THE NUTRITION AND GROWTH OF A HAND-REARED, LOW-BIRTHWEIGHT BLACK RHINOCEROS *Diceros bicornis* DURING HER FIRST SIX MONTHS

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INTRODUCTION

Hand-rearing is an important aspect of the management of small endangered populations maintained in captivity, especially in species which give birth to single young and which have long interbirth intervals. In these cases the survival or loss of a baby may have a large impact on the subsequent fortunes of the entire population. There are rather few accounts of hand-rearing black rhinoceroses (11) or of causes of juvenile mortality of these animals in captivity (12), and the technology not well-established.

Here we describe the management and performance of a full-term but low-birthweight female black rhino, born at the Zoological Society of London on 24th November 1988. This animal was taken for hand-rearing because she was too weak to stand to suck from her mother.

CASE HISTORY

Birth and the first 24 hours

The birth was not observed but occurred between 20.00 and 20.30 on the evening of the 24th November 1988. Discreet observation began immediately and the mother and baby were watched throughout the night. The baby wasobviously small, had great difficulty getting to its feet and her attempts to suck were increasingly feeble and completely unsuccessful. The next morning she was removed by pulling her out beneath the bars of the den, using a large wire hook attached to a long pole whilst distracting the mother.

She weighed 18 kg, was weak, and had a rectal temperature of less than 31°C. Her pulse rate was 90 and respiration rate 24. She was taken immediately to the Animal Hospital and her body temperature was raised gradually using heating pads and blankets.

By 16.00 her temperature was 36.6°C. She was given 200 ml of 10% glucose and 60 ml horse serum by stomach tube, one litre of 5% dextrose saline i.v (into the

medial carpal vein), and 1 ml each of amoxycillin (Clamoxyl), Beecham Animal Health) and a vitamin E and selenium preparation (Dystosel, Intervet UK Ltd) im. By 18.00 she was just able to stand and took quite readily to a bottle fitted with a horse teat. A mixture of 10% glucose and cow colostrum was given at 2-hourly intervals until the following day.

Milk formula

The milk of the black rhinoceros was found by Gregory et al (5) and Aschaffenburg et al (1) to be dilute (only 8.8% dry matter), of low energy density (0.35 kcal/ml), and to contain very little fat and relatively little protein compared with other species. The dry matter of the samples analysed comprised 2% fat, 16% protein and 75% lactose (5). Specialist Diet Services kindly agreed to prepare a formula based on these findings. In the meantime the human milk replacer Lactogen (Nestle) was chosen because its composition was not too dissimilar to rhino milk and because it has been fed to young black rhinos with some success (Jill Wooley, The David Sheldrick Wildlife Appeal, personal communication).

From the age of about 36 hrs feeds consisting of a mixture of 100 ml Lactogen (made up at 15% dry matter), 100 ml 10% glucose, and 30 mls cow colostrum were given at two-hourly intervals. The cow colostrum was replaced with 80 mls per feed of milk obtained manually without restraint from the mother the following day and for a further week, after which lactation ceased. The amount offered at each feed was gradually increased and the composition of the formula was gradually altered to more closely approximate that indicated by Gregory et al (5) by adding carefully weighed amounts of lactose, casein and lactalbumen. The frequency of feeds was gradually reduced to 5 each day by 3 months of age.

When the calf was 16 days old the new artificial rhino milk (Rhinomilk 1) was introduced. 27 g each of Rhinomilk 1 and 27 g of Lactogen were mixed and made up to a volume of 600 ml with water. Thereafter few changes were made to the milk formula. The concentration was increased cautiously upto 15% over a 2 month period, and the composition of the artificial rhino milk formula was adjusted slightly to increase its calcium, sodium and selenium content, and to increase the concentration of long-chain fatty acids (Rhinomilk 2). The composition of this formula which, mixed with an equal weight of lactogen, was the calf's staple diet through most of the first 6 months is shown in Table 1.

The plasma vitamin E concentration of captive black rhinos has been found to be considerably lower than that in wild individuals, and it has been suggested that this may be a factor in the aetiology of the haemolytic disease recognised in captive individuals (2,4). For this reason vitamin E was added to the 'Rhinomilk' formulae made by Specialist Diets Services to give the high concentration of 529 kg/kg dry powder.

