

Infanticide in captive stump-tailed macaques (*Macaca arctoides*) is in accordance with the sexual selection hypothesis

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The present study reports infanticide among stump-tailed macaques. The incident was observed when the study group was manipulated by introducing the β -male to the mother–infant pair at the breeding centre. As no copulation was observed between the β -male and the victim's mother, it was safe to exclude the β -male as the probable father. The infant was 14 months old and still suckling when she was killed. The aftermath of the infanticide was a successful copulation and eventual conception by the victim's mother. This observation was found to be in accordance with the sexual selection hypothesis.

Keywords: Copulation, infanticide, mounting, sexual selection, stump-tailed macaques.

INFANTICIDE by adult males in primates has been reported both in the wild and in captivity¹. Several hypotheses have been proposed for infanticide in non-human primates^{2,3}. In the case of sexual selection hypothesis, the following conditions should be fulfilled: (1) the infanticidal male is not related to the infant, (2) the infant may have prevented the mother from resuming ovulatory cycles, for example, via nipple contact and (3) the infanticidal male has a high chance to sire the next infant of the victim's mother¹. The majority of reported infanticides support the sexual selection hypothesis^{4–10}, although certain observed infanticides were found to be in accordance with the social pathology hypothesis^{11,12} and food competition hypothesis¹³. Infanticide in captive primates was mainly due to: improper housing conditions leading to intermingling of groups¹⁴, artificial changes in group composition leading to the absence of the victim's father within the group⁴ and group take-over by new males¹⁵. Infanticide by adult males has been reported in several species of *Macaca* including *Macaca cyclopis*, *M. fascicularis*, *M. fuscata*, *M. mulatta*, *M. nemestrina*, *M. silenus*, *M. sinica* and *M. sylvanus*¹. Macaques live in multi-male multi-female groups where mating is promiscuous and as a result, there are more males to defend the infant. This increases the risk for infanticidal males and reduces the likelihood that infanticide occurs¹. Furthermore, seasonal breeding also reduces any likelihood that males will benefit from infanticide, since females who lose their infant cannot resume cycling until the following mating

season⁵. However, among annual breeders the subsequent infant might have a higher chance of survival¹⁶ and in species where the breeding cycle covers more than one year, infanticide has been reported repeatedly^{5,17}.

The stump-tailed macaques (*Macaca arctoides* I. Geoffroy Saint-Hillaire, 1830) are an arboreal primate of the family Cercopithecidae. They occur in Bangladesh and North East India in the South Asian region, from South China to West Malaysia, Thailand and North Myanmar. In Bangladesh, the species is now locally extinct and in India its population is critically endangered¹⁸. *Macaca arctoides* are the least studied primate species in India. The present report is part of a larger study we are conducting on the breeding behaviour of this species.

The present communication reports infanticide in stump-tailed macaques under captive condition. Here, we describe the circumstances under which infanticide occurred and examine whether this incident is in accordance with the sexual selection hypothesis.

We studied a captive group of stump-tailed macaques (*M. arctoides*) housed at the Aizawl Zoological Park (Mizoram) from June 2009 to January 2012. The monkeys were provisioned once a day with leaves, fruits and vegetables. Breeding is seasonally restricted with matings during September to February, and births during February to August. Inter-birth interval was counted from one conception to another, each followed by the birth. Gestation period was counted from the day of detumescence of conception cycle to the day of infant birth¹⁹. From the nine births recorded during the study period, none of the females gave birth in consecutive years. Thus, the inter-birth interval was estimated to be 23 ± 2 months and the gestation period to be 7 months \pm 20 days. During the mating season between September 2009 and February 2010, the study group consisted of 18 animals, three adult males (named as α -male, β -male and γ -male) of 29, 27 and 8 years respectively; nine adult females between 6 and 22 years; four juveniles and two infants. All the individuals were identified on the basis of morphological features such as face and genital colour, nipple shape and pattern of dark patches/scars on the face. The monkeys were housed in the main enclosure with two indoor rooms and one outdoor enclosure covering 850 m². Individuals of the study group could be readily observed at all times.

During the mating season of 2009–10, the α -male was never found to copulate with any female and prevented the β -male from mating. Only the γ -male mated with 60–110 pelvic thrusts²⁰. From our observation no ejaculation occurred with less than 60 pelvic thrusts. Ejaculation was identified by a pause during which the male's body stiffened and muscular spasms could be observed. Once the female (named Rani) became pregnant she was moved to the breeding centre on 5 June 2010, where she was kept by herself to facilitate observation of parturition. Rani gave birth to a female infant on 25 July 2010. The breeding centre consisted of one indoor room and an outdoor

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enclosure covering an area of 1920 m², where only the mother–infant pair was allowed. About eight months later, the β -male was introduced to the breeding centre on 10 April 2011. Animals at the breeding centre were observed twice a week from 0700 to 1700 h, and focal animal and scan sampling data were recorded.

