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Reproductive behaviour of captive Sumatran rhinoceros (*Dicerorhinus sumatrensis*)

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Abstract

The Sumatran rhinoceros (*Dicerorhinus sumatrensis*) is on the verge of extinction in Malaysia. At the Sumatran rhinoceros Conservation Centre in Sungai Dusun, the reproductive behaviour of two female and two male rhinoceroses were studied for 8–10 months during attempts to breed them in captivity. Due to the paucity of scientific information on the reproductive biology of the Sumatran rhinoceros, this study was conducted to obtain information on the reproductive behaviour of this species. The male rhino was introduced to a female rhino in the morning for 1–2 h daily in order to observe for behavioural oestrus. Observations were made on the signs of oestrus and mating behaviour. Oestrus was determined by receptivity towards the male and lasted about 24 h. Common signs of oestrus were an increase in frequency of urine spraying, tail raising or swinging, anogenital and other contacts. Although the males exhibited mounting, the inability of the male to achieve intromission was poor. The study demonstrated that the pattern of courtship and copulation of the captive Sumatran rhinos were comparable with those of other rhino species, reported previously by other scientists and flehmen reflex was also exhibited by the male Sumatran rhinos. In a captive breeding programme, it is recommended that only an oestral female is introduced into a male enclosure due to the male solitary behaviour and to avoid serious injuries inflicted onto the females. © 2004 Elsevier B.V. All rights reserved.

Keywords: Behaviour; Sumatran rhinoceros; Extinction

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1. Introduction

The Sumatran rhinoceros is the most critically endangered of all rhinoceros species in the world. Over the last 15 years, Sumatran rhinoceros have declined in numbers by more than 50%, due to poaching and loss of habitat (Zainal Zahari, 1995). These threats have fragmented the estimated wild population of Sumatran rhinoceros of <400, to very small and isolated pockets in the South East Asian forests, with Indonesia and Malaysia being the most significant territories.

The Sumatran rhinoceros, a descendant of the woolly rhinoceros is the oldest living rhinoceros species today and the only species found in Malaysia. The wild population of Sumatran rhinoceros in Malaysia was estimated to be 50 in 2001 (Zainal Zahari et al., 2001); and the population may have progressively dwindled in this millennium since sightings of this animal in the forest are rare. The future of this species in Malaysia looks bleak, as to date captive breeding success at the Sumatran Rhinoceros Conservation Centre in Sungai Dusun, Malaysia has been poor. In addition, serious injuries were inflicted onto females that were introduced prior to oestrus. The knowledge on contact promoting behaviour would help identify behaviour patterns that indicate an on coming oestrous or post-oestrous thus reducing the incidence of injuries. However, the birth of a male calf at the Cincinnati Zoo and Botanical Garden (Roth et al., 2001) has provided some encouragement in preventing extinction of this rhinoceros species.

Since the Sumatran rhinoceros is on the verge of extinction, the Malaysian Department of Wildlife and National Parks initiated in 1984, a long-term study for the conservation of the Sumatran rhinoceros. One of their strategies was to breed these animals *ex situ*, however, before successful breeding can occur, there is the need for research on several aspects of the reproductive biology of the Sumatran rhinoceros. The study documents the reproductive behaviour of captive male and female Sumatran rhinoceroses from the aspects of precopulatory and copulatory behaviours.

2. Materials and methods

The behavioural study was conducted at the Sumatran Rhinoceros Conservation Centre in Sungai Dusun, Selangor, Malaysia over a period of 8–10 months. The animals used in this study were two wild-caught females and two wild-caught males. The choice and use of the behavioural parameters was based on studies done previously in the African (Baishya, 1979), Indian (Laurie, 1978, 1982) and Sumatran rhinoceroses (Hubback, 1939; Schenkel and Schenkel-Hulliger, 1969; Borner, 1979; Zainal Zahari et al., 1990; Richard et al., 1990). At the time of study, blood collection was difficult as the animals were not cooperative and, moreover, hormonal assays for hormone metabolites in urine and faeces were inaccurate.