Little solid food was offered prior to two months of age (when bodyweight reached 38 kg), but thereafter mixed fruit and vegetables and soon after a mixture of bran, oats, and browser breeder pellets (Specialist Diets Services Ltd) began to be eaten in increasing quantities. Water and clover hay were also available.

Bottle-feeding was on the whole straightforward but initially the calf was prone to 'blowing up' with swallowed air until experience with technique, teat size and milk flow rate was gained. Faeces were firm and pelleted throughout. There was some concern about constipation during the first 6 weeks since faeces were passed quite infrequently, sometimes at 48 hour intervals. On one or two occasions a Micralax enema (Smith Kline & French Laboratories Ltd) administered but the constipation was not a serious problem.

Energy intake and growth

The daily consumption of milk formula was recorded, and it was also possible to estimate the intake of solid food items. Regular checks of the nutrient composition of the total daily intake were made using the Animal Nutritionist software (N^2 Computing, Oregon).

The volume of milk replacer consumed daily increased from 2.3 litres at two days of age to about 5 litres at 17 days of age and thereafter gradually to 12 litres at 146 days of age (Fig 1). Upto this time, although solids were being eaten, most of the daily energy requirements had been provided by the milk (Fig 2). In order to encourage the intake of solid food the amount of milk offered began to be reduced from 150 days of age, so that by 190 days about 35% of the daily energy was from the solid food. Estimated metabolisable energy intake showed a gradual and approximately linear increase to 8.2 Mcal/d at 146 days of age (Fig 2). Per unit of metabolic weight ($kg^{0.75}$), estimated metabolisable energy intake averaged about 200 kcal/d during the first 50 days and thereafter increased to about 250 kcal/d (Fig 3).

The calf was weighed to the nearest 250 g each day during the early stages of growth and thereafter to the nearest kilogramme. Daily weight gain averaged close to 300 g/d throughout the first 50 days, but subsequently the growth curve steepened to a growth rate of just over 1 kg/d at about 140 days of age (Fig 4), when the calf weighed about 90 kg. There was a slight drop in rate of weight gain at about 150 to 160 days of age, associated with a drop in appetite for solid food. She remained very bright at this time and the cause was not established.

Immune status and disease problems

The immune status of the calf was a cause of concern. She had been unable to suck from her mother and although some cow colostrum and horse serum had been administered, it seemed likely that this was too late for satisfactory absorbtion of immunoglobulins. Furthermore the relevance of the immunoglobulins in cow colostrum and horse serum, both collected at other establishments, was in doubt. For these reasons amoxycillin was administered by intramuscular injection for 10 days after birth. Plasma globulin and total protein levels were found to be low during the first month (globulin 21-22 g/l, total protein 39-44 g/l).

Our strategy, in view of doubt about immune competence, was to keep the calf in a clean environment and to take care to make changes to her environment as gradual as possible. Her health was monitored closely and at first sign of possible infection antibiotics were administered. On two occasions during the first 6 weeks there were signs of reduction in appetite, slight depression, an increase in rectal temperature (from 37°C to 38.3°C), and a neutrophilia (14.35×10^9/l [neutrophils were subsequently in the $7\text{-}10 \times 10^9$/l range]) and raised fibrinogen

level (5.9 g/l [subsequently 1-3 g/l]). In one instance there was a suspicion of a navel infection and in the other of pneumonia. Fortunately in both instances response to antibiotics (first trimethoprim/sulphadiazine (Tribrissen, Coopers Animal Health), then cephalexin (Ceporex, Glaxovet Ltd) was prompt. Blood samples were taken from the superficial vein running across the medial aspect of the forelimb just proximal to the carpal joint whilst manually restraining the animal in lateral recumbency.

Subsequently, a litre of blood was collected from an unsedated adult male, housed in the same building, using citrate anticoagulant. From this 600 ml of plasma was prepared for iv infusion to provide immunoglobulins, should the need arise. However this plasma, which could not have been administered without sedation, was not used.

