Behavioural Processes 142 (2017) 21–28

Contents lists available at ScienceDirect

Behavioural Processes

journal homepage: www.elsevier.com/locate/behavproc

Mother-young recognition in goitered gazelle during hiding period

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ARTICLE INFO

Keywords:
Gazella subgutturosa
Hider ungulates
Olfactory cues
Mother-young recognition
Vocal/visual cues

ABSTRACT

The mother-young recognition process is crucial for the growth and survival of progeny. In "follower" ungulate species, vocal and visual cues have been found to play a leading role in the mother-young identification process from the first days postpartum, with olfactory cues also important in establishing the initial selective mother-young bond immediately after birth. In "hider" species, however, much less has been documented of mother-young recognition behaviors, especially in their natural habitat. In this paper, we investigated this process in goitered gazelle (*Gazella subgutturosa*), a typical hider species, in its native environment in Kazakhstan. Over the course of our study period, we investigated the behaviors of 257 females with twins and 158 females with singles through visual observations. We found that within the first month after birth, when females spend only a short time with their young, mothers recognized their fawns using mostly olfactory cues, while vision was used to locate their hiding offspring. Fawns vocalized very rarely, producing only distress calls that did not seem intended for individual identification. Licking of young by their mothers was observed frequently, not only during the first week after birth, when this action was very important for fawn stimulation for a number of physiological functions, but for several weeks after (until one month of age), when licking lost its physiological importance and likely became more of a recognition procedure. Fawns did not recognize their mothers at all, either through vision or vocalizations, since during their first weeks after birth, they responded to any gazelle that approached their hiding area. By a month after birth, when mothers and fawns began to stay together for longer periods of time, their recognition process became more enhanced, and in addition to olfactory cues, the mother and her young began to use more and more visual cues for longer distance identification, as well as vocalizations for shorter distances. Similar dynamics are likely typical for most hiding species, although information for wild ungulates is still very limited, especially for those with strong hider behaviors.

1. Introduction

In mammalian species, the most direct and vital component of maternal investment in offspring is lactation (Clutton-Brock et al., 1989), with suckling itself a crucial element contributing to the reproductive success of both the mother and her young (Lavigueur and Barrette, 1992). Most ungulate species belong to precocial mammals, which give birth to a small litter (usually 1–2 newborns) of fully developed young that have the ability to follow their mothers shortly after birth (Nowak et al., 2007). The rapid establishment of mother-young mutual bonding, when mothers individually recognize their neonates within hours after birth, is typical for maternal behavior of all ungulates species (Poindron et al., 1993). Although milk stealing and allosuckling can sometimes be observed in some ungulate species (Roulin, 2002), they typically restrict care to their own offspring and reject any unrelated young, thus displaying selective maternal investment (Torriani et al., 2006). Since lactation has the greatest energetic expenditure (Clutton-Brock et al., 1989) and the quantity of milk has a strong impact on the growth and survival prospects of juveniles, especially during early lactation when milk is the sole source of nutrition (Skogland, 1983; Sams et al., 1996), mother-young recognition is crucial to avoid a mother mistakenly suckling an alien fawn. This, then, allows the mother to devote her available energy resources to her own young to ensure its survival (Torriani et al., 2006).

Olfactory cues are very important for all ungulate mothers in the recognition process of their fawns (Searby and Jouventin, 2003). Before parturition, pregnant females typically (with rare exception – Roberts and Rubenstein, 2014) leave their herds to isolate themselves and their neonates from conspecifics, which is considered essential not only as a means of protection from predators, but also to establish a selective mother-young bond (Lent, 1974; Ciuti et al., 2006). Immediately after giving birth, the mother is attracted to her newborn because of the

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http://dx.doi.org/10.1016/j.beproc.2017.05.016
Received 19 January 2017; Received in revised form 28 April 2017; Accepted 22 May 2017
Available online 24 May 2017

amniotic fluid that covers its body, triggering intense licking of her neonate (Nowak et al., 2007). The attraction to amniotic fluid helps a female learn the individual olfactory characteristics of her offspring, so that within 5–10 min she has established a selective bond with her young through smell. Most mothers show a stable selectivity in nursing within 0.5–2 h after birth (Keller et al., 2003), but are only able to keep these olfactory cues in memory for no more than 3 days, if not in close proximity to their young (Keller et al., 2005). Non-olfactory recognition with help from vocal and visual cues appears slightly later, and becomes fully effective by 6–12 h (Ferreira et al., 2000; Keller et al., 2003) or in some cases even earlier at 2–4 h postpartum (Poindron et al., 2007b; Keyserlingk and Weary, 2007), when mothers have developed a strong enough visual and acoustic recognition of their neonates to distinguish between their own offspring and an unfamiliar one without the help of olfactory cues. Acoustic signals have the benefit that they can be used over both short and long distances, while olfactory signals are effective for recognition only at short distances (Torriani et al., 2006).

In general, the maternal care strategy of ungulates for avoiding predators can be roughly classified into two groups: followers and hiders. The main difference between these two strategies for fawn protection is the distance between mother and infant and the frequency of contacts between them during the first weeks after birth. Young of follower species remain close to their mothers from shortly after birth and constantly follow them everywhere, while hider young remain hidden at a distance from their mothers between suckling bouts and do not follow them during the initial period after birth (Lent, 1974). In follower species, mothers and young recognize each other mostly by auditory cues, using contact calls (*Ovis aries* – Sebe et al., 2010; *Rangifer tarandus* – Espmark, 1971, 1974; *Bison bonasus* – Daleszszyk, 2004), though mothers also use olfactory signals for conformation of fawn identity before nursing (Daleszszyk, 2004; Torriani et