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NEWS AND PERSPECTIVES

Maternal responses to dead infants in Yunnan snub-nosed monkey (*Rhinopithecus bieti*) in the Baimaxueshan Nature Reserve, Yunnan, China

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Abstract How a nonhuman primate mother responds to her dead infant is an indication of maternal behavior and perspectives on death. Here we describe three cases of a mother's response toward her dead infant in Yunnan snub-nosed monkeys (*Rhinopithecus bieti*) at Baimaxueshan Nature Reserve in Yunnan, China. The mother, whose infant died at 1 month of age, showed strong maternal affection to the corpse and carried it for 4 days. A mother with a stillborn infant showed similar maternal behavior to her dead offspring, but only held it for 1 day. The mother of an aborted infant abandoned the carcass without carrying it or displaying other forms of maternal behavior. Our results suggest that the mother–infant bond in the Yunnan snub-nosed monkey is strongly influenced by the infants' age. Postdeath infant-carrying behavior could be affected by the combined action of reproductive hormones and the emotional response of the mother. This manuscript represents the first detailed report of a mother carrying her dead infant in this endangered monkey species.

Keywords Mother–infant bond · Death · Stillbirth · Abortion · *Rhinopithecus bieti*

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Introduction

The mother–infant relationship is the strongest social interaction in primates (Altmann 1980). Given the extended period of infant dependence in many primate species, the actions of both the mother and the infant are responsible for maintaining this mother–infant relationship (Poirier 1968). Recently, several papers have been published detailing maternal and individual responses in primates to the death of group members. In primate species such as Japanese macaques (*Macaca fuscata*), gelada baboons (*Theropithecus gelada*), and chimpanzees (*Pan troglodytes*), mothers have been observed to carry the bodies of their dead offspring for several days (Sugiyama et al. 2009; Cronin et al. 2011; Fashing et al. 2011). In other species such as mountain gorillas (*Gorilla beringei*), group members are reported to exhibit allomaternal behavior toward another's dead infant (Warren and Williamson 2004). As carrying dead infants appears to have no direct benefit to primate caretakers, the question of why postdeath infant-carrying behavior persists in some primate species and not others (e.g., *Lemur catta*: Nakamichi et al. 1996) is an important question in both human and nonhuman primate evolution. Several hypotheses have been proposed to explain the mechanism underlying this behavior:

1. The postparturient condition hypothesis (Kaplan 1973; Biro et al. 2010) proposes that postpartum hormones influence maternal behaviors toward dead infants, i.e., hormones are essential for the onset and maintenance of infant-carrying behavior and the development of the mother–infant bond.
2. The slow decomposition hypothesis (Fashing et al. 2011) suggests that under conditions in which a hot, dry (or cold, dry) climate slows down the

decomposition process, primate mothers may continue to carry dead infants until clear signals of decomposition (possibly particular odor cues) indicate death.

3. The unawareness of death hypothesis (Hrdy 1999) posits that mothers and other group members cannot distinguish dead infants from immobile infants. According to this hypothesis, dead infants that continue to resemble live infants may be initially responded to as if they were alive.

Evidence favoring one or more of these hypotheses has been discussed in a paper by Anderson (2011). However, due to the scarcity of detailed and systematic observations of individuals responding to the death of conspecifics in most primate species, more field and laboratory studies are needed to understand the origin and any possible function of this behavior.

The Yunnan snub-nosed monkey (*Rhinopithecus bieti*), a highly endangered species, inhabits alpine temperate forests at an altitude of 3,000–4,500 m in the trans-Himalayas in northwestern Yunnan and southeastern Tibet, China (Long et al. 1994). *R. bieti* forms large social groups, with many one-male units (OMUs) and one all-male unit (AMU). An OMU is composed of one adult male, several adult females, and their offspring (Kirkpatrick et al. 1998). Mothers are the principle caretaker of their infants. However, individuals in the same OMU other than the mother have been observed to carry, groom, and even nurse a newborn infant in snub-nosed monkeys (Xi et al. 2008).

In the Sichuan snub-nosed monkey (*R. roxellana*), Lv et al. (2007) described one case of a mother carrying her dead infant. The mother groomed, nuzzled, and sniffed her dead infant and carried it for more than a month. Maternal responses to dead infants have not previously been reported in *R. bieti*. In this study, we present data from long-term observations of a provisioned group of *R. bieti*, and describe three instances of a mother's response to her dead infant.