DISCUSSION

Birthweight

Dittrich (3) reported the birthweight of three male calves at 30, 38.5 and 45 kg. A female born at Detroit weighed 48.6 kg at 11 days and her birthweight was estimated to be 32 kg (11). A calf born at Los Angeles weighed 36 kg at 2 days old, and at Cincinatti Zoo a female weighed 37.2 kg at birth (11). From these records it appears that mean birthweight is about 35 kg. Our calf, weighing 18 kg at birth, was very light. However this was probably not due to premature birth as the birth occurred 500 days after mating had been observed, and Jones (9) in a review of the sparse literature on the subject, a mean gestation of 452 days with a range from 419 to 469 days.

Growth rate

The mother-reared calf studied by Dittrich(3) from 38.5 kg at birth to 80 kg at 39 days, and to 163 kg at 119 days. Growth throughout this period appeared to be linear and averaged 1.05 kg/d. Thereafter growth rate increased to about 1.25 kg/d, and the calf reached 205.5 kg at 153 days.

Hand-reared calves for which information is available have not done so well. The Detroit baby grew from 48.6 kg when taken for hand-rearing at 10 days of age, to only 55.9 kg at 120 days: an average of 66 g/d. The baby died. The female hand-reared at Cincinatti weighed 37.2 kg at birth, 72.7 kg at 42 days, and 227 kg at 365 days; an average of 0.52 kg/d (11). The growth of an Indian rhinoceros Rhinoceros unicornis calf averaged about 1.2 kg/d during the first 200 days (6).

The growth of our calf compared with Black rhino calves for which data are available is shown in Fig 5.

Milk replacers

Although many baby mammals have been successfully reared using milk replacers that differ considerably in composition from that of their mother's milks, it seems sensible, where possible to make the match as close as possible. Reliable data on the relative proportions of the major constituents of milk: water, fat, protein and carbohydrate; are available for only a minority of species (14),

and the literature on the concentrations of other constituents and of the nature of the protein and fats is even more scant. Selecting or designing appropriate milk replacers for hand-rearing wild animals is therefore not a straightforward task.

The only detailed publication on the composition of Black rhino milk of which we were aware was that by Gregory et al (5). However we were somewhat cautious of the findings of these authors, because their results indicated that the energy content of rhino milk was only 0.35 kcal/ml. The energy intake of mammals during growth is generally in the range 200 to 350 Kcal/d per unit of metabolic size ($kg^{0.75}$). Thus we would expect the intake of a 40 kg baby rhino to be between about 3200 and 5500 kcal/d. To achieve this intake on a milk containing 0.35 kcal/d would require a daily consumption of about 9 to 16 litres; equivalent to 22 to 37% of bodyweight, which seemed a surprisingly large volume. In view of this, and because human milk replacers (which have a higher fat and energy density) have been used for rearing black rhinos, we decided to use our specially-designed rhino milk replacer mixed half and half by dry weight with Lactogen. The relative proportions of the major constituents of this mixture and of some others that have been used are shown in Table 2.

A formula based on a mixture of skimmed cow's milk and low-fat cow's milk has been recommended (13) for rhinos and has been used successfully (7,8,11,15). However this formula contains higher protein and lower lactose levels than are thought to occur in natural rhino milk.

This low-birthweight, female calf grew well on the milk formula provided and fortunately no serious health problems were encountered in spite of her failure to ingest her mother's colostrum during the first 24 hours after birth. The milk formula was palatable, well-tolerated (there were no episodes of enteritis or diarrhoea), and as the main source of nutrients for the first six months, supported a quite adequate growth rate.

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REFERENCES

1. Aschaffenburg, R., Gregory, M.E., Rowland, S.J., Thompson, S.Y. & Kon,V.M. (1961) The composition of the milk of the African Black Rhinoceros (Diceros bicornis Linn.). Proceedings of the Zoological Society of London 137: 475-479.

2. Dierenfeld, E.S., du Toit, R. & Miller, R.E. (1988) Vitamin E in captive and wild black rhinoceroses. Journal of Wildlife Diseases. 24: 547-550.