When the β -male was introduced to the breeding centre, the infant was about 8 months old. The β -male never interacted aggressively towards either the mother or the infant, except on the day of infanticide. On 5 September, the β -male mounted the mother for the first time. All attempted mountings by the β -male were harassed by the infant, by climbing onto her mother's back, which ultimately forced the male to dismount. No ejaculations were observed. On 17 September 2011, at 0935 h, the β -male mounted the mother with 15 pelvic thrusts. When the infant jumped onto the back of the mother, the male instantly dismounted. About 10 min later, the β -male grabbed the infant by her tail and hit her head on the cemented wall of the night house. The mother did not defend her daughter even though she was only a few metres away. The whole incident took only a few seconds. Afterwards, the mother approached the infant and touched her head. She stayed with her for a few minutes then moved toward the β -male and both walked away. When we subsequently removed the infant about 10 min after the incident, we noticed that it had died due to severe head trauma. The infant was 14 months old and still in nipple contact when she died. In the evening of the same day, copulation followed by ejaculation was observed. After the infanticide, the victim's mother and the β -male were found to closely associate with one another and they copulated several times. Ultimately, the victim's mother became pregnant and gave birth on 28 April 2012.

The evolutionary significance of infanticide and the context in which infanticide occurs have been a subject of interest³ and have remained a hotly debated issue²¹. Sussman *et al.*²¹ have argued that infanticide cannot be an important cause of death among primates. However, infanticide has been estimated to be responsible for 20–64% of all infant mortality in some well-studied species^{5,22–25}. In the present study, during the mating season (September 2009 to February 2010), all the animals were part of a multi-male, multi-female group residing in the main enclosure. Here, none of the adult males behaved aggressively towards the infants. The infants were well protected by the dominant male and adult females, including their mothers even when the juveniles attempted to touch them. In fact, the α -male was found to maintain proximity to the mother–infant pairs, especially when the infants were less than 2 months. Furthermore, the α -male was believed to be the father of all infants until the next breeding season. The incident was observed after the group was manipulated by shifting the mother–infant pair (prior to parturition) and the β -male (after parturition) into the breeding centre. Frequency of infanticides in

multi-male groups is low when compared to those of one-male groups²⁶. However, many studies have reported infanticide by males in both multi-male groups^{5,17,27,28} and seasonal breeders^{5,29}. Absence of the adult male's aggressive behaviour towards the infant within the main enclosure could be attributed to the presence of the infant's father and other group members, including the adult females that might have defended the infant.

New immigrants were the most likely to commit infanticide; however, within-group males should also not be ruled out in the absence of direct evidence³⁰. During the mating season, no successful copulation was observed between the β -male and any of the oestrus females, including Rani, as mounting was immediately disturbed by the α -male²⁰. Thus, in spite of the β -male being present in the group when the female was conceived, it was unlikely to be the father of the infant. Furthermore, the infant was born when the β -male was absent.

Infants residing within the main enclosure showed earlier independence from their mother and weaned at the age of about 10 months. This could likely be due to the presence of the group members and particularly their peers (unpublished data). However, the female and her daughter were alone in the breeding centre and thus may have developed a strong mother–infant bond compared to those inside the main enclosure and the infant remained unweaned even at the age of 14 months. The suckling intensity influences the cyclic pattern of the mother and suckling inhibits the postpartum resumption of normal reproductive function in primate females³¹. Thus, the maintenance of regular nipple contact might have prevented the mother from resuming ovulatory cycles. Furthermore, no successful copulation could be performed as the infant disturbed any attempt of mounting by climbing onto the back of the mother, thereby causing the β -male to dismount. Therefore, it seems likely that the β -male could no longer tolerate the infant's action and finally killed her. The death of the infant ultimately allowed the infanticidal male to mate with the victim's mother efficiently and with ejaculation. In other words, infanticide increased the chance of the β -male to sire the subsequent infant. In the light of the above discussion, we confirm that the infanticide observed in captive stump-tailed macaques is in accordance with the sexual selection hypothesis.

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Evaluation of census techniques to estimate the density of slender Loris (*Loris lydekkerianus*) in Southern India

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Reliable estimates of species density are fundamental to planning conservation strategies for any species; further, it is equally crucial to identify the most appropriate technique to estimate animal density. Nocturnal, small-sized animal species are notoriously difficult to census accurately and this issue critically affects their conservation status. We carried out a field study in southern India to estimate the density of slender loris, a small-sized nocturnal primate using line and strip transects. Actual counts of study individuals yielded a density estimate of 1.61 ha⁻¹; density estimate from line transects was 1.08 ha⁻¹; and density estimates varied from 1.06 ha⁻¹ to 0.59 ha⁻¹ in differ-

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