Int. Zoo Yb. (2006) **40:** 372–378

Developing models for mother–infant behaviour in Black rhinoceros and Reticulated giraffe *Diceros bicornis michaeli* and *Giraffa camelopardalis reticulata* at Brookfield Zoo, Illinois

T. V. GREENE[1], S. P. MANNE & L. M. REITER[2]

Chicago Zoological Park (Brookfield Zoo), 3300 Golf Road, Brookfield, Illinois 60513, USA

E-mail: ZooBird@sbcglobal.net

For over a decade the behaviours of mothers and newborn calves of Black rhinoceros *Diceros bicornis michaeli* and Reticulated giraffe *Giraffa camelopardalis reticulata* have been observed at Brookfield Zoo during the critical first few weeks post-partum. Consistent patterns were seen for individuals within species, allowing models of time budgets, including ranges of variability surrounding each behaviour, to be developed. Once the model is created any data collected for neonates can be compared to the mean values in the model so infant development and the adequacy of maternal care can be assessed quantitatively.

Key-words: behaviour, behavioural modelling, black rhinoceros, development, maternal care, mother–infant interactions, reticulated giraffe, time budgets

It is common practice in zoos to monitor behaviour and development of newborn animals. Close observation can alert keepers to congenital or emergent problems, and early warning is often the best way to avert life-threatening situations. In order to assess the development of infants, the range of 'normal' developmental patterns that characterize good health must be identified for each species. Brookfield Zoo has successfully participated in captive-breeding programmes for many ungulates and the results of 12 years of formal observations of mothers and infants in two taxa of large mammals are described. Data have been collected on a sufficient number of births to allow baseline activity profiles to be established for Black rhinoceros *Diceros bicornis michaeli* and Reticulated giraffe *Giraffa camelopardalis reticulata,* which are included in the Species Survival Program (SSP), where successful neonatal development is important. Rhinoceros and giraffe were chosen for this study because multiple breeding ♀♀ were maintained at the Zoo, thus providing a large enough sample size for analysis.

For many species a wide range of mothering styles results in the successful rearing of infants (Bettelheim, 1987). However, for giraffes the literature is contradictory, with some researchers describing a weak cow–calf bond (Innis, 1958; Foster, 1966; Foster & Dagg, 1972) while others report a stronger bond and protective mothers (Spinage, 1968; Guggisberg, 1969). Without tables of baseline data giving acceptable ranges of maternal behaviour and infant development, it is difficult to assess whether the maternal care provided is adequate for infant survival. However, maternal care extends beyond simply nursing infants, which also need to learn about their environment, such as suitable foods to eat, hazards to avoid, conspecific recognition and introduction to the social group (Lent, 1974).

[1] Thomas V. Greene died in January 2004.

[2] Present address: Loyola Center for Health and Fitness, 2160 South First Avenue, Building 130, Maywood, Illinois 60153, USA.

Giraffes use a 'nursery' care system in the wild (Langman, 1977). In captivity, after the initial post-partum period, a mother may move away from her calf but she will usually come to its aid if it is distressed. In contrast, Black rhinoceros cows, both in captivity and in the wild, keep calves close to them so that they can protect them from predators (Penny, 1987).

A model that defines the range of expected or 'adequate' maternal care in captivity was generated from the observations of six calves in each species, and their mothers, and this was then used to determine if an animal was deviating significantly from the normal range. Any deviations should be examined to see if they can be explained, indicating that there is probably no cause for concern, or whether they are an indication of a problem that needs to be rectified. Because parental care, primarily maternal care in the case of mammals, is essential for infant survival, this understanding can prove valuable when planning husbandry procedures. By describing the range of normal behaviour, the ability to identify deviations and act upon them is enhanced.

METHODS

In order to generate a normative model, data were collected between 1986 and 1994 for three Reticulated giraffe ♀♀ (two nulliparous) and six calves, and between 1986 and 1998 for two Black rhinoceros ♀♀ and their six calves (Table 1).

Giraffe mothers and calves are isolated for the first week post-partum and then introduced to the herd, so they were observed in both multiple stalls and outdoor enclosures. Rhinoceros mothers and calves were housed by themselves in indoor enclosures for the duration of the observations.

Because of inherent variations over time, details of environmental conditions and husbandry were recorded for all subjects. These records included information on feeding schedules, cleaning schedules, types and amounts of food, as well as the timing of the introduction of new items to the enclosure, such as logs or water basins provided for rhinoceros neonates. This information was assessed at the onset of observations to ensure comparable environments.