2.1. General management

2.1.1. Facilities

At the Sungai Dusun Conservation Centre, the enclosures were of circular with eight night stalls at the centre and each stall was connected to a paddock. Each paddock had a mud

wallow and a pool. One of the paddocks was modified to include a crutch (2.5 m × 1.2 m × 1.5 m) made of galvanized iron rods (10 cm diameter) anchored into the cement floor. The front consisted of a double swing gate made of metal pipes (5 cm diameter) while the rear entrance consisted of three removable galvanised iron pipes (10 cm diameter), slotted into the cemented floor.

2.1.2. Feeding

All the animals were fed with 30–40 kg of forages (*Ficus variegata*, *Macaranga gigantea*, *M. tribola* and *Artocarpus rigidis*), fruits, vegetables, sweet potatoes and 3 kg concentrates daily. Clean water supplemented with vitamins and minerals were given ad libitum. In the daytime, animals were let out into their respective paddocks and penned in individual stalls at night. In the night stalls, the animals were sprayed with water to remove mud from their body and to induce defecation.

2.1.3. Reproductive behaviour

Reproductive behaviour was studied by introducing a male to a female rhinoceros in an outdoor paddock for a period of 1–2 h every morning until behavioural oestrus (standing to be mounted) was observed. Once the day of oestrus was established, each female was tested for oestrus daily for about 3 weeks from the previous oestrus. When severe aggression was displayed, the male and female rhinoceroses were separated immediately.

The behaviours recorded were: (a) precopulatory behaviour—vocalization, tail raising, urination and contact promoting behaviours with the head (snout) involving the flank, hind limbs, neck, head, rump, perineum and external genitalia; (b) copulatory behaviour—penile exposure, erection, mounting and dismounting. The frequency, duration and the postures were all recorded during mating.

3. Results

3.1. Male behaviours

The male approached the female with its lower jaw raised to expose the lower canine. It sniffed the female's rump and urine followed by chin lifting with the tip of the tongue exposed which initiated the flehmen reflex (Laurie, 1978; Baishya, 1979). Exposure of the tip of and retraction of the tongue were repeated several times. In addition, urine spraying was observed on several occasions including normal daily urination, when placed in a new enclosure, during excitement, and in the presence of a female rhinoceros (Fig. 1).

In the adult male rhinoceros, masturbation was exhibited by striking the erected penis against its body. This act was observed in the morning before feeding but without ejaculation. The male would demonstrate signs of flehmen, spraying small volume of urine and protrusion of the erected penis from the prepuce. There would also be frequent quivering of the hindquarters. During the period of study, the male sprayed urine for 27.6% of the total number of days observed but normal urination was observed on only two occasions.

When the male was introduced to the female, a series of responses were observed. Physical contact from the head to the perineal area (Fig. 1) was displayed by both genders. During the



Fig. 1. Contact promoting behaviour in Sumatran rhinoceros: (A) head to head contact; (B) head to perineum; (C) male rhino spraying urine; (D) female rhino squirting urine.

first week of introduction, only 0.7% of the contact promoting behaviour involved the hind limbs and perineum of the female. Contacts made by the male onto the head ($\mu = 10.17 \pm 1.93$ times) and neck ($\mu = 5.5 \pm 1.7$ times) of the female accounted for 70.4% and those made by the female on similar areas of the male totalled 47.4% ($\mu = 10.33 \pm 1.86$ and 6.5 ± 3.23 times, respectively). There were no contacts observed on the hind limbs and fore limbs of the female during the first week of introduction. In another pair, snout-to-snout was the first contact promoting behaviour observed.

3.2. Female behaviours and copulation

During the first week of introduction, the female rhinoceros made approximately 4% contacts on the anogenital region of the male. The least contact were made on the male's forelimbs (1.9%) and the most, onto the back (29.1%) and head (29.1%) (see Table 1 and Fig. 2).

Vocalization ranging from a squeal to a blow was made by the female throughout the study period. During oestrus, vocalization ranged from 33 to 56 ($\mu = 45.7 \pm 7.28$) times/day. A peak of 72 vocalizations was made on the 12th day of the oestrous cycle.