Methods

This study was conducted between February 2010 and March 2011 at Xiangguqing (27°30′N, 99°20′E) in the Baimaxueshan Nature Reserve, Yunnan, China. The vegetation and climate in this area have been described by Li et al. (2010). The study group was composed of approximately 90 individuals distributed in seven OMUs and one AMU (from April 2010 to January 2011). The study troop has been provisioned with lichens, apples, carrots, and peanuts two or three times per day in the provisioning site since 2008. The monkeys were well habituated to the presence of researchers and could be approached to within 5–30 m (Ren et al. 2011). We classified individuals into six age/sex categories: adult males, adult females, subadult males, subadult females, juveniles, and infants (Kirkpatrick 1996; Li et al. 2010). All individuals were recognized and named. Our study mainly began when morning provisioning took place (0800 hours) and ended between 1730 and 1900 hours when the group left the provisioning site and entered the night-time sleeping site. We focused on six mother–infant dyads from three OMUs (YDH, HC, and BL) and recorded mother–infant relationships and infant-handling behavior. Focal samples include both point and one/zero recording methods at 30-s intervals (Altmann 1974). We also recorded all instances in which group members responded to a dead infant from another OMU (ZZ, SB, BC, and JJ). Once we found a dead infant, we conducted continuous observations of the mother and recorded her behavior toward the corpse. The responses of other group members toward the dead infant were recorded ad libitum (Martin and Bateson 1993). During the >400 days of contact time we established with this group, we found three cases of dead infants. Some cases of mothers whose infant disappeared but no body was found are not presented here.

Results

Case 1: responses toward the dead Infant by the mother and other group members

At 1534 hours on 3 April 2010, we found a dead infant DI in the SB unit (Table 1), which was carried by its mother DF. DF was multiparous. DI was a 1-month-old male who died from agnogenio. No visible injuries were found on the body, supporting our observations that DI has not been killed by a predator or conspecific.

DF held the dead infant when feeding (Fig. 1a) and carried the dead infant with one arm when she moved

Table 1 Organizations of the SB unit (3 April 2010) and ZZ unit (14 January 2011)

Resident male	Adult female	Subadult female	Juvenile	Infant
SB	DF	DS	JT	DI[a]
	EF	ES		EI
	SF			SI
ZZ	SY	YS	LL	DZ
	DY	BS		EZ
	BG	TS		SZ
	BE			
	PP			

[a] DI was born to DF on 5 March 2010

Fig. 1 DF and her dead infant: **a** DF holds her dead infant DI during feeding; **b** DF carries the corpse with one forelimb; **c** while at rest, DF grooms the corpse

(Fig. 1b). This type of carrying behavior previously had only been observed when a mother carried her newborn infant, who was unable to cling to the mother's ventrum on its own. When alarm calls from other group members were heard, DF quickly cuddled the corpse to her chest. During resting, DF grasped the corpse and groomed the dead body occasionally (Fig. 1c).

At 1607 hours on 3 April, a subadult female of the SB unit approached DF and stared at DI for 10 s without touching it. DF then left carrying the corpse. At 1222 hours on 4 April, DF climbed into a tree with the dead infant and groomed it on three separate occasions while resting [mean ± standard error (SE) = 14.33 ± 5.53 min, $N = 3$). The longest grooming bout lasted 24.5 min. The average duration of grooming bouts of the six focal mother–infant dyads was 1.52 ± 0.22 min. Thus, DF spent a markedly greater amount of time grooming her dead infant. At 1330 hours on 6 April, DF left the corpse on the ground and climbed into a tree. By this time, the dead infant had lost most of the hair on its body and showed other signs of decay. The dead infant was retrieved by the reserve staff and buried. When DF found its infant missing 30 s later, she moved through the tree canopy and vocalized "wa-wa-". The searching effort diminished quickly and ceased in the evening. DF had kept her dead infant for almost 4 days. No direct contact with the dead infant or social activities toward the mother by any group member was observed in these 4 days. DF appeared to avoid interacting socially with the rest of her OMU.