3. Dittrich, L. (1967) Breeding the Black rhinoceros Diceros bicornis at Hanover Zoo. Int. Zoo Yearb. 7: 161-162.

4. Ghebremeskel, K., Williams, G., Lewis, J.C.M. & du Toit, R. (1988) Serum alpha-tocopheral, all trans-retinol, total lipids and cholesterol in the Black rhinoceros (Diceros bicornis). Comp. Biochem. Physiol. 91A: 343-345.

5. Gregory, M.E., Rowland, S.J., Thompson, S.Y. & Kon, V.M. (1965) Changes during lactation in the composition of the milk of the African Black rhinoceros (Diceros bicornis). Proc. Zool. Soc. Lond. 145: 327-333.

6. Hagenbeck, D. (1966) Report on the hand-rearing of an Indian rhinoceros Rhinoceros unicornis at Hamburg Zoo. Int. Zoo Yearb. 6: 82-87.

7. Hagenbeck, D. (1969) Notes on the artificial rearing of a Great Indian rhinoceros Rhinoceros unicornis at Hamburg Zoo. Int. Zoo Yearb. 9: 99-101.

8. Hansjergen, J. (1985) Notes on a White rhino. In Taylor, S.H. & Bietz, A.D. (Eds) Infant diet/care notebook. American Association of Zoological Parks and Aquariums, Wheeling.

9. Jones, D.M. (1979) The husbandry and veterinary care of captive rhinoceroses. Int. Zoo Yearb. 19: 239-252.

10. Lewis, J.C.M. (1989) Studies on the supplementation of vitamin E in a Black rhinoceros. Proceedings of the British Veterinary Zoological Society Meeting, Jersey, May 1989. In press.

11. Maruska, E.J., Dresser, B.L. & Barden, A.D. (1986) Black rhinoceros international management survey. American Association of Zoological Parks and Aquariums, Species Survival Plan.

12. Miller, R.E., Cambre, R.C., de Lahunta, A., Brannian, R.E., Spraker, T.R., Johnson, C. & Boever, W.J. (1989) Encephalomalacia in three black rhinoceroses (Diceros bicornis). Journal of Zoo and Wildlife Medicine. (In press.)

13. Nelson, L. & Fowler, M.E. (1986) Rhinocerotidae. In Fowler, M.E. (Ed.) Zoo and Wildlife Medicine. W.B. Saunders Co, Philadelphia. Pp934-938.

14. Oftedal, O.T. (1984) Milk composition, milk yield and energy output at peak lactation: a comparative review. Symp. Zool. Soc. Lond. 51: 33-85.

15. Schottelkotte, C.A. (1985) Notes on a Black rhinoceros. In Taylor, S.H. & Bietz, A.D. (Eds.) Infant diet/care notebook. American Association of Zoological Parks and Aquariums, Wheeling.

16. Wallach, J.D. (1969) Hand-rearing and observatins of a White rhinoceros Diceros s simus. Int. Zoo Yearb. 9: 103-104.

TABLE 1. The composition of Special Diets Services Ltd 'Rhinomilk 2' and the composition of the Rhinomilk 2/Lactogen mixture used through most of the first 6 months.

Nutrients (in dry powder)	Rhinomilk 2	Rhinomilk 2/Lactogen (mixed 1:1 by weight)
ME kcal/g	3.42	4.25
CP %	16.2	15.8
Ash %	8.6	6.2
Fat %	3.8	14.1
Lactose %	71.1	63.1
Vit A iu/g	38	27
Vit D iu/g	1.3	2.1
Vit E mg/kg	529	300
Vit C mg/kg	177	293
Ca %	1.47	1.01
p %	1.09	0.77
Mg %	0.06	0.06
K %	0.26	0.50
Na %	0.15	0.20
Fe mg/kg	77.3	69.7
Zn mg/kg	27.6	33.8
Cu mg/kg	2.1	2.6
Mn mg/kg	13.8	7.2

ME is metabolisable energy, CP is crude protein.

Complete details of the composition of Rhinomilk 2 can be obtained from Special Diets Services, PO Box 705, Witham, Essex CM8 3AD

TABLE 2. The composition of black rhinoceros milk and of some substitutes used and their constituents.

