



TITLE:

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Feral horses' (*Equus ferus caballus*) behavior toward dying and dead conspecifics

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Abstract

In the rapidly expanding field of comparative thanatology, reports from a wide range of taxa suggest that some aspects of a concept of death may be shared by many non-human species. In horses, there are only a few anecdotal reports on behaviors toward dead conspecifics, mostly concerning domestic individuals. Here, we describe the case of a 2-month-old, free-ranging male foal that died around 12 h after being found severely injured due to a presumed wolf attack, focusing on other individuals' reactions to the dying foal. We also placed camera traps near horse carcasses to investigate reactions by other horses. Kin and non-kin of both sexes showed unusual interest in the dying foal. However, horses appeared to avoid dead conspecifics. Recording individual reactions to dead and dying conspecifics in naturalistic settings will enhance our knowledge about death-related behaviors in horses, allowing comparisons with other species that have been more thoroughly studied, to understand the evolutionary basis of these behaviors.

Keywords Horse · Death-related behaviors · Thanatology · Awareness of death · Wolf attacks · Injured individual

Introduction

Reactions toward dead and dying conspecifics by wild and domestic animals have been poorly documented (Pierce 2013; Gonçalves and Biro 2018). However, recent interest in animal thanatology has been growing. Despite the anecdotal nature of many reports, compiling these records may shed light on how non-human animals perceive and respond to death, including their awareness of death in others, and behavioral and physiological changes. Comparative thanatology can thus help us to understand the evolutionary foundations of animals' mental states as well as their social bonds (Bercovitch 2012; Anderson 2016). Here, we focus on mammalian species.

Thanatological behaviors have been reported particularly in primates, African elephants (*Loxodonta africana*), and cetaceans taxa which live in common complex societies, with long-lasting parental care and large brains, attributes comparable to those in humans (Marino et al. 2007; Byrne and Bates 2007). The behaviors include mobbing/alarm calling, aggression, dead infant carrying, vigils and visiting the corpse (primates: Sugiyama et al. 2009; Biro et al. 2010; Anderson 2011, 2016; Cronin et al. 2011; Watson and Matsuzawa 2018; elephants: Bere 1966; Moss 1988; Payne 2003; Douglas-Hamilton et al. 2006; cetaceans: Bearzi et al. 2017). In ungulates, giraffes may interact with dead infants for several days after their death (Muller 2010; Bercovitch 2012); they also approach and inspect other conspecific carcasses (Muller 2010; Carter 2011). Other mammalian species for which thanatological responses have been described include manatees (*Trichechus manatus*, Hartman 1979), harbor seals (*P. vitulina concolor*, Rosenfeld 1983; Austin et al. 2001), sea otters (*Enhydra lutris*, Kenyon 1969), dingoes (*Canis dingo*, Appleby et al. 2013), dwarf mongooses (*Helogale parvula*, Rasa 1983), lions (*Panthera leo*, Schaller 1972), foxes (*Vulpes vulpes*, Macdonald 1991), and peccaries (*Pecari tajacu*, de Kort et al. 2018). Reports on thanatological behaviors in horses are scarce. Almost 150 years ago, Murray (1871) described the offspring of a dying mare standing near her, looking at her and staying there when a human approached. Marais (1969) described the reaction of a female, toward her 2-day-old foal after it drowned. The female showed signs of distress, she nuzzled the body and whinnied softly. Another anecdotal account mentions the formation of a circle by horses around the mound where one of their companions had recently been buried (King 2013).

In a study concerning horses' reactions to conspecifics being euthanized (Dickinson and Hoffmann 2016), veterinarians reported various reactions including following and vocalizing to the soon-to-be euthanized individuals. After the death of conspecifics, horses have also been described as showing signs of anxiety, cessation of feeding, and social withdrawal, as

well as approaching and behaving possessively with regards to the carcass (King 2013; Dickinson and Hoffmann 2016). Berger (1986) reported that an adult mare abandoned a 1-day-old foal after it had been attacked by coyotes. Reports on horses' reactions to death come from different sources and backgrounds, but a common theme is that the survivors and the dying or dead individual shared a close social bond. Given also the growing literature on horses' impressive social cognitive skills (Krueger et al. 2010; Proops et al. 2009; Proops and McComb 2012; Smith et al. 2016; Takimoto et al. 2016; Wathan et al. 2016; Ringhofer and Yamamoto 2017), their ability to form and discriminate concepts (Hanggi 1999, 2003; Hanggi and Ingersoll 2009), and their social system consisting of long-term stable bisexual social groups (Cameron et al. 2009), it seems reasonable that cognition might be important in shaping these animals' behaviors toward injured or dead conspecifics.

