

A PRELIMINARY EVALUATION OF A HAND-REARING FORMULA FOR SOUTHERN WHITE RHINOCEROS (*Ceratotherium simum simum*) CALVES

Katherine Mertes, BS¹, Michael L. Schlegel, PhD, PAS^{1,2}, Alejandra Renjifo BS¹, and Eduardo V. Valdes, PhD^{1*}

¹Disney's Animal Kingdom, PO Box 10000, Lake Buena Vista, FL 32830 USA and
²Department of Animal Sciences, University of Florida, Gainesville, FL 32611, USA

Abstract

Exotic neonates may be hand-raised in captivity for various reasons. Records and evaluations of these hand-rearing efforts, the protocols used to achieve typical species growth and behavior, and data on the composition of mother's milk, are needed to increase the success of hand-rearing a number of exotic species, including the southern white rhinoceros (*Ceratotherium simum simum*). Disney's Animal Kingdom (DAK) has successfully parent-reared four *C. s. simum* calves. The acquisition of a female *C. s. simum* calf (HR) for hand-rearing in early January 2005 offered an opportunity to evaluate the institution's hand-rearing protocol, adapted from the literature and previous experiences with rhinoceros calves in the DAK collection. The birth of a second-generation dam-reared *C. s. simum* calf (DR) on March 2, 2005, enabled detailed comparisons between two similarly-aged calves concurrently housed and cared for, and the collection of contemporary samples of *C. s. simum* milk for nutritional analysis. Animal keepers recorded body weight, formula consumption, feeding response, urine and fecal production, stool consistency and general behaviors of calf HR and body weights and general behavior of calf DR. Calf HR exhibited greater body weight and daily gains to those of DAK dam-reared *C. s. simum* calves and calf DR, and far greater than those of hand-reared *C. s. simum* calves in the literature. Although total solids, fat, and protein of milk from the dam of calf DR (Total solids, 9.23%; fat, 7.3% of DM; protein 16.1% of DM; and sugar, 42.3% of DM) were similar to previous reports, sugar was lower. The hand-rearing protocol used resulted in a healthy calf; however, increased daily weight gains suggest that a more dilute formula may be a necessary modification to the protocol.

Introduction

Exotic neonates may be hand-raised in captivity for various reasons. Records and evaluations of these hand-rearing efforts, the protocols used to achieve typical species growth and behavior, and data on the composition of dam's milk, are needed to increase the success of hand-rearing a number of exotic species.¹² Although much international interest and conservation planning have been focused on the Southern white rhinoceros (*Ceratotherium simum simum*), data on the species remain lacking in several key areas. Records of hand-rearing efforts and calf growth rates are needed, both to increase the understanding of rhinoceros biology⁵ and to provide current examples of hand-raising protocols to zoological institutions that may find it necessary to hand-rear rhinoceros calves. Data on the physiological response of *C. s. simum* calves to various milk replacers are particularly needed, as selecting and formulating an appropriate milk replacer can be one of the more challenging aspects of hand-rearing exotic young.⁵ This is especially true for *C. s. simum*, because dam's milk has not been analyzed extensively or recently, and in cases

where nutritional values have been published, lactation periods have been unspecific, multiple periods have been mixed, or sample sizes were small.^{8,14} Milk composition is typically similar in phylogenetically close species.¹¹ White rhinoceros milk is high in carbohydrates and low in protein and fat; however, it is more dilute than other ungulates' milk,⁵ and appears to differ from its biomodel, the domestic horse. A white rhinoceros milk replacer should reflect these differences, while matching available data for dam's milk as closely as possible.

Disney's Animal Kingdom (DAK) adapted a protocol for hand-rearing *C. s. simum* calves from available literature^{3,14} and from previous experience with the DAK animal collection. Zoologic Milk Matrix 20/14 (PetAg, Hampshire, Illinois; detailed nutritional information available at www.PetAg.com) was selected as the milk replacer. Manufacturer's directions recommend a formula made up of 8.6% solids but a formula of 11.35% solids was used, following the protocol by Blakeslee and Zuba (Table 1).³

From 1999 – 2001, DAK successfully birthed and parent-reared four *C. s. simum* calves. Body weights, behaviors, and general body condition were recorded, providing a comparison for any hand-reared individuals. A second-generation dam-reared calf (DR) born at DAK on March 2, 2005, offered excellent opportunities for gathering additional data on *C. s. simum* calf growth, as well as collecting milk samples from its dam. This case study evaluated the effectiveness of a hand-rearing protocol for white rhinoceros calves by comparing growth rates to parent-reared calves.