Periodically, the female would approach the rear of the male to sniff the urine. During the observation, the female only urinated in a flow.

As the male sniffed the female's rump, she snorted and squealed and whenever the male made contact with the perineum, the female would reverse. The female also frequently displayed rapid swinging of the tail. In the horn sparring behaviour, the female would

Table 1

Forms of contact promoting behaviour (%) during male–female encounters^a in captive Sumatran rhinoceroses

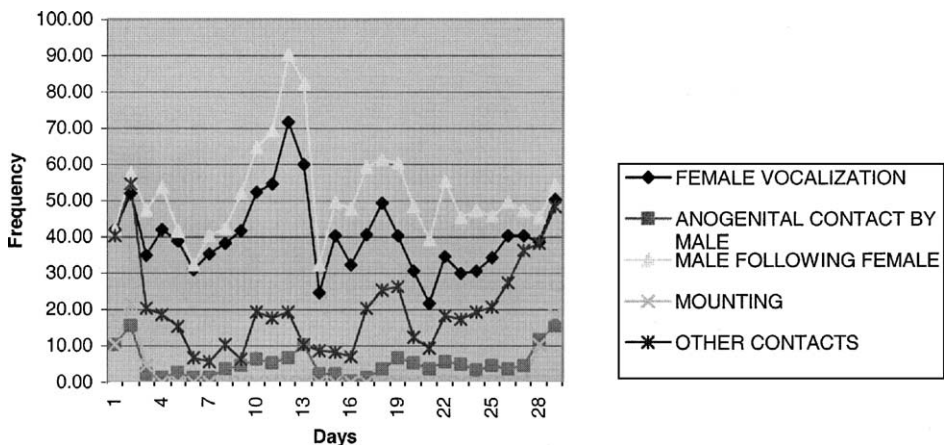
Sex	Head/snout	Neck	Flank	Back	Foreleg	Hindleg	Anogenital
M	9(45)	5(25)	5(25)	1(5)	0(0)	0(0)	0(0)
F	10(21)	10(21)	6(13)	16(34)	2(4)	2(4)	1(2)
M	11(55)	7(35)	2(10)	0(0)	0(0)	0(0)	0(0)
F	11(28)	7(18)	2(5)	11 (28)	0(0)	5(13)	4(10)
M	9(36)	8(32)	7(28)	1(4)	0(0)	0(0)	0(0)
F	9(24)	9(24)	6(16)	10(27)	0(0)	1(3)	2(5)
M	13(52)	4(16)	7(28)	1(4)	0(0)	0(0)	0(0)
F	11(28)	6(15)	7(18)	10(26)	1(3)	3(8)	1(3)
M	8(31)	5(19)	7(27)	5(19)	0(0)	0(0)	0(0)
F	9(30)	6(20)	3(10)	8(27)	1(3)	3(10)	0(0)
M	11(61)	4(22)0	0(0)	3(17)	0(0)	0(0)	0(0)
F	12(60)	1(5)	0(0)	7(35)	0(0)	0(0)	0(0)

M: male snout on female; F: female snout on male.

^a During a period of 100 min.

reverse and swung her head, initiating the male to charge and this behaviour was repeated several times.

During the oestrous cycle, the anogenital contacts made by the male ranged from 0 to 22 ($\mu = 5.2 \pm 4.0$). On the day of oestrus, characterised by mountings, the anogenital contacts ranged from 9 to 22 ($\mu = 13.3 \pm 3.8$). Similarly, the other male contacts involving the neck and shoulder of the female increases during oestrus ($\mu = 45.4 \pm 7.3$). However, there was no distinct pattern of female vocalization. Aggressiveness between both sexes included biting, head butting, nose-to-nose nuzzling and horn clashes which would result in severe lacerations inflicted on the female. When the male approached the female's perineum, she displayed bobbing of the head. A day before oestrus, both sexes displayed tail raising or swinging, which lasted for 5–10 min. The female often displayed squirting of the urine in

Fig. 2. Behaviour of a pair of Sumatran rhinoceros (*Dicerorhinus sumatrensis*) between two oestrous periods.