Here, we report horses' reactions toward (1) a foal that was found injured, dying later the same day, and (2) conspecific carcasses. Although largely opportunistic, our observations may help clarify (1) mother-foal attachment and other factors affecting the mother's behavior, (2) more generally, horses' perception of and responses toward dying kin and non-kin, and (3) responses to dead conspecifics.

Methods

Study site

The study site was at Serra d'Arga Mountain (825 a.s.l.) within an area of 4493 ha, in northern Portugal (8420 N, 41,480 E; see Matsuzawa 2017; Ringhofer et al. 2017 for details). This region has a temperate Mediterranean climate, and the habitat comprises pasture, rocky ground, forest, and shrub areas. The garrano horse is a pony breed endemic to northern Portugal and Galicia, Spain (Morais et al. 2005). The free-ranging population inhabiting this area is subject to predation by Iberian wolves (*Canis lupus signatus*; Álvares 2011; Ringhofer et al. 2017), and managed by the local people, who sometimes capture individuals. Field research on these horses has been ongoing since May 2016. So far, around 35 harem groups have been identified, including more than 210 individuals (excluding foals).

Data collection

We combined data from direct observation of horses' behavior and camera traps. Groups were followed on a daily basis during September 2016, May–July and September–December 2017, and May–July 2018.

Reaction toward an injured foal

We conducted opportunistic observations on the behavior of an injured foal prior to his death on 8 June 2018. We (RM, PP) followed him for 60 min during the morning, about 80 min in the afternoon (MR), and 190 min in the late afternoon (RM, MR, PP, SI). Behavioral observations were conducted using binoculars and video cameras (Sony handycam). The observers were usually more than 10 m away from the horses. We used all-occurrences sampling to record behaviors directed toward the foal and social behaviors among individuals near him. Activity budgets of all observable individuals (including feeding, moving, resting, social interactions, suckling) were recorded by scan sampling every 5 min. Every 2 min, the distance between all observable individuals and the injured foal was recorded as contact, 0–2, 2–5, 5–10, 10–20, and > 20 m.

Reaction toward the dead individuals

Four cases were observed using camera traps (Bushnell Trophycam) programmed to take videos and photos. In each case, two camera traps were placed perpendicularly to each other within 2 m of the carcass. Two carcasses were of adult females and camera traps were in place 18–20 and 22 November, and 25–29 November 2017. The other two carcasses were of foals. One was less than 2 months old at death (the case described, 8–12 June 2018), and the other one was about 1 month old (14–26 June 2018). The camera traps were left for 4–12 days, until the carcasses were completely consumed by scavengers or the bones became scattered. In the fifth case, the behavior of one harem group (Hakata and Nijo group: two males, four females, and four foals) toward a dead female was video-recorded for about 10 min in September 2016.

Results

Reaction toward an injured foal

On the morning of 8 June, at around 10:00, we found “Tsu's group”, which had one male (Tsu), three adult females, and two foals. On this morning, one of the foals was missing, and the other one, a male less than 2 months old, was found alone 300 m away from the group. He had an open wound to the right hind leg and was limping on both hind legs. We presumed

he had survived a wolf attack and that the other foal, which we did not find, was killed by wolves (see Fig. 1 for a summary of the events).