Methods

On January 15, 2005, DAK (Lake Buena Vista, Florida) received a female southern white rhinoceros calf, aged 48 d and weighing 114 kg, from Peace River Refuge (Arcadia, Florida). This calf (HR) was transferred to DAK for hand-rearing after its dam died of unknown causes.

Management

All hand-reared animals at DAK are treated so as to limit their imprinting on humans. Detailed daily data sheets to track body weight, formula consumption, feeding response, urine and fecal production (including stool consistency, which may be an indicator of formula digestibility), and general behaviors were recorded for calf HR. From arrival at DAK to 110-d old, calf HR was housed in a location separate from other animals, except for the 36-d trial period of a companion domestic goat, where it was possible to make extremely detailed observations and give specific care. From d 110 on, calf HR was housed in the general DAK *C. s. simum* location, for introduction to other rhinoceros and exposure to gastrointestinal microflora. Milk formula was prepared using warm tap water (Table 1) and was offered in a large rubber bowl. Following the hand-rearing protocol developed, bermudagrass hay (*Cynodon dactylon*) and water were offered *ad libitum*, with additional solid food items such as Calf Manna (Pro Manna Corporation, Chesterfield, MO), DAK High-fiber pellets (PMI Nutrition International, LLC., Brentwood, MO 63144), and timothy-alfalfa cubes (Stampede, Hay Exchange, Plant City, FL 33563) offered after 3 mo of age.

Calf DR (born March 2, 2005) was housed in the same holding area, and cared for by the same team of DAK animal keepers, as calf HR. Records of body weight and general body condition for this calf, as well as data collected during the preweaning period for *C. s. simum* calves previously parent-raised at DAK, were used as comparison material for calf HR.

Milk Collection

Milk samples were collected by DAK animal keepers at various times of day. To milk the dam of calf DR, the female was requested to station against the ballards of the pen. To maintain stationing, it was fed by a keeper, while a second keeper milked the rhinoceros, collecting milk from both teats (volume varied from 5 – 30 mL). During the milking, the calf was distracted by a third keeper. Samples were frozen (-26°C) and stored until analyzed (DairyOne, Ithaca, NY 14850) for total solids, protein, fat, and sugar content.

Energy Requirements

Metabolizable energy (ME) requirements for maintenance and growth of calves HR and DR were estimated based on equations in Robbins.¹³

$$ME_{\text{maintenance}} \text{ (kcal/d)} = 141.4 \times W^{0.75}$$

$$ME_{\text{growth}} \text{ (kcal/d)} = 2000 \times \text{ADG}$$

Where W is the weight of the animal (kg) and ADG is the average daily gain (kg/d). For this publication, to calculate average monthly body weight, average daily gain and intake, 1 mo = 28 d. Estimated ME intake was determined using the ME energy content of the formula (3.77 kcal/g, manufacturer literature) multiplied by the dry matter intake of the formula (11.35% solids).

Results and Discussion

C. s. simum milk composition

Because milk composition is typically similar in phylogenetically close species¹¹, available data on the nutritional composition of black rhinoceros (*Diceros bicornis*)^{6,7} and Indian rhinoceros (*Rhinoceros unicornis*)¹⁰ milks are also presented for comparison. The rhinoceros milk from the dam of calf DR was similar in total solids, fat, and protein of those previously published for *C. s. simum* (Table 2) but the sugar was less than determined for other rhinoceros samples analyzed. Although Zoologic Milk Matrix 20/14 is one of the recommended milk replacers for hand-rearing *C. s. simum* calves, it appears to be higher in fat and protein and lower in sugar than the average of the rhinoceros milk samples analyzed.

