EVALUATION OF A HAND-REARING FORMULA FOR GREATER INDIAN RHINOCEROS *(RHINOCEROS UNICORNIS)*

Michele Gaffney, MS* and Michael L. Schlegel, PhD, PAS

Nutritional Services, San Diego Zoo and San Diego Zoo Safari Park, San Diego, CA 92112

ABSTRACT

Since opening in May 1972, the San Diego Zoo Safari Park (historically known as the San Diego Wild Animal Park) has hand-raised a number of rhinoceros calves, including southern white (*Ceratotherium simum simum*), black (*Diceros bicornis michaeli*) and greater Indian (*Rhinoceros unicornis*). In order to improve success rates and generate appropriate protocols with any hand-reared neonate species, it is important to document each animal's daily status and changes implemented to husbandry practices with each experience. Milk formula composition and consumption, solid food intake, body weights, and fecal output and consistency are all closely monitored by animal care staff.

Rhinoceros milk is more dilute compared to other ungulate species. It is low in solids and proteins, very low in fat and high in sugar (Oftedal, 1984; Robbins, 1993). Greater Indian rhinoceros samples collected from one animal during mid-lactation at 30, 37, and 44 days post-partum contained 9.81% total solids (TS); 14.2% crude protein (CP); 14.2% fat, and 77.5% lactose, on a dry matter basis (DMB) (Oftedal, 1984). A blend of fresh non- and low-fat cow's milk is suitable to use as a replacement for rhino milk. Lactose (powdered, edible grade) is added to the formula to increase the milk sugar content, and because cow's milk is low in iron, a liquid iron supplement (Vi-sorbin or Lixotinic, Pfizer Animal health, New York, NY 10017) was added. For the white and black rhino calves that have been hand-raised previously, during the first 3.5 months, the formula is composed of 29 parts non-fat cow's milk, 9 parts low-fat cow's milk, 1 part lactose, and 1 part water (NFC:LFC:Lactose:Water 29:9:1:1) by weight (Blakeslee and Zuba, 2002). Nutrient composition of the fore-mentioned formula is 11.39% TS; 28.1% CP; 2.6% fat; and 49.4% lactose, on a DMB. (Wagner and Edwards, 2001) compared to findings from Nath et al. (1993) (study, the hand-raised calves' milk formula is higher in solids, and lower in crude protein, fat, and lactose, on a DMB. To approximate changes in milk composition observed in rhinoceros during early, mid- and late-lactation, (Oftedal, 1984) the water portion in the formula is increased at specific points during the hand-rearing process (Wagner and Edwards, 2001). The result is lower percent solids, without major changes to the remaining major nutrients; total solids gradually decrease from 11.39% (birth to 3.5 months) to 9.62% (15 months to weaning at approximately 18 months). This paper summarized the effectiveness of a hand-rearing protocol developed for black and white rhinoceros with four greater Indian rhinoceros born at the San Diego Zoo Safari Park between 28-Nov-01 and 21-Dec-08.

When the decision was made to hand-raise an animal, usually due to dam neglect or medical issues with the calf, each rhino calf was relocated from the exhibit to the Animal Care Center (ACC). The calf was first examined by the veterinary staff and received treatment for any medical problems, if necessary. Detailed records were kept on each animal, noting body weight, formula composition and intake, feeding frequency, urine output, and stool frequency and

quality. The calves remained at the ACC for the first 4 months (7 mo for Calf 1), and were then moved to a larger off exhibit yard. Solid foods were assessable to the calves starting at week 1. Food offered was low- (ADF 16) and high-fiber (ADF 16) herbivore pellets (Western Milling, Goshen, CA 93227 and Land O Lakes Purina, Turlock, CA 95380); Pro Pellet (milk replacer pellet) (Western Milling); Horse Ration (Western Milling) and Bermuda and Sudan grass hays.

Birth weights for Calves 2, 3 and 4 (71.9 kg, range = 68.6 to 74.5 kg) were higher than average, while Calf 1's birth weight was lower (52.4 kg) than average, compared to previous greater Indian rhinoceros birth weights (n = 3) from San Diego Zoo Safari Park records (65.4 kg, range = 63.0 to 68.2 kg), and as reported in Zschokke and Baur (2002) (68 kg) (Table 1). Average daily gain (ADG) for Calves 2, 3 and 4 was within the predicted range of 2.12 to 2.40 kg/d, however Calf 1's ADG was below the predicted range (Table 1), based on adult weights of 1800-2300 kg, (Zschokke and Baur, 2002) and the following prediction equation for growth [ADG, kg/d = 0.0766 x (adult weight, g)$^{0.71}$] (Robbins, 1993).