Around 11:00, the group approached the foal, and they remained with him when we inadvertently caused the group to move. From 11:50 the group was followed for 1 h, during which the foal was mostly inactive, moving only when herded by Tsu (15 out of 19 herding events were directed toward the foal: 0.25 events/min). Nabari (the mother) and Tsu were the only individuals to interact with and stay close to the foal (see Supplementary Fig. 1, and supplementary material for details). At 15:55 the foal was found lying in a muddy puddle, apparently unable to stand up. Nabari was feeding less than 10 m away, sometimes exchanging whinnies (0.23 events/min) with the group and interacting with the foal by sniffing and touching his face and front legs. At 16:14, the group started to move away leaving Nabari and her foal behind. From 16:18 to 16:25, Tsu attempted to herd Nabari back to the group; she resisted these attempts and approached the foal seven times (one event/min, Fig. 2a). From 16:25 Tsu remained near Nabari and prevented her from leaving; she continued to look and whinny toward the foal, ten times in total (1.43 events/min). The foal replied to Nabari only once, as she approached him.

At 16:32, “Taiji’s group” (one male, Taiji, and five females) arrived near to where the foal was lying alone and remained within 20 m from the foal for about 40 min (Fig. 2b). All group members initially showed interest in the foal, but most soon lost interest and started to feed nearby. Only two young adult females, Kitayama and Katsuura, remained interested; they started to sniff his face and leg, and licked his left hind leg. Katsuura also investigated and pawed the ground around the foal with her right leg for 5 s. Katsuura threatened and displaced Kitayama four times and also showed some aggression to other group members. In total, she remained within 10 m of the foal for 33 min and had licked him for about 7 min. Around 100 m away from the foal, Tsu remained in front of Nabari, preventing her from approaching the foal. Nabari whinnied 44 times (0.73 events/min) toward the foal, who responded only once, after Taiji’s group had left.

At 18:57, Nabari was found feeding 5–10 m from the foal, still lying at the same place. She was approximately 200 m away from the group; two bachelor males, Usa and Saito, were feeding 10–20 m from her (Supplementary Fig. 2). Nabari and the group’s females exchanged whinnies (females: 0.28 events/min, Nabari: 0.36 events/min) during the 25-min period before she left the foal. The older bachelor male, Usa, harassed Nabari by approaching and nickering at her; Nabari responded aggressively by rearing up and kicking three times (0.12 events/min). At 19:20 Nabari gradually moved away in the direction of the group and whinnied five times, receiving a reply three times from one group member. Three min after his mother’s departure, the foal whinnied twice and got up (at 19:28). While limping in the direction of Nabari, he slipped on the rocks and fell twice, and did not get up after the second fall at 21:40. From the complete lack of movement on the camera trap videos, we estimated that the foal died shortly after 22:38.

Reactions toward dead individuals

Only two indications of interest in the carcasses were recorded by the camera traps. On the night of 9 June 2018 at around 21:15, a group passed by within 5 m from the foal (the case described previously): two males and four females. Two of the four females showed no reaction to the carcass, whereas the other two stopped and looked towards it, with a vigilant posture (Supplementary Fig. 3A). Two males, traveling at the rear, also stopped and looked; one appeared to sniff the ground then became vigilant and continued walking (Supplementary Fig. 3B). No direct contacts with the carcass were observed. On 20 June 2018 at 20:00, a bachelor male was observed moving near the carcass of the other dead foal, which was already partially consumed by wolves. He stopped and looked at the carcass, then continued walking. In the two other cases where the carcasses of two adult females were monitored using camera traps, we saw no clear reactions by horses. Other species including wolves, foxes (*Vulpes vulpes*), crows (*Corvus corax*), a common buzzard (*Buteo buteo*), domestic cows (*Bos taurus*), and a wild boar (*Sus scrofa*) were observed nearby or consuming the carcasses.

In one direct, daytime observation of harem group (Hakata and Nijo group) in which an adult female died giving birth, several individuals (especially one male) stopped and stared at the carcass from 3 to 5 m away, for about 5 min.

Discussion

This is the first detailed report of behaviors shown by a mother and other individuals toward a mortally wounded foal, and what happened after the foal died. The observations indicate conflict between the mother–foal bond and the mother’s bonds with the other members of the group. In the morning when the foal was still able to move, the group male interacted with him, and herded both him and his mother. After the foal fell and was unable to move, only his mother remained nearby, despite attempts by the male to herd her back to the group. However, she eventually abandoned the foal and re-joined group.

