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An historical retrospective study of black rhinoceroses *Diceros bicornis* Linné, 1758 in Italian zoos: a useful integration of cross-institutional studies?

Eine rückblickende Studie über die Haltung von Spitzmaulnashörnern *Diceros bicornis* Linné, 1758 in italienischen Zoos: nützliche Integration institutsübergreifender Studien?

Spartaco Gippoliti [a,*], Kees Rookmaaker [b]

[a] Safari Ravenna scientific consultant, Italy
[b] Rhino Research Center, 669592 Singapore

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Abstract

Although an extensive literature exists on the management of zoo animals, not all zoos have contributed in an equal way. This paper is the first retrospective account of black rhinoceros husbandry and breeding in Italian zoos. Considering the precarious status of wild and captive populations, it is hoped that the results presented in this paper may furnish additional insights that are necessary to resolve some management problems in zoos today.

Keywords: Naples Zoo; Rome Zoo; Husbandry; Breeding; Diet; Enclosure size

Introduction

The black rhinoceros *Diceros bicornis* is one of the rarest large African mammals today. The distinctive *Diceros bicornis longipes* from West Central Africa was declared extinct in 2007, and surviving populations of other subspecies exist under strict protection only in

*Corresponding author.
E-mail addresses: spartacolobus@hotmail.com, spartaco.gippoliti@tiscali.it (S. Gippoliti).

small areas of Eastern and Southern Africa, often in fenced reserves (Caro & Riggio, 2014). Although captive breeding programs seem to play a secondary role in zoos' missions today, there is increasing evidence to suggest that this may soon change as the perception of the current extinction crisis increases (Gippoliti, 2012), and that this may be particularly true for rhinoceroses.

A pair of black rhinoceros *Diceros bicornis* arrived in Naples from Kenya between 1960 and 1964 and bred there five times between 1971 and 1987. Nothing has been published on the husbandry of these rhinoceroses. Regrettably, no living black rhinoceros today is descendent of the Naples 'line' due to a mix of bad luck and improper management. Only the first female, 'Lucia', was successfully paired with a wild-caught male, 'Ghibli', to produce one offspring in Rome, the male 'Rino', on 3rd February 1980. Yet the fact that Italy had two breeding pairs of black rhinoceroses in the early 1980s (in Naples and Rome) which left no descendents represents a lesson (albeit bitter) for those who are interested in the management of viable captive populations of threatened species.

This paper addresses some issues relating to the keeping and breeding of black rhinoceros in Naples Zoo, with comparative data from Rome Zoo and some reflections on zoo-based conservation programs.

Materials and methods

Basic information on the management and husbandry of Naples rhinoceroses was obtained retroactively from studbook data and through interviews with senior keepers, supplemented with occasional personal observations and direct knowledge of the facility. Data on Rome rhinoceroses was the results of direct observations. The Pachyderm house in Naples was first realised in 1938–1939 as part of a short-term exhibition ('Mostra Triennale d'Oltremare') that consisted of three semicircular outdoor moated enclosures connected to a rectangular building that contained the indoor stalls for hippopotamuses, elephants and rhinoceroses (Fig. 1). In Rome, the outside enclosure was about 700 sqm, much longer than wide (Fig. 2), and connected to four stalls. An adult male Indian rhinoceros lived in the adjoining enclosure.

Results

Rhinoceroses in Naples Zoo had daily access to their outdoor enclosure of about 900 sqm, including dry moat, while the night was spent in two small indoor stalls without public view. A large circular pond was situated in the centre of the outside enclosure, and no particular enrichment devices were present. Public view was allowed through about two thirds of the perimeter. It is interesting to note that the staple diet in Naples was hay of *Hedysarum coronarium*, a typical Mediterranean leguminous grass particularly rich in tannins (Priolo & Vasta, 2007), supplemented with fruits, vegetables and crushed cereals. In Rome the bulk of the diet for black rhinoceroses was lucerne hay (fresh in the good season) supplemented by carrots and green vegetables. Two of the three rhinoceroses held in Rome (the two males) had serious health problems (kidney failure and skin lesions) resulting in a premature death,

Fig. 1. The Naples Zoo black rhinoceros pair in their outside enclosure, July 1996. Photo: courtesy of L. Sclawe.

Fig. 2. Lucia and her calf in their outside enclosure at the Giardino Zoologico in Rome, 1982. Photo: S. Gippoliti.

Table 1. Breeding records of the Naples black rhinoceros.

Studbook	Sex and name	Birth/arrive date	Transfer or death date
037-NAP2	f *Caterina*	1960.10.06 from Kenya	died between 1997 and 1998
036-NAP1	m *Keddi*	1964.07.06 from Kenya	died between 1998 and 1999
165-NAP4	f *Claire* (*Lucia*),	born 1971.10.20	1974.03.12 to Rome
242-NAP5	f *Ciccia*	born 1975.12.14	1976.11.02 to Fasano
270-NAP6	f *Loredana*	born 1978.07.25	1982.06.10 to Frankfurt
345-NAP7	f *Assunta*	born 1983.08.15	1984.10.28 to Port Lympne
	f unnamed	born 1987	died after a few days

and this may well be diet-related (Clauss & Hatt, 2006). Fresh branches with leaves were given to Naples rhinoceroses in the summer months.