Body weight gain and formula intake

A summary of weight gain, formula intake, and estimated energy requirements are presented in Table 3. Calf HR consumed 11.4 – 15.1% of its body weight in formula. This is slightly lower

than the range described by Blakeslee and Zuba.³ Although, the calf did not consume the quantity of formula suggested, the increased percent solids fed (11.35 vs 8.6%) compensated for the lower intakes.

Body weight of calf HR is shown in Figure 1, along with daily weight change, which ranged from +9.07 to -5.22 kg/d, with an overall ADG of 1.97 kg/d (d 48 to d181). This range in daily weight gain is as variable as documented by Blakeslee and Zuba³ (0.4 - 3.0 kg/d).^{3,8} Predicted growth rate¹³ based on an 1800 – 2000 kg adult weight would be 2.12 – 2.28 kg/d [ADG = 0.0766 x (adult weight, g)^{0.75}]. Compared to other white rhinoceros calves, calf HR had a greater ADG than the current parent-reared calf DR (1.39 kg/d, d 8 to 128), previous DAK parent-reared calves (0.53 - 1.59 kg/d, Figure 2), and hand-reared calves from the literature (0.23 - 1.4 kg/d).^{1-4,8} The greater growth rate observed in calf HR will need to be monitored to ensure no medical problems develop and suggests that the total solids of the formula could be decreased to slow the growth rate. Based on the current protocol, at 6 mo of age, the formula quantity offered will stop being increased to match consumption and the total solid content of the formula will begin to decrease resulting in an energy deficit to stimulate greater solid food consumption as the weaning process begins.

The formula selected for use by DAK appears to have been successful in raising a *C. s. simum* calf of typical size and growth rate. The presence of calf DR allowed a closer comparison between similarly-housed parent- and hand-reared calves during which time body weights, general behaviors and ADG could be compared. In addition, it allowed comparing basic nutritional composition of the selected hand-rearing formula to *C. s. simum* milk.

Hand-rearing of neonates in zoological institutions may be necessary for any number of reasons. The establishment of solid, proven hand-rearing protocols, especially including a milk replacer or formula similar in nutritional composition to dam's milk, is important to ensure the survival of hand-reared infants. While data on the hand-rearing of *C. s. simum* are available in the literature,^{1-4,7,14} additions to this body of knowledge may be useful to zoological institutions attempting hand-rearing; and inclusion of one calf's response to a specific milk replacer and feeding regime may assist these institutions in selecting their own formula and schedule.

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Table 1. Formula mixing directions for a white rhinoceros (*Ceratotherium simum simum*) hand-rearing protocol used at Disney’s Animal Kingdom.^a

Animal age	Formula, g per 1000 g			Total solids, %	Feedings/Interval
	Colostrum	Milk Matrix 20/14 ^b	Water		
d 1 ^{c,d}	1000	0	0	--	7 times / 2 h
d 2 ^{c,d}	500	58	442	--	7 times / 2 h
d 3 to 1 mo ^{c,d,e}	100	105	795	--	7 times / 2 h
1 – 3.5 mo	0	117	883	11.7	5 times / 3 h
3.5 – 6 mo	0	114	886	11.4	4 times
6 – 9 mo ^f	0	111	889	11.1	3 times
9 – 12 mo	0	109	891	10.9	3 times
12-15 mo	0	104	896	10.4	2 times
15 – 16 mo	0	99	901	9.9	2 times

^aAdapted from the protocol of Blakeslee and Zuba, 2002.

^bPetAg, Hampshire, Illinois 60140.

^cFor the first 3 days, feed formula at 10% of body weight.

^dFeed no more than 80% of stomach capacity (kg) at a feeding (stomach capacity = 0.05 x body weight, kg).

^eAfter the third day, feed formula at 15 – 20% of body weight.

[†]After 6 mo of age, feed a constant amount of formula (~ 11 kg per feeding) until weaning begins at 1 yr of age.

Table 2. Nutrient composition of rhinoceros milk replacer and rhinoceros milk.