Case 2: abandoned aborted dead infant

At 1000 hours on 24 December, 2010, the dead body of an aborted infant was found on the ground at the group's night-time sleeping site (Fig. 2). The group had left their sleeping tree at 0800 hours that morning, and we were

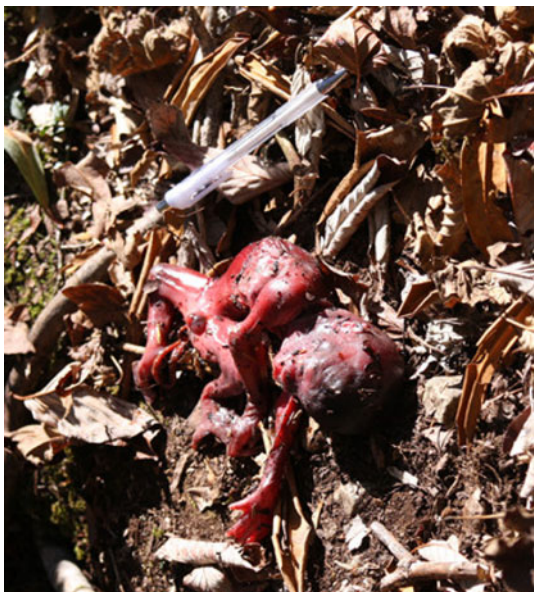

Fig. 2 Abandoned aborted infant, 24 December 2010

unable to confirm the dead infant's mother. The corpse was fresh and hairless, and we did not find the placenta. We estimate that the corpse had been delivered <6 h before it was found. The baby was at least 1 month premature and died before or during parturition (reserve veterinarians' diagnosis).

Case 3: responses toward the stillborn Infant by the mother and other group members

At 1020 hours on 14 January 2011, the female SY in the ZZ unit (Table 1) was observed carrying a dead infant (Fig. 3a). The baby was born on the night of 13 January. Based on its size and thin hair, we believe that the baby was stillborn (Fig. 3b).

Fig. 3 SY and her stillborn infant: **a** SY carries a dead infant; **b** corpse of the stillborn infant; **c** LL tries to touch her dead sibling; **d** SY sits close to ZZ with her stillborn infant on her ventrum

SY handled the dead infant in a manner similar to DF. LL, the elder sister of this stillborn baby, showed interest in her dead sibling: At 1052 hours, LL sat near her mother, peered at the corpse, and tried to touch it (Fig. 3c). SY rejected LL's attention to the infant by hitting her. Mothers of newborn babies show similar mild aggression toward juveniles who try to touch their baby (unpublished data). At 1157 hours, LL was bitten by SY for attempting to touch the corpse. LL was bitten by SY again at 1453 hours as she continued to be attracted by the stillborn infant. Other adult females in the ZZ unit glanced at the corpse a few times at a distance. At 1430 hours, SY moved toward the harem male, ZZ, and sat close to him with the corpse on her ventrum (Fig. 3d). ZZ was indifferent to SY and the corpse. At 1507 hours, infants of the ZZ unit were playing with one another. One infant jumped to SY and looked at the corpse curiously. SY made a threatening call at the infant, and it quickly ran away. On the morning of 15 January, SY did not come to the provisioning site with other members of her group. She was observed to remain at the sleeping site alone without the corpse, and we never saw the stillborn infant again. SY had carried the dead infant's body for 1 day. Due to a heavy snowfall, we discontinued our observations until the afternoon of 16 January. At that time, SY was observed traveling and foraging with the ZZ unit and behaved like other adult females. At 1535 hours, SY grabbed and tried to groom an infant of another female in the ZZ unit. The infant screamed and escaped from her. Our observation ceased at 1700 hours because of heavy snowfall. We had not previously recorded any allogrooming between SY and any other member of her OMU during our 3-day observation period.