The mother’s final abandonment of her dying foal seems likely to have arisen from a combination of social and environmental factors. Feral female horses form long-term social relationships with other females and with the harem male,

who protects them by herding and restricting their movements (Feh 2005). Moreover, given the high predation pressure at our study site, grouping is likely to be important for survival and hence reproductive fitness. The persistent harassment of the mother by two bachelor males might have also contributed to her final decision to abandon the foal, similar to what was observed by Berger (1986).

A few days after the events described above, we found an injured foal that remained lying on the ground as the group moved away. The next day the foal was assumed to have died, as the mother was with the group but the foal was not. On another occasion, a mother was missing for a full day before re-joining her group but without her foal. Remaining close to dead infants for hours or even days is reported in other ungulates, including giraffes (Muller 2010; Bercovitch 2012). As horses have a relatively long gestation period (Feh 2005), and a several-months-old foal is still dependent on the mother for nutrition and protection (Heitor and Vicente 2008), the mother–foal bond is likely to be particularly strong, although it can be influenced by social and environmental factors, as described above.

Non-kin individuals—especially two young adult females—also showed affiliative behaviors toward the injured foal, even though adults usually behave agonistically towards extra-group foals. One young adult, Katsuura, even remained in close contact with the injured foal more than his mother; her foal-directed behavior, including licking and protecting it from other group members resembles maternal behavior towards a newborn (Waring 2003). Interestingly, wolves had attacked this female's own foal a year earlier, and it was presumed to have died from the wounds it received. This female appeared generally more vigilant than the other females in her group (Ringhofer, unpublished data). Thus, her past experiences allied with an inquisitive nature (Siebenaler and Caldwell 1956) possibly triggered her epimeletic behavior toward the injured foal. The other young female, Kitayama, was nulliparous and had dispersed from her natal group about a year earlier. Her behavior possibly derived from curiosity—a common trait in immature individuals (Byers 1984; Byers and Walker 1995; Pereira 2002)—combined with social learning (Forss et al. 2017).

The events described here suggest that horses react to injured individuals with whom they share close bonds (mother–foal) or even looser bonds (e.g., non-kin adults–foal). Such reactions might result from a combination of (1) visual cues, e.g., open wounds, behavioral changes such as limping; (2) olfactory cues, eliciting sniffing by approaching individuals, and (3) other behavioral cues, such as lack of appropriate responsiveness to others' approaches or contacts, e.g., withdrawing from unknown individuals, or non-responding to the male's herding behavior. Social structure also needs to be taken into account; like other species living in stable groups, it is important for horses to understand others and predict their behavior for maintaining stable social bonds (Waller et al. 2016).

After the foal died, only one other group appeared to show interest in the carcass. Some individuals stopped and stared, but no direct interactions with the carcass were observed; this was also true for the other three carcasses for which we set up camera traps: only one bachelor male stopped and stared at the carcass of a foal. In addition, we directly observed a group stopping and staring at a dead adult female 3–5 m away. Horses may generally avoid approaching dead conspecifics, similar to some other animal species (see Gonçalves and Biro 2018 for a review).

Our study shows that horses react and behave differently toward injured or dead kin and non-kin conspecifics, and they pay more attention to individuals when they are still alive than to dead ones. Although some studies suggest that horses have the ability to form abstract concepts (Hanggi and Ingersoll 2009), more research should be done on their cognitive and behavioral responses to death. Integrating such findings with those from studies of other mammalian species will bring new insights into the evolutionary basis of death-related behaviors and ultimately the concept of death.