The first rhinoceros calf was observed for 1 month post partum but subsequently we extended the observation period to 6 weeks for the remaining five calves. For giraffes, six mother–infant pairs were observed for periods of 3–6 weeks. When two births overlapped in time, observations on the older calf were terminated by

SPECIES	MOTHER	CALF	GENDER
Black rhinoceros	Brook (born 1970)	Corky (1986)	♂
		Miadi (1988)	♀
		Akili (1991)	♀
		Kijito (1993)	♂
	Shima (born 1985 to Brook)	Johari (1995)	♂*
		Kizuri (1998)	♀
Reticulated giraffe	Carol (born 1973)	Baraka (1988)	♂
		Kama (1990)	♂
	Magic (born 1982 to Carol)	Kipaji (1988)	♂
		Hodari (1990)	♂
		Zawadi (1994)	♀
	Mithra (born 1990)	Kio (1994)	♂*

* First calf for mother.

Table 1. Black rhinoceros *Diceros bicornis michaeli* **and Reticulated giraffe** *Giraffa camelopardalis reticulata* **calves and mothers observed at Brookfield Zoo between 1986 to 1998.**

the fourth week. A third calf was doing well, so observations were only carried out for 4 weeks. At the start of the study observations were only carried out for 6 hours per day for the first 2 weeks followed by 3 hours per day (morning or afternoon) for 4–6 weeks, owing to the time restrictions on personnel. The observation periods were not all-day sessions but were carried out during the morning on one day and in the afternoon on the next.

Instantaneous sampling, at 1 minute intervals for activity and proximity, was used to observe the infants (Altmann, 1974). This was supplemented with *ad libitum* observations of key interactions and events, such as play, urination, defecation and vocalization. The ethograms were formulated to encompass the important behavioural activities (Table 2). Initially, data were collected using paper and pen but in 1991 laptop and palmtop computers, loaded with an observation program that we developed, were used. This development greatly facilitated observation and data entry, and allowed a finer-grain division of behavioural categories. Prior to inputting the data directly into a laptop computer, the Play, Groom, Investigate and Other activities were lumped together (for six animals) on the record sheets, therefore the lumped categories were also used for the analyses. The Play/Investigate category was only for Black rhinoceros and the Groom/Investigate category was only for Reticulated giraffes. The proximity of calf and mother was also recorded (Table 2).

The duration of nursing bouts was recorded to provide the daily data for a long-standing keeper report on this activity, and any unusual events, such as vocalizations, for either calf or mother were also noted. Interactions between the keepers and animals, for feeding, cleaning or medical reasons, were recorded. Descriptive statistics were used to present means, along with 95% confidence intervals, for time budgets and behaviour frequencies.

The data gathered were used to generate a model that provides the mean and range for the behaviours of the observed

	DESCRIPTION
ACTIVITY	
Feeding	eating hay, pellets; drinking water; nursing (calf only)
Moving	locomotion from one location to another
Settled	laying down at rest
Motionless	standing at rest
Playing/Investigating	(rhinoceros only) 'Playing' applies to a calf. 'Investigating' includes sniffing around the enclosure, licking, etc
Grooming/Investigating	(giraffe only) 'Grooming' is either licking oneself or the other member of the mother–calf pair; 'Investigating' includes sniffing around the enclosure, licking, etc
Other	a catchall activity for mothers consisting primarily of defecating, urinating and sniffing around the enclosure
No score	unable to see the animal or keeper interacting with animal
PROXIMITY	
Contact	mother and calf touching each other
Close	mother and calf within a body length (chest to rump measurement of mother)
Distant	more than a body length apart

Table 2. Activity and proximity states recorded for Black rhinoceros and Reticulated giraffes in a study into mother–infant behaviour at Brookfield Zoo.

animals, to serve as an indicator of normal infant development and maternal care, and a gauge of whether the behaviours of both mother and calf fall within an acceptable range.

To generate the model, the observation data were analysed in several ways. The basic data partition was called an 'observation day', which may comprise observations taken on the same day or on subsequent days. Each observation day contains 360 samples (one observation per minute for 6 hours). An observational unit was defined as 3 hours of minute-by-minute observation data in a morning (0900–1200 hours) and 3 hours in an afternoon (1300–1600 hours). All the statistical analyses for generating the model are based on this observational unit.