Discussion

Observations documenting the manner in which primates interact with dead infants offer important insight into maternal affection and perspectives on death in nonhuman primates (Nakamichi et al. 1996). In order to better understand primate views of death, we need to evaluate an individual's reaction to abnormal or unexpected behavior, and in the case of a mother, how this expectations interact with the neuroendocrine system in both forming and

breaking the mother–infant bond. In this study, the mother DF showed intense maternal attachment to her dead infant, DI, which died at 1 month of age. DF carried the corpse for 4 days before it was taken by the reserve staff. In this same study group, a mother was observed holding the remains of her dead infant for more than 1 month (Ren BP, unpublished data). Thus, it appears that in *R. bieti,* a mother might continue to carry her dead infant much longer than we reported here. Considering that DF and SY were both multiparous, we can assume that they could detect abnormal infant behavior. While SY carried her immobile infant for an entire day, and DF continued to carry the corpse of DI even after it had begun to decay, it is unlikely that they were not aware that the infants were not responding in an appropriate manner. Thus, we can assume that mothers of *R. bieti* realized they were carrying dead or abnormal infants, which is not consistent with the unawareness of death hypothesis.

Based on our observation of this group, adult females and subadult females in the same OMU carry and groom infants, especially when these infants are younger than 1 month old. However, although there were two adult females and two subadult females in the SB unit and four adult females and three subadult females in the ZZ unit who were capable of performing allomaternal behavior toward live infants, only SY's young daughter, LL, showed obvious interest in the corpse. Is it possible that LL was too young to understand her sibling was dead, whereas other group members were fully aware? Young monkeys of *R. bieti* are curious about new objects (personal observation), so there is also the possibility that LL tried to touch the newborn dead infant merely out of curiosity.

Overall, our results do not support the slow decomposition hypothesis. Although Yunnan snub-nosed monkeys live in high-altitude forests characterized by low temperatures, which could act to slow decomposition, SY only carried her dead infant for 1 day. This occurred even though the infant died on a cold winter day. The abandoned aborted infant also was delivered in winter, but its mother never carried it. In contrast, DF's infant died during a much warmer period of the year, and she continued to carry her dead infant for 4 days. Thus, we conclude that in *R. bieti*, climatic conditions and decomposition of the corpse were not the primary factors influencing maternal response to these dead infants. We reject the slow decomposition hypothesis.

Based on our three cases, there is evidence that a mother's response to her dead infant in *R. bieti* was possibly affected by the length of the time period during which a mother bonded with her infant. The aborted infant was never carried, the stillborn infant was only carried for only 1 day, and the infant who died at 1 month of age was carried for 4 days. A similar pattern has been reported in squirrel monkeys (*Saimiri sciureus*) (Kaplan 1973) and Japanese monkeys (Sugiyama et al. 2009) and may be related to endocrine changes during pregnancy and postpartum that provide a basis for the formation of a strong mother–infant attachment bond (Maestripieri and Zehr 1998; Bardi et al. 2001). Physiological-endocrinological changes during the first few days of postpartum may act in coordination with the cognitive-experiential system in helping primate mothers to attach with their infant (Bardi et al. 2004). The strong interest SY showed in another infant soon after she lost her own infant may be explained by hormonal changes associated with parturition that sensitized her to directing maternal behavior to another female's infant. In this regard, given that DF had established a strong bond with DI during its first month of life, this may explain why she continued to carry her dead infant for several days after its death. Our results are consistent with the report of Kaplan (1973) that maternal response to her dead infant appears to be more selective with the passage of time after parturition.

Chimpanzees are reported to experience grief in the presence of dying or dead group members (Anderson et al. 2010). A bereaved mother continued to carry her 2-month-old dead infant in response to the strong emotional bonds they developed (Biro et al. 2010). Close relatives groomed a dying group member for an extraordinary amount of time, and they remained lethargic and quiet for several days postdeath (Anderson et al. 2010). These behaviors appear to be analogous to behaviors exhibited by humans experiencing similarly traumatic events (Pearson 2003). In our report, DF and SY both stopped social activities for at least 3 days after their infants died, and DF's unusually long time spent grooming her dead infant also might be an expression of grief. Unfortunately, we do not have behavioral data on either DF or SY before they lost their infants and therefore we are unable to compare their infant-directed behavior pre- and postinfant death. Overall, it is likely that hormones associated with parturition and lactation combined with the formation of a strong mother–infant attachment, which requires the active participation of both mother and infant, offer the strongest explanation for our observations.

We conclude that in some species of nonhuman primates, mothers experience a grieving process similar to that experienced by human mothers, and therefore, primatological perspectives on death are relevant for studying human thanatology. Many questions remain unanswered, including under what conditions and why a mother cease carrying her dead infant. Further research on maternal responses to infant death is required to better understand maternal affection and perspectives on death in snub-nosed monkeys.