Formula intake (percent of body weight) during the first two months was within the range of 15-20% of body weight (BW), as suggested (Blakeslee and Zuba, 2002), for Calf 2, 3 and 4, but Calf 1's intake (11.0% of body weight) was below expected range. Following the first two months, average formula intake (% of BW) decreased monthly as animals met daily ME requirements with increase in solid food intake (Blakeslee and Zuba, 2002). Average formula intake (kg/d, as-fed) increased from 12.3-18.4 kg to 32.5-38.4 kg over the first approximatly six months; then all animals were maintained at a constant formula amount until weaning began, at approximately 12 months (Blakeslee and Zuba, 2002).

Metabolizable energy (ME) requirements for maintenance and growth of calves' was estimated based on equations in Robbins[4] for maintenance (ME (kcal/d) = 141.4 x W$^{0.75}$) and growth (ME (kcal/d) = 2000 x ADG). Hand-raising was divided into four 4-mo time periods. During the first 4 mo of age, calves consumed 107% of the estimated ME requirement from formula (Table 2). As the calves grew and formula intake reached its maximum at 6 mo of age, energy consumed from formula, as a percent of estimated requirement, decreased to 94% during months 5 to 8 and then to 67% and 47% for months 9 to 12 and 13 to 16, respectively.

Calf 1 had the lowest values for birth weight, ADG, consumed ME, and formula intake (% of BW). This may have been the result of chronic medical issues during hand-rearing. The other 3 calves were consistently near the expected or predicted birth weight, ADG, consumed ME, and formula intake (% of BW).

Hopefully, there will be few instances, in the future, necessitating the hand-raising of Greater Indian Rhinoceros. However, any opportunity will allow animal care staff to collect more information (milk formula composition and consumption, solid food intake, body weights, fecal output and consistency) and further improve hand-rearing successes with this species.

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Table 1. Animal identification, birth date, birth weight (kg) and average daily gain (kg) for hand-raised greater Indian rhinoceros (*Rhinoceros unicornis*) calves.

Animal ID	Birth Date	Birth Weight (kg)[a]	Average daily gain, kg[b,c]
Calf 1 "Choto"	28-Nov-01	52.4	1.43
Calf 2 "Echo"	7-Jan-05	75.2	2.15
Calf 3 "Khali"	24-Feb-06	72.6	2.12
Calf 4 "Ramir"	27-Dec-08	68.6	2.06

[a]Calves 1, 2 and 4: Day 0; Calf 3: Day 1.
[b]To calculate average monthly body weights, average daily gains (ADG) and intakes, 1 mo = 28 d.
[c]Mean of monthly average daily gain (ADG), Calf 1: 1-16 mo, Calf 2: 1-15 mo, Calf 3: 1-13 mo; Calf 4: 1-12 mo.

Table 2. Actual and average daily formula ME[a] intakes compared to estimated ME[a] requirement for four hand-raised greater Indian rhinoceros (*Rhinoceros unicornis*) calves.

Calf	Actual formula ME intakes, kcal[b]	Estimated daily ME requirement, kcal[b]
Period 1[c]		
Calf 1	8990	10103
Calf 2	12317	9552
Calf 3	12173	11255
Calf 4	12484	11887
Average	**11491**	**10699**
Period 2[c]		
Calf 1	14518	14493
Calf 2	15754	18156[d]
Calf 3	16714	17976[d]
Calf 4	17365	17585
Average	**16088**	**17053**
Period 3[c]		
Calf 1	11879	18938
Calf 3	12173	23758[d]
Calf 4	12484	11887[d]
Calf 2	16084	23892[d]
Average	**13155**	**19619**
Period 4[c]		
Calf 1	11719	19483
Calf 2	10837	28523[d]
Average	**11278**	**24003**

[a]Metabolizable energy.

[b]To calculate actual ME intakes and estimated ME requirement, 1 mo = 28 d.

[c]Period 1 = 1 to 4 mo; Period 2 = 5 to 8 mo; Period 3 = 9 to 12 mo; and Period 4 = 13-16 mo.

[d]Estimated ME requirement calculated assuming theoretical average daily gain of 2.28 kg/d when daily weight not recorded.