The model comprises the mean and $\pm$95% confidence interval of the various behavioural states for mother and calf based on the percentage of time spent daily in each state (Table 2).

For Black rhinoceros a single model was created for the first 6 weeks post-partum because there were no significant behavioural changes over this period.

Although the observation period for six mother/calf giraffes was 3–6 weeks, three of the observations ended during the fourth week so only data collected during the first 3 weeks were used for behaviour modelling. The lifestyle and behavioural patterns for the giraffe differ from those of the rhinoceros and, therefore, the modelling is not identical for both species. The giraffe calves in this study were born to three mothers in three different years giving three couplets of calves born within a few weeks of each other (Table 1). The behaviour of second calves in any given year may have been influenced by interactions with first-born calves of the same year. Additionally, mother and calf were isolated from the other giraffes for the first week post-partum so a substantial change in behaviour between weeks 1 and 2 may be predicted. The Reticulated giraffe model takes this changing pattern into account because it is based on weekly averages and on variances based on weekly summations, giving an individual model for each week.

To justify aggregation of the behavioural data into a 'typical' or 'model' view for the species, for each behaviour the data for a mother/calf pair was compared to the model's mean value to determine whether actual behaviours for each animal fall within the distribution range defined by the model.

Mother–infant interactions involve two participants so means were calculated for both animals, although the primary focus was the infant, in order to assess the mother–infant relationships.

RESULTS

Behavioural model for Black rhinoceros The mean and 95% confidence interval for the activity time budgets of five calves and their mothers for 6 weeks post-partum were used to develop the model (Fig. 1). The data for proximity show that the calves spend 75% (range 58–85%) of time close to their mothers, 14·5% (range 5–27·25%) in contact and 10·5% (range 1·4–20·3%) of time at a distance.

A sixth rhinoceros calf was born in 1998 and the behaviours of this mother and calf were compared to the model. For Feeding (mother), Play and Settle (calf) the behaviours fell outside the 95% bounds defined by the model (Fig. 1); however, these differences did not appear to have any ill effects on the mother or calf.

Behavioural model for Reticulated giraffe The weekly means and 95% confidence intervals for activity time budgets for six calves were calculated (Fig. 2). There is variation in most behaviours from week to week, with the first week having the most significant variation, perhaps reflecting isolation from the herd at that time.