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Figures

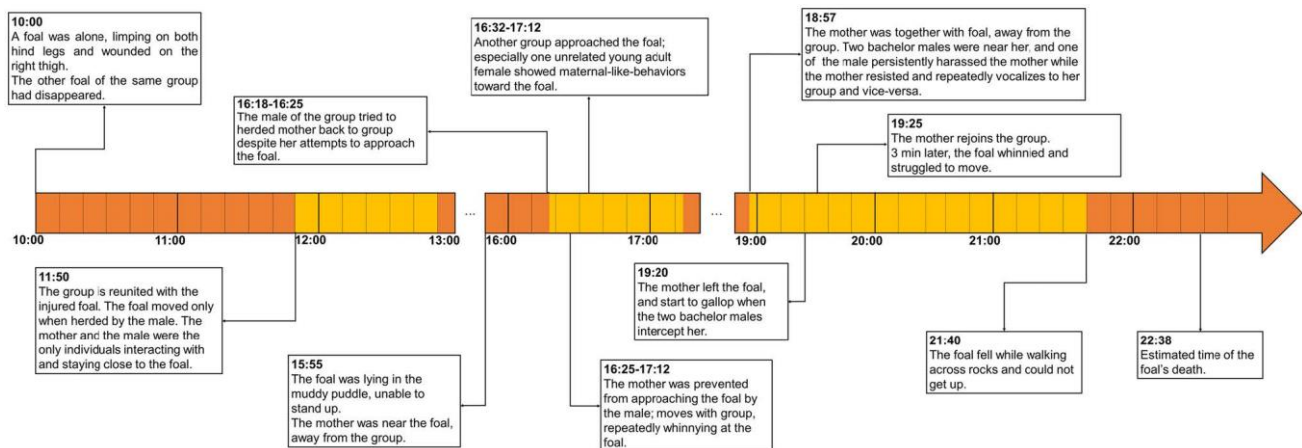


Fig. 1 Timeline including the summary of the events. The yellow part represents when the foal was directly observed

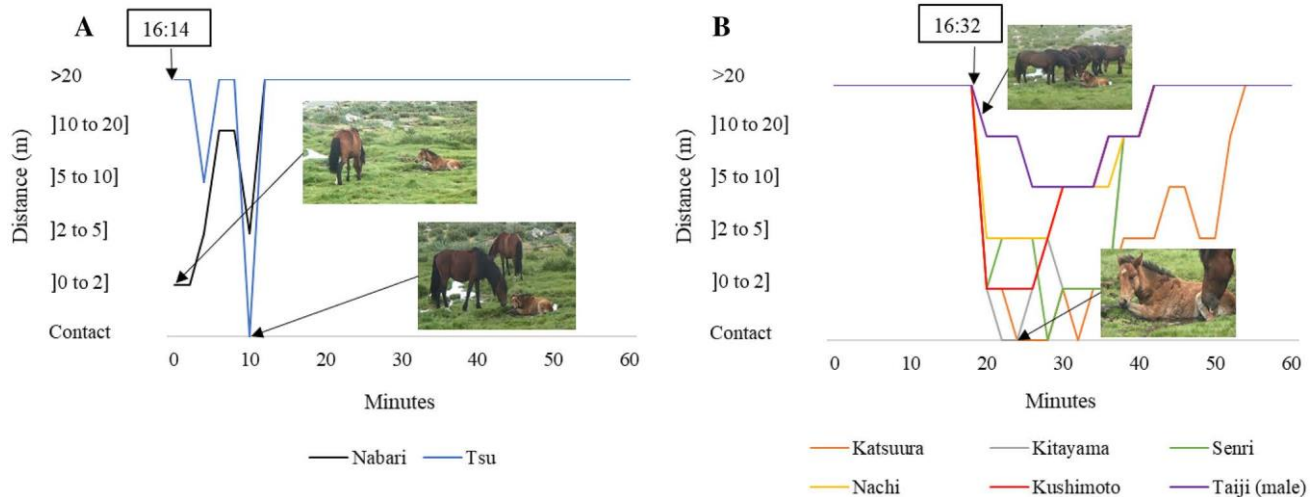


Fig. 2 a Distances between Nabari, the mother (black) and Tsu, the male (blue) and the injured foal during a 1-h observation starting at 16:14. The pictures in the plot represent interactions occurring at minutes 2 (Nabari feeding near the foal) and 10 (Tsu sniffing the foal). b Distances between members of Taiji group and the foal during a 1-h observation period; Katsuura (orange), Kitayama (grey), Senri (green), Nachi (yellow), Kushimoto (red), Taiji (male) (purple). The pictures in the plot represent interactions occurring at minutes 19 (Taiji group meeting the foal) and 24 (Katsuura licking the foal). Coinciding plot lines coincide indicated that individuals were the same distance from the foal