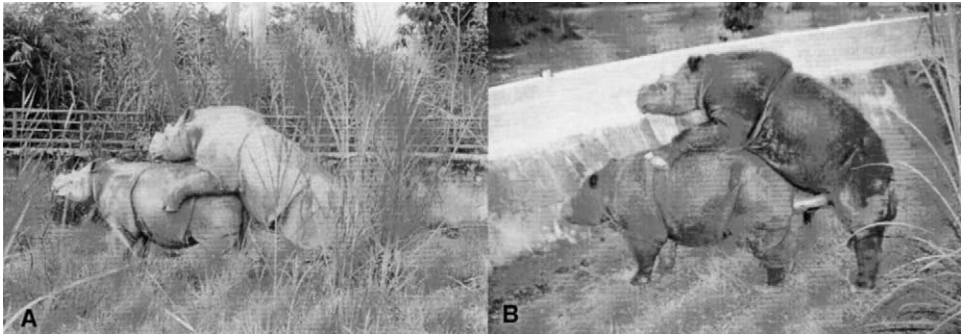


Fig. 3. Sequence of events during mating: (A) male rhino rows forward to position on female lumbar region; (B) fully erected penis seeking vagina.

the night stall but feeding and defecation were not altered. Chasing occurred over a short distance in the paddock. The pair sniffed the ground frequently.

One day before oestrus, the female rhinoceros continued to squeal and blow (vocalization), followed by increased frequency of tail raising and swinging. Increased anogenital contacts were displayed by the male as the female reversed towards the male. When the male placed its chin on the female's rump, she would move forward, initiating a driving reaction. On the day of oestrus, rubbing of each other's flank and tail raising or swinging became frequent. During standing oestrus, sniffing, licking and biting of the perineum on either side of the vulva occurred. However, there was minimum contact on the head and snout of the female.

Mounting was initiated when the female stood for the male. During oestrus, the number of mountings ranged from 8 to 25 ($\mu = 15.3 \pm 5.7$). The male moved forward with the neck and shoulder touching the female's perineum and base of the tail. The male then rested its lower jaw on the female's rump and slowly rotated it to the left and right using the chin as the pivot (Fig. 3). Subsequently, the male pushed forward and lifted its forelimbs onto the rump; and anchored its chin firmly on the sacrum. The male's tail was slightly curled and raised with hind limbs placed wide apart. Then, the animal "rowed forward" with its forelimbs on the lumbar region before finally securing at the shoulder fold (Fig. 2). Mounting was preceded by penile erection that took about 5–100 s.

After full penile exposure, erection usually occurred within the next 1 min followed by expansion of the paired lateral projections, 1–2 min later. The portion anterior to the lateral projections remained flexed posterior-ventrally albeit the complete erection of the body of the penis. Initially, the flexed portion moved ventrally, then dorsally before the male began thrusting. In one observation, the male displayed 36 thrusts during one mounting but without intromission.

4. Discussion

The reproductive behaviour of the Sumatran rhinoceros was successfully studied in captivity, even though numbers were limited. Observations on the establishment of the oestrus

cycle based on sexual behaviour was conducted with extreme caution since it is well known that the male rhinoceros can be aggressive and inflict injuries to the female rhinos and to the animal handlers.

Sexual behaviour in the rhinoceros begins with consort behaviour, followed by courtship or sexual display, culminating in erection, penile protrusion, mounting, intromission, ejaculation, then dismounting and refractoriness. The courtship behaviour in the wild Sumatran rhinoceros was described as mostly peaceful although fights do occur between a male and a female rhinoceroses (Borner, 1979).

In our study, the Sumatran rhinoceros exhibited a pattern of courtship which was similar to that of the Black rhinoceros, except for the greater excitability in the latter. Furthermore, horn jousting which reportedly occurs between the male and the female Black rhinoceros was also observed in the Sumatran rhinoceros but this act was not always seen in every mating. In the White rhinoceros, attacks on the male by the female rhinoceroses were limited to the ritualised clash of horns which served as a distance increasing display (Goddard, 1967; Owen-Smith, 1973).