Sample Origin, (sample size)	Stage of Lactation, age of calf, days	Total Solids, %	Fat, %		Protein, %		Sugar, %	
			As-fed	DM	As-fed	DM	As-fed	DM
Zoologic Milk Matrix 20/14	--	93.2	13.6	14.6	19.9	21.3	42.6	45.6
<i>Ceratotherium simum simum</i>								
Mathews, 1973 (n = 1)	1	14.2	1.7	12.1	7.3	51.6	ND ^b	ND
DAK ^a (n = 3)	20 – 44	9.2	0.6	6.1	1.5	16.4	ND	ND
DAK ^a (n = 1)	49 – 55	9.3	1.0	10.9	1.4	15.0	3.9	42.3
Wallach, 1969 (n = 1)	150	8.8	0.6	6.8	1.5	17.4	6.5	73.5
Wallach, 1969 (n = 1)	540	8.3	trace	--	1.2	14.3	6.1	82.9
<i>Diceros bicornis</i>								
Gregory et al., 1965 (n=1)	14	9.3	ND	ND	2.3	24.4	5.8	63.1
Gregory et al., 1965 (n=13)	30-480	8.8	0.2	2.3	1.4	15.9	6.6	75.0
Greed, 1960 (n = 1)	570	8.1	trace	--	1.5	19.0	6.1	74.8
<i>Rhinoceros unicornis</i>								
Nath et al., 1993 (n = 3)	30 - 44	9.8	1.4	14.5	1.4	14.4	7.6	78.8

^aDisney's Animal Kingdom.^bNot determined.

Table 3. Average monthly body weight, average daily gain, and formula intake of hand-reared (HR) and dam-reared (DR) white rhinoceros (*Ceratotherium simum simum*) calves.

Calf	Age, mo ^a	Monthly average			Metabolizable energy requirement, kcal/d			Consumed ME, kcal/d ^e
		Weight, kg	Gain, kg/d	Formula intake, kg as-fed/d ^b	Maintenance ^c	Growth ^d	Total	
HR	1	--	--	--	--	--	--	--
	2 ^f	123.7	1.67	15.5 (12.5%) ^g	5244	2833	8077	6638
	3	152.3	2.15	23.0 (15.1%)	6131	3659	9790	9846
	4	207.1	1.88	25.1 (12.1%)	7719	3204	10923	10741
	5	265.5	2.08	32.6 (12.3%)	9300	3536	12836	13928
	6	333.4	2.18	37.9 (11.4%)	11032	3702	14734	16222
DR	1	81.2	1.47	--	3824	2499	6323	--
	2	114.6	1.88	--	4953	3196	8149	--
	3	145.6	1.66	--	5925	2822	8747	--
	4	204.8	1.54	--	7655	2618	10273	--
	5	224.8	0.76	--	8207	1292	9500	--

^a1 mo = 28 d.

^b11.35% solids.

^cMetabolizable energy for maintenance, kcal/d = 141.4 x (BW, kg)^{0.75} (Robbins, 1993).

^dMetabolizable energy for gain, kcal/d = 2000 x (ADG, kg) (Robbins, 1993).

^eFormula 3.77 kcal/g.

^fAverage of d 48 – 56.

^gFormula consumed as a percent of body weight.