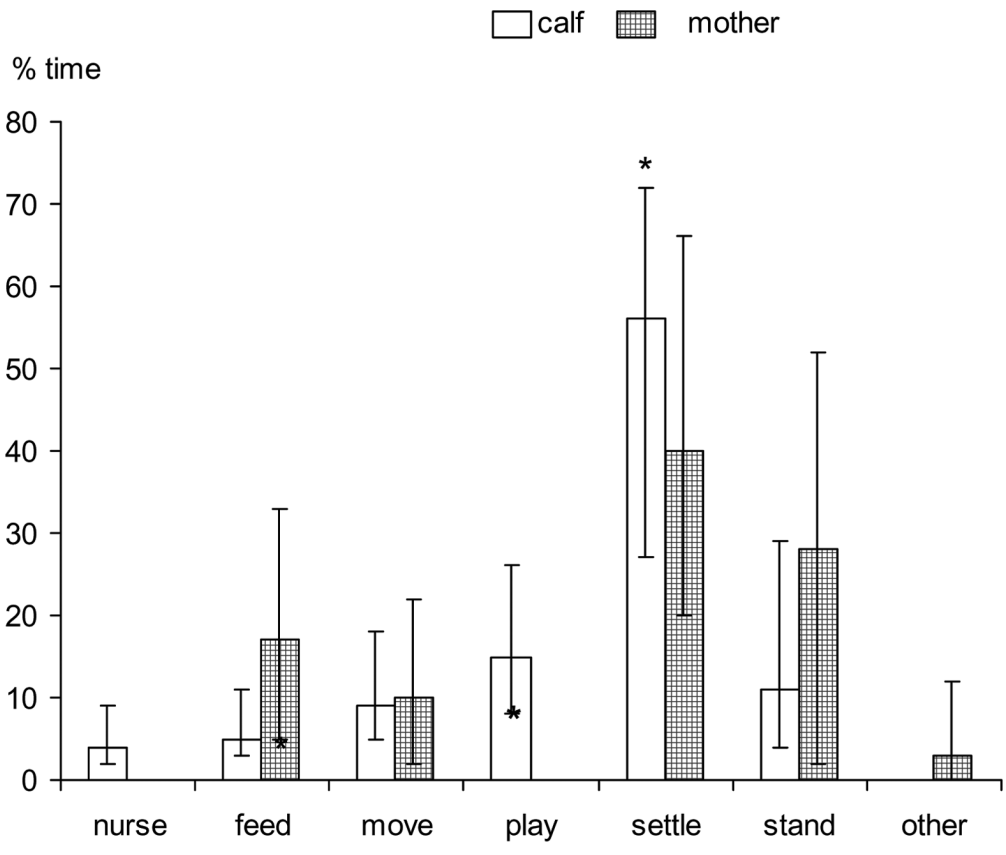

Fig. 1. Activity time budgets for five Black rhinoceros *Diceros bicornis michaeli* **calves (open bars) and their mothers (single-cross bars); * represents variant data for the sixth calf.**

When comparing the behaviour of individuals to the model, one result showed noticeable variations from the norm in the first week. One calf was separated from the giraffe herd briefly because of intra-group aggression and was reunited with the herd once the aggression subsided. This calf was Settled for only 1% of the time (compared to a mean 30% for the other calves) and it was distant from its mother for 41% of the time (compared to a mean 71% for the other calves). These deviations are the sort of factors that a good model would indicate as problems to be investigated.

DISCUSSION

The reason for carrying out these observations was to generate a dataset of normal behaviour that could be used to identify and correct problems that affect the well-being of developing neonates. Behavioural deviations from the norm, either in calf development or maternal care, can provide valuable insights into the causes of such problems. All the infants observed in this study developed well, regardless of the level of maternal care. However, defining a range of acceptable maternal care is useful when making animal-management decisions and is

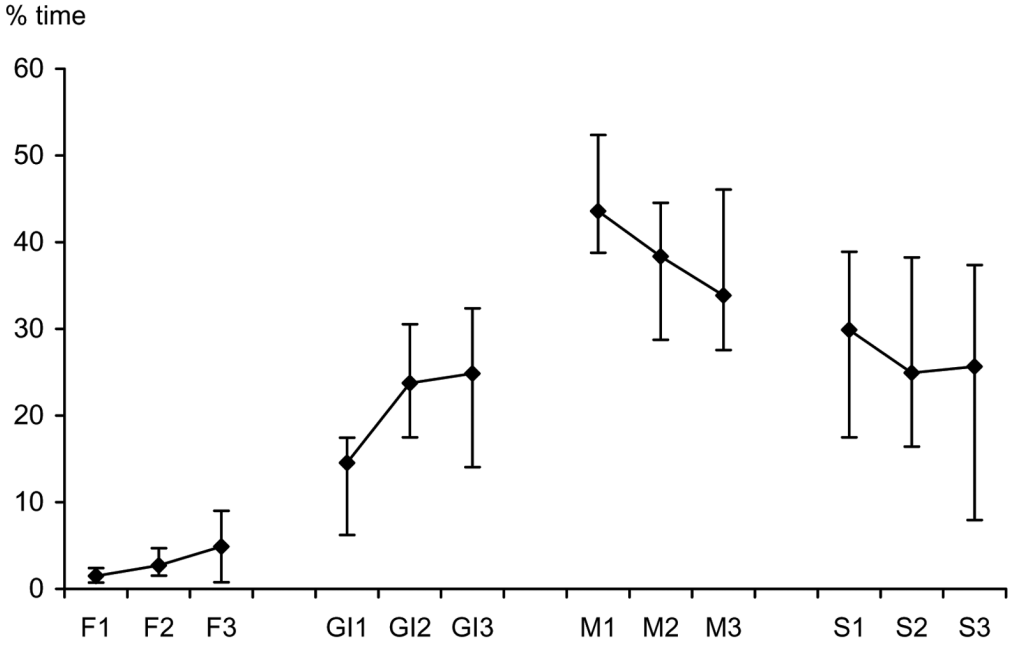

Fig. 2. Activity time budgets (mean and ±95% confidence interval) per week for 3 weeks for six Reticulated giraffe *Giraffa camelopardalis reticulata* **calves: F1. feed, week 1; F2. feed, week 2; F3. feed, week 3; GI1. groom and investigate, week 1; GI2. groom and investigate, week 2; GI3. groom and investigate, week 3; M1. motionless, week 1; M2. motionless, week 2; M3. motionless, week 3; S1. settled, week 1; S2. settled, week 2; S3. settled, week 3.**

especially helpful for the long-term success of SSPs.

When evaluating the behaviour of the sixth rhinoceros calf against the model, the categories that showed significant deviation for the calf were all traceable to reduced Feeding activity by the mother. Because the mother was determined to be clinically overweight, her hay portion was reduced. This was initiated before the study period. When observing the first five calves a good supply of hay was available and the mothers would spend their time slowly wandering around the enclosure, feeding through the day. However, after the mother of the sixth calf consumed the limited hay supply and other food items offered, she would tend to stand Motionless (15% more of the time than the mean). Black rhinoceros calves typically stay by their mothers so, in this instance, the increased maternal inactivity resulted in increased inactivity of the calf, which tended to Settle. Mothers usually move around enclosures feeding and this stimulates Playing/Investigating activities, which in this calf were also reduced. However, the decreased maternal activity level did not lead to deviations in all behavioural categories and nursing remained within the range of the model.

The behavioural data on Reticulated giraffes showed more variability, particularly for the mothers. The social organization of herds allows mothers to leave calves in a safe environment, tended by other giraffes, while they search for food. At Brookfield Zoo, the giraffes could roam between inside stalls and outdoor enclosures and, because the observation protocol was to keep calves in view, mothers could be out of sight of the observer. Consequently, the data collected on the mothers may have some behav-

ioural bias because behaviour while out of sight could differ from behaviour when in view. The amount of time that a mother was not visible had a bimodal distribution for the six mother/calf observations. For three calves the data show the mother was not visible for *c.* 20% of the time and for the other three the mother was not visible for *c.* 3% of the time, consequently limiting the ability to generate a broadly applicable model. Another factor that may have led to this variation was the construction of a new exhibit area in 1992, which provided a more spacious, elaborate inside and outdoor environment for two of the giraffes in the study, both of which were in the 'not visible for 20% of time' group.

The creation of datasets for ranges of normal infant development and maternal care has practical implications for animal management. First, these models allow us to define a relatively short critical period during which behavioural monitoring may provide an indication of likely reproductive outcome. Second, such models can serve as conservation tools to help managers decide when, or if, to intervene in infant care.

ACKNOWLEDGEMENTS

The authors are particularly indebted to Dr Jeanne Altmann who provided the guidance and encouragement for this modelling effort and Dr Sue Margulis for her excellent comments as a reviewer. The authors are also indebted to Pamela Parker, Ann Petric and Tim Sullivan for their generous support over the last 13 years. We also would like to thank Mary Burke, Meryle Nelson, Mary Schollhammer-Delbecq, Joan and Joseph Myszkowski, Glen Alaks, Allison Walsh, Cindy Flaherty, Ed Laird, Roger Reason, Carol Ann Carr, Bill Vogt, Mary Feay and Delta Greene. In addition, many other keepers at Brookfield Zoo have been extremely helpful.

REFERENCES

Altmann, J. (1974): Observational study of behavior: sampling methods. *Behavior* **49:** 227–267.
Bettelheim, B. (1987): *A good enough parent.* New York: Vintage Books.
Foster, J. (1966): The giraffe of Nairobi National Park; home range, sex ration, the herd and food. *East African Wildlife Journal* **4:**139–148.
Foster, J. & Dagg, A. (1972): Notes on the biology of the giraffe. *West African Wildlife Journal* **10:** 1–16.
Guggisberg, C. (1969): *Giraffes.* London: Arthur Barker Ltd.
Innis, A. (1958): The behavior of the giraffe in the Eastern Transvaal. *Proceedings of the Zoological Society of London* **131:** 245–781.
Langman, V. (1977): Cow-calf relationships in giraffe. *Zeitschrift fuer Tierpsychologie* **43:** 264–286.
Lent, P. C. (1974): Mother–infant relationships in ungulates. In *The behaviour of ungulates and its relation to management:* 14–55. Geist, V. & Walther, F. (Eds). Morges: IUCN.
Penny, M. (1987): *Rhinos, Endangered Species.* London: Christopher Helm.
Spinage, C. (1968): *The book of the giraffe.* London: Collins.

Manuscript submitted 9 February 2004; accepted 22 March 2005; revised 24 February 2006