactation the fat

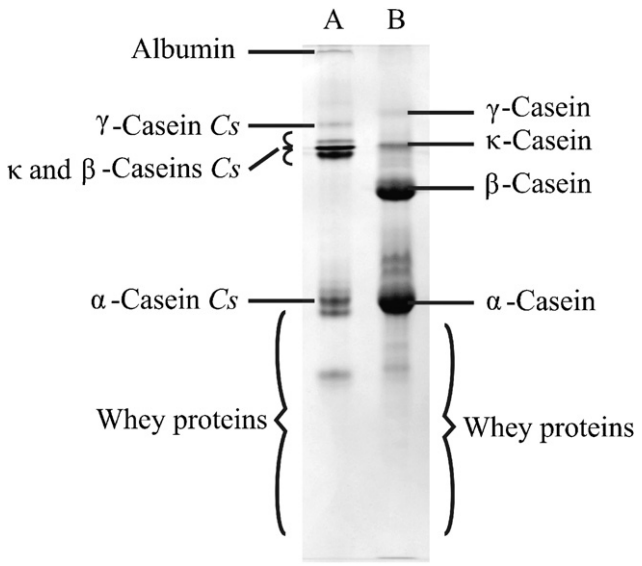

Fig. 1. Electrophoretograms of white rhinoceros (*Ceratotherium simum*) milk (lane A) and bovine milk as reference (lane B).

content in the Indian rhinoceros milk was 150–190 g/kg (Klos et al. 1972), while in the white rhinoceros 17.3 g/kg and the black rhinoceros 20 g/kg was reported. A compilation of these data would therefore suggest that the fat content of milk decreases over the progression of lactation, as is the case with other animals (Whittlestone 1953; Voutsinas et al. 1990), and also that the milk of the African rhinoceros species have a lower fat content. The latter conclusion was already drawn by Nath et al. (1993) regarding the milk of the black rhinoceros.

The lipid fraction of white rhinoceros milk (Table 2) contains a relatively small number of fatty acid types. Of approximately 35 types, only 14 were detected in this study. Fatty acids that have been detected in milk fats of other sources, but not in the white rhinoceros milk under study were butyric (C4:0), caproic (C6:0), hendecanoic (C11:0), tridecoic (C13:0), myristoleic (C14:1c9), heptadecenoic (C17:1c10), elaidic (C18:1t9), nonadecanoic (C19:0), linolelaidic (C18:2t9,12), eicosenoic (C20:1c11), γ-linolenic (C18:3c6,9,12), heneicosanoic (C21:0), eicosadienoic (C20:2c11,14), behenic (C22:0), eicosatrienoic (C20:3c11,14,17), eicosatrienoic (C20:3c8,11,14), arachidonic (C20:4c5,8,11,14), docosadienoic (C22:2c13,16), eicosopentaenoic (C20:5c5,8,11,14,17), lignoceric (C24:0) and docosahexanoic (C22:6c4,7,10,13,16,19).

The milk fat is characterized by high amounts of saturated fatty acids at 603.7 g/kg milk fat, and 104.8 and 61.9 g/kg monounsaturated and polyunsaturated fatty acids, respectively. A great variation of the capric acid content in the milk of the Indian rhinoceros from 180 to 360 g/kg was shown at various stages of lactation (Klos et al. 1974), but the amounts are in the same order of magnitude as the 225.2 g/kg found in the white rhinoceros. All other fatty acids showed the same comparison, except for lauric acid, where the white rhinoceros milk with 165.2 g/kg milk fat contains twice as much as the Indian rhinoceros with 42–80 g/kg. While small amounts of C10:1, C12:1, C16:3 and C26 were found in the milk of the Indian rhinoceros (Klos et al. 1972, 1974), none were detected in that of the white rhinoceros. To draw conclusions regarding species specificity of fatty acid contents, more studies of the fatty acid composition have to be done.

The lactose content of 75.5 g/kg in white rhinoceros milk is comparable with the 68.5 and 66.0 g/kg reported for white and black rhinoceros respectively, and 55–84 g/kg for the Indian rhinoceros. Unfortunately the lactose content of the white rhinoceros (Mathews 1973) and Indian rhinoceros (Klos et al. 1972) at early lactation was not reported, so that no conclusion on its dynamic change can be derived for the separate species. However, a collective comparison over the three species suggests that the lactose content is decreasing over the lactation time, which is in agreement with that of other single stomach animals such as the pig (Csapó et al. 1996) and elephant (McCullagh and Widdowson 1970). Besides lactose, small amounts, 0.5 g/kg, of oligosaccharides were found in the milk of the white rhinoceros, which is in the same order of that found in milks of ruminants such as the cow (Urashima et al. 1991; Mc Jarrow and Amelsfort-Schoonbeek 2004), goat (Viverge et al. 1997), and water buffalo (Saksena et al. 1999).

Regarding the mineral content of white rhinoceros milk (Table 3), the sodium content of 177.0 mg/kg is in the same order of magnitude as the 160–280 mg/kg reported for milk of the Indian rhinoceros from 44 days to 15 months lactation (Klos et al. 1972, 1974; Nath et al. 1993), as is the 608.0 mg/kg calcium with 590–1070 mg/kg and the 272.9 mg/kg phosphorous with 200 mg/kg. However, the potassium content of 60.8 mg/kg is 10 times lower than the 610–1250 mg/kg reported in the other milks. The content of the other minerals listed in Table 2 cannot be compared with the literature, as none were reported.

The current report does not only add data to the milk composition of the white rhinoceros, but also to the Rhinocerotidae as a group. The accumulated data on rhinoceros milk to date would suggest that the milk of the African rhinoceros species has a lower fat content than the Asian cousins, and that lactose is the major source of energy.

Acknowledgements

The authors acknowledge the contribution of Mrs. Eileen Roodt for the lipid extractions. Special words of thanks are directed at Lutopi Game Ranch for donating the milk and Dr. Peter Rodgers of Wildlife

Services for his veterinary expertise and drawing of the milk sample.

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