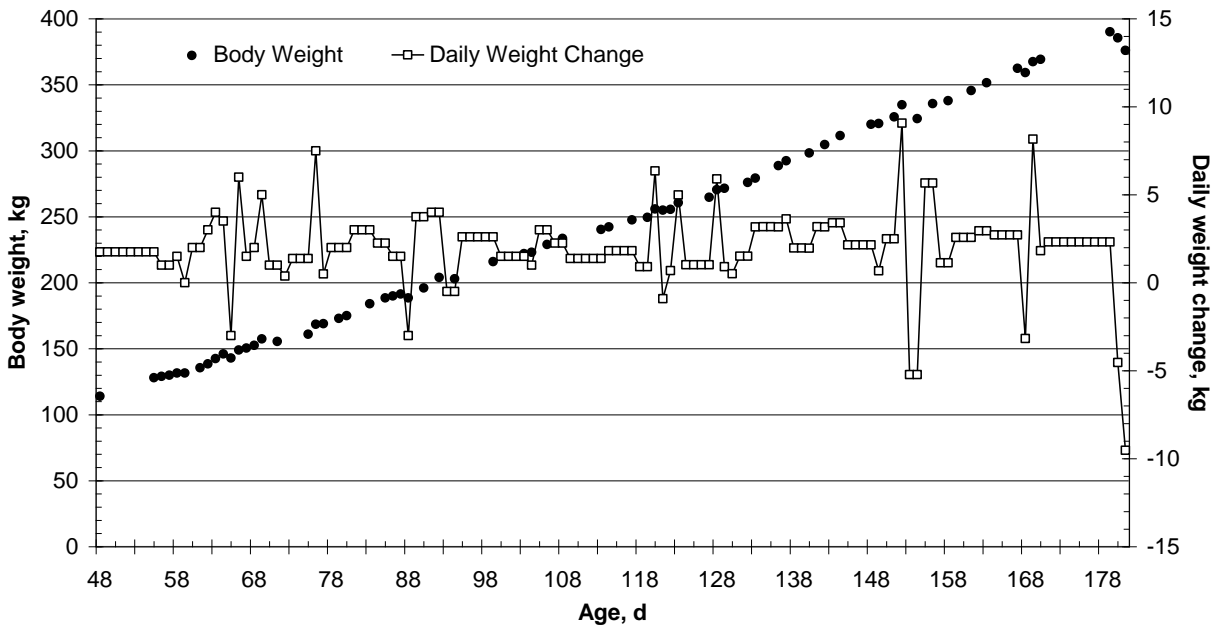


Figure 1. Body weight and daily weight change of white rhinoceros (*Ceratotherium simum simum*) calf HR hand-reared at Disney's Animal Kingdom.

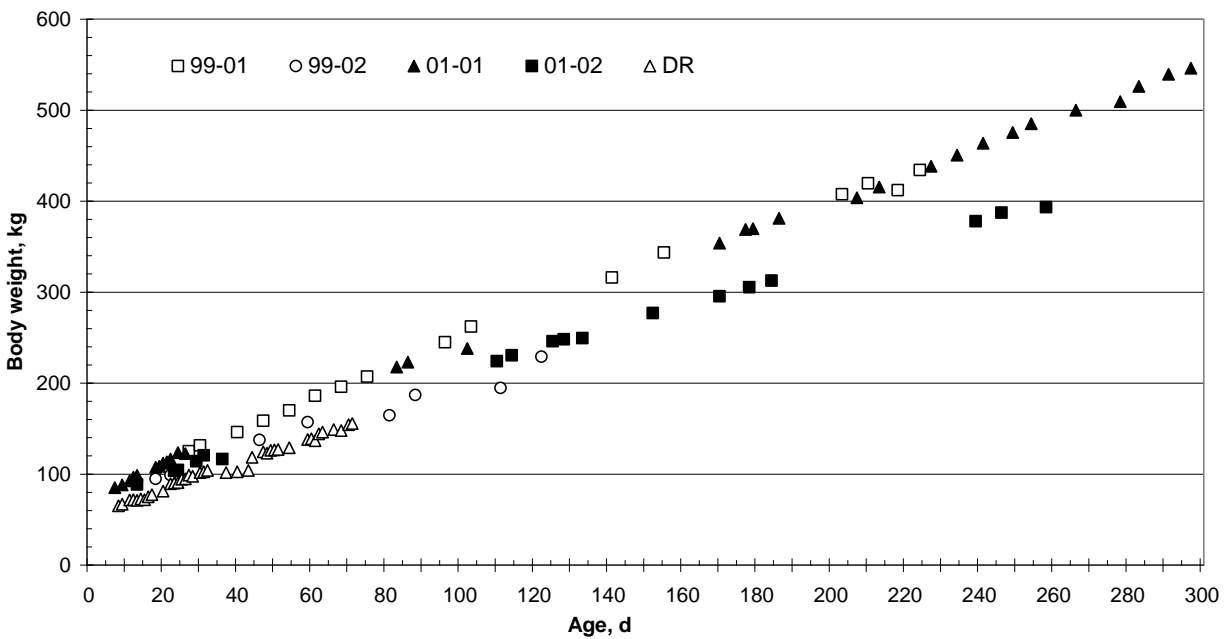


Figure 2. Body weights of dam-reared white rhinoceros (*Ceratotherium simum simum*) calves (females, open symbols, males, closed symbols) at Disney's Animal Kingdom.