Oestrus in captive Sumatran rhinoceros as determined by sexual receptivity to the bull rhinoceros and lasted about 24 h which is similar to findings in other species of rhinoceroses (Tong, 1961; Goddard, 1970; Owen-Smith, 1972, 1973; Laurie, 1978). However, a duration of 3–4 days (Dittrich, 1967) and 1–6 days (Goddard, 1970) were reported in the Black rhinoceros.

Signs of oestrus commonly observed in the Sumatran rhinoceros were increased in the frequency of urine spraying, tail raising or swinging, anogenital and other contacts involving the hind quarters and flank of the male. Aggression displayed by chasing and biting were observed a day before oestrus. Many observers have drawn a relationship between courtship behaviour and displays of dominance or aggression. However, the aggressive tendencies of the territorial White male rhinoceros seem strongly muted throughout the courtship period. Males quickly moved away from females when threatened (Owen-Smith, 1973).

Unlike in the other species of rhinoceros, copulation was not prolonged in the Sumatran rhinoceros. In the other species, copulation may range from 15 min to more than 1 h (Backhaus, 1964; Greed, 1967; Hallstrom, 1967; Owen-Smith, 1972, 1973; Jones, 1978; Laurie, 1978). In the present study, intromission was not observed although mounting and penile erection in the Sumatran rhinoceros was analogous to the Indian and White rhinoceros (Laurie, 1978). During mating, intromission should occur before the paired lateral projections became fully expanded. However, in this study, the delay in intromission resulted in a continuous expansion of the lateral projections, which consequently resulted in failure of intromission after several attempts.

Apart from the accurate detection of oestrus, the problems with breeding captive Sumatran rhinoceros are associated with compatibility of the pair, age as well as the layout and size of the breeding enclosure. It was observed that much more aggression was seen in some pairs than others. The aggressive nature of the male would almost immediately start upon introduction and would intensify as the female vocalizes and tries to defend itself. More severe injuries are inflicted on the female in the form of deep lacerations and punctures. Immature male would require a longer period of orientation before a successful breeding. At Basel Zoo, the female Indian rhinoceros (*Rhinoceros unicornis*) only conceived on the

20th observed oestrous cycle (Lang, 1961). Similarly, at the National Zoological Park, Smithsonian Institution, a considerable orientation was required to augment the male's innate reproductive behaviour before a successful copulation was accomplished (Buechner and Mackler, 1976). A common problem with immature males is its repetitive aggressive nature, the timing and correct orientation of a mount and a long period of searching for the vulva before intromission.

During mounting by the male, the stability of the female depends greatly on the firmness of the ground, the surface level, the gradient and the presence of obstacles. Soft slippery grounds cause the female to slip easily and lose balance. Similarly, if the ground were markedly uneven, the female would not be able to support the weight and movements of the male prior to intromission. A slight gradient up to 20° is acceptable, with the female facing downwards and the male mounting from a higher point. Objects including logs, posts, trees and fences within a small enclosure (540 m²) do create a problem during mounting and postmounting. However, the presence of natural obstacles including logs, trees, slopes, clump of shrubs and wallows in a large enclosure (>1000 m²) provides an escape for female against the male's aggression, during the initial contact promoting behaviour. Similar observations were reported with small enclosures and obstacles including fences, gates and ramps (Buechner and Mackler, 1976).

It is also common to see the female, not in oestrus, being submissive to the severe aggression of the male and stood still as in "standing heat". This severe contact promoting behaviour occurs in a small, open enclosure where the female is constantly exposed to the male.

5. Conclusions

The results of this study have demonstrated that the reproductive behaviour of the Sumatran rhinoceros can be studied in captivity. The pattern of courtship was comparable to the Black rhinoceros, except that the Sumatran rhinoceros displayed lesser excitability. Like many other domesticated animals, the Sumatran rhinoceros exhibited flehmen reflex especially near an oestrous female rhinoceros. Copulation time displayed by the Sumatran rhinoceros was shorter than that of other rhinoceros species reported previously. However, the solitary behaviour of the male rhinoceros in the wild would necessitate that only females in oestrus are introduced into the males' enclosure in a captive breeding programme.

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