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References

Altmann J (1974) Observational study of behavior; sampling methods. Behaviour 69:227–267

Altmann J (1980) Baboon mothers and infants. Harvard University Press, Cambridge

Anderson JR (2011) A primatological perspective on death. Am J Primatol 71:1–5

Anderson JR, Gillies A, Lock LC (2010) Pan thanatology. Curr Biol 8:349–351

Bardi M, Shimizu K, Fujita S, Borgognini-Tarli S, Huffman MA (2001) Hormonal correlates of maternal style in captive macaques (*Macaca fuscata* and *M. mulatta*). Int J Primatol 22: 647–662

Bardi M, French JA, Ramirez SM, Brent L (2004) The Role of the endocrine system in baboon maternal behavior. Biol Psychiatry 55:724–732

Biro D, Humle T, Koops K, Sousa C, Hayashi M, Matsuzawa T (2010) Chimpanzee mothers at Bossou, Guinea carry the mummified remains of their dead infants. Curr Biol 20:351–352

Cronin KA, Van Leeuwen EJ, Mulenga IC, Bodamer MD (2011) Behavioral response of a chimpanzee mother toward her dead infant. Am J Primatol 73:415–421

Fashing PJ, Nguyen N, Barry TS, Goodale CB, Burke RJ, Jones SCZ, Kerby JT, Lee LM, Nurmi NO, Venkataraman VV (2011) Death among geladas (*Theropithecus gelada*): a broader perspective on mummified infants and primate thanatology. Am J Primatol 73: 405–409

Hrdy SB (1999) Mother nature: a history of mothers, infants and natural selection. Pantheon Books, New York

Kaplan J (1973) Responses of mother squirrel monkeys to dead infants. Primates 14:89–91

Kirkpatrick RC (1996) Ecology and behavior of the Yunnan snub-nosed langur (*Rhinopithecus bieti*, Colobinae) Ph.D. dissertation. University of California, Davis

Kirkpatrick RC, Long YC, Zhong T, Xiao L (1998) Social organization and range use in the Yunnan snub-nosed monkey *Rhinopithecus bieti*. Int J Primatol 19:13–51

Li DY, Ren BP, Grueter CC, Li BG, Li M (2010) Noctural sleeping habits of the Yunnan snub-nosed monkey in Xiangguqing, China. Am J Primatol 72:1092–1099

Long YC, Kirkpatrick CR, Zhong T, Xiao L (1994) Report on the distribution, population, and ecology of the Yunnan snub-nosed monkey *Rhinopithecus bieti*. Primates 35:241–250

Lv JQ, Zhao DP, Li BG (2007) Prolonged carrying of a dead infant among the golden monkey *Rhinopithecus roxellana* in the Qinling Mountains, China. Acta Zool Sinica 53:175–178

Maestripieri D, Zehr JL (1998) Maternal responsiveness increases during pregnancy and after estrogen treatment in macaques. Horm Behav 34:223–230

Martin P, Bateson P (1993) Measuring behaviour: an introductory guide. Cambridge University Press, Cambridge

Nakamichi M, Koyama N, Jolly A (1996) Maternal responses to dead and dying infants in wild troops of ring-tailed lemurs at the Berenty Reserve, Madagascar. Int J Primatol 17:505–523

Pearson M (2003) The archeology of death and burial. Sutton Publishing, Phoenix Mill

Poirier EE (1968) The Nilgiri langur (*Presbytis johnii*) mother–infant dyad. Primates 9:45–68

Ren BP, Li DY, He XM, Qiu JH, Li M (2011) Female resistance to invading males increases infanticide in langurs. Plos one 6:1–4

Sugiyama Y, Kurita H, Matsui T, Kimoto S, Shimomura T (2009) Carrying of dead infants by Japanese macaque (*Macaca fuscata*) mothers. Anthropol Sci 117:113–119

Warren Y, Williamson EA (2004) Transport of dead infant mountain gorillas by mothers and unrelated females. Zoo Biol 23:375–378

Xi WZ, Li BG, Zhao DP, Ji WH, Zhang P (2008) Benefits to female helpers in wild *Rhinopithecus roxellana*. In J Primatol 29: 593–600