	DM%	Energy kcal/ml	Fat	Protein as % of DM	CHO
Rhino milk[5]	8.82	0.35	2	16	75
SDS Rhinomilk 1	9.0	0.32	2	16	76
SDS Rhinomilk 2	9.0	0.39	3.5	15	71
Lactogen	12.6	0.64	24	16	53
Rhinomilk 2/Lactogen	<15	<0.63	14	16	63
Skimmed-milk	9.1	0.33	1.3	36	53
Low-fat milk	10	0.48	16	32	46
Cincinatti formula[11]	16	0.67	5	46	46
White rhinomilk formula[13]	9.8	0.41	9.3	33	51

FIGURE 1. Milk intake of a young black rhinoceros in relation to age.

FIGURE 2. Metabolisable energy intake of a young black rhinoceros in relation to age. The upper line shows total energy intake, and the lower one energy intake from milk.

FIGURE 3. Metabolisable energy intake in relation to metabolic size in a young black rhinoceros.

FIGURE 4. Growth of a young black rhinoceros

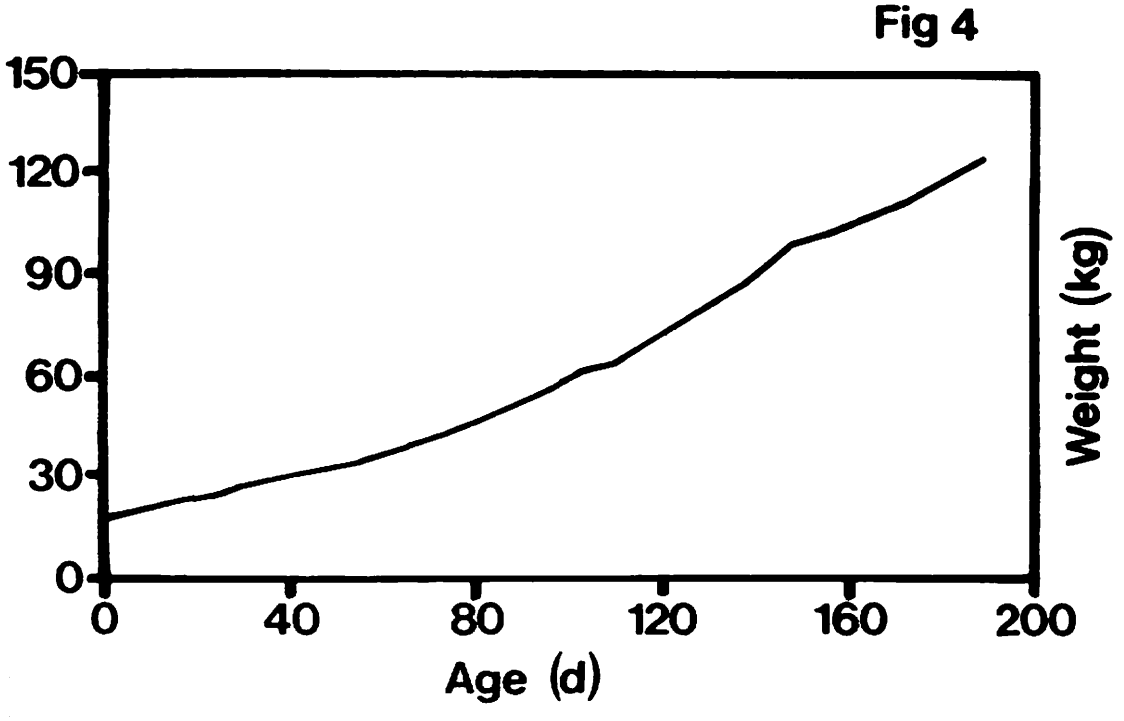

FIGURE 5. Comparison of the growth of the Zoological Society of London's hand-reared black rhinoceros, with that reported for other individuals. 1. Mother-reared[3]. 2. Hand-reared at Cincinatti[11]. 3. Hand-reared at ZSL (this study). 4. Hand-reared at Detroit[11].