Natal sex ratio in Naples was quite favorable as all five calves were females (Table 1). This is of interest, as male calves predominate in the captive populations with possible negative consequences for its long-term viability (Foose & Wiese, 2006). All of the five newborns were successfully mother-reared except the last one that was very weak and died after a few days. Their relationship with their keepers was very good both in Naples and Rome, as is often the case with black rhinoceroses.

Discussion

When a large portion of a perimeter is exposed to the public in an outside area, it is now believed this can be a cause of stress to black rhinoceroses (Carlstead & Brown, 2005), as is the continued coexistence of adult animals in the same enclosure. Thus it is recommended that adults are kept separate except for breeding (Carlstead & Brown, 2005). The physical environment in Naples may therefore be described as a potentially stressful situation according to the present knowledge available. The circular shape of the enclosure is believed to have had a positive role in avoiding serious aggression between the adult pair in Naples (Fontana, pers. comm.). To note that in Rome, in a more linear-shaped outdoor enclosure, it was not possible to reintegrate the adult pair after the birth of the first calf, due to serious aggression. In Naples, the adult female was separated from the male when rearing the calves, and could be reunited only after the latter had been sent to other zoos.

Multi-institutional cross-institutional studies are increasingly recognised to be of great relevance in understanding environmental variables that affect the breeding and welfare of specific taxa (Carlstead, Fraser, & Kleiman, 1999; Hosey, Melfi, & Pankhurst, 2009). Greater sample size allowed statistical analysis to be performed and, in turn, this makes publication of the results in peer-reviewed journals possible. Recommendations provided by these papers are usually inserted in the species husbandry guidelines. Some concern has been expressed about the difficulty to compare some variables, and integration with longitudinal monitoring of physiological and behavioural aspects has been proposed (Shepherdson, Carlstead, & Wielebnowski, 2004; Carlstead & Brown, 2005). Even in ecological research, it has been proposed that longitudinal studies cannot be replaced by cross-sectional research

Lindenmayer et al., 2011). It should be quite useful if results from multi-institutional studies should be confronted and integrated with historical longitudinal data from a single zoo to be confirmed or not. This latter approach is not eligible for publication in high profile scientific journals, nor does it allow for the monitoring of behavioural and hormonal parameters, yet it may provide valuable information from an otherwise overlooked but significant sample.

In our case the historical data from *Diceros bicornis* at Naples Zoo does not support some of the previous conclusions derived from multi-zoo studies. It is possible that some variables, such as time spent in holding areas, familiarity with keepers, and early habituation to certain environmental conditions – such as presence or not of public in indoor areas – have been overlooked in previous research. Naples rhinoceroses certainly benefitted from daily outside access year round and indoor privacy; a situation not present in another zoo where one of the Naples-born female lived for a few years without successfully breeding (Gippoliti, pers. obs.). Sex ratio of births in Naples seem to support the theory relating to a role for nutrition in current skewed sex ratio in favour of males (Clauss and Hatt, 2006; Dennis et al., 2007). Furthermore, valuable data on the efficacy of former diets, both mechanically and nutritionally, can also be furnished from the study of skeletal remains stored in natural history museums (Taylor et al., 2014). Incidentally, Naples rhinoceros newborns were not evidently affected by the excessive iron storage syndrome now affecting the North American population (Paglia, Kenny, Dierenfeld, & Tsu, 2001). In this regard, the high percentage of tannins in *Hedysarum coronarium* may have played a role, as it is well known that phenolics may hamper the successive utilization of the iron for synthesis of haemoglobin (Lavin, 2012). Naples was not the only successful zoo breeding black rhinoceroses in those years. A quite prolific pair in Teheran Zoo, for instance, has been recorded in the same period (Rookmaaker, 1998) but nothing has been published on their history. Sydney's Taronga Zoo imported a large group of 4.7 black rhinos from Tanzania in 1947–50; one male breeding with five females produced a total of nine (3.6) births, favourably skewed towards females (Rookmaaker, 1998). Studbooks are thus not only valuable for assessing genetic data of captive populations, but a unique primary source of information for beginning historical reviews on species' zoo history, including identification of environmental variables positively linked to welfare and breeding.

Conclusions

Zoo biologists often limit the analysis of captive populations to contemporary individuals. However, results obtained in this way should be confirmed by the known history of earlier individuals, often wild-born and held in somewhat 'archaic' accommodations. In the black rhinoceros case discussed here, it seems that successful breeding was accomplished under physical conditions that appear less than ideal for the species (Carlstead & Brown, 2005). Thus it highlights the importance to gather and disseminate data on husbandry, diet and accommodation for past breeding success of threatened species – such as black rhinoceros – from as many zoos as possible. Human–animal relationships in zoos is receiving scientific attention only recently (Claxton, 2011), whilst its relevance in the captive husbandry of rhinoceroses is certainly of paramount importance. The difficulty the black rhinoceros has

in adapting to unfamiliar environments after movement between *zoos has so far received little attention and this aspect deserves the maximum attention.*

Urban zoos were traditionally thought to exhibit a wide variety of organisms, often represented by a few individuals living in one enclosure. Even today it is often assumed that coordinated breeding programs may alleviate the need to have sizeable breeding nuclei in a single institution. This may create severe problems for the long-term viability of rhinoceros captive populations. Single zoos achieving notable breeding success with threatened species should do all they can to disseminate information and explore ways to maximize their conservation contribution, including allocating extra space and resources to a few threatened species. Although visitors can comply the over-presence of some species, this should also be a good occasion to communicate the conservation significance of contemporary zoos and specifically the *ex situ* component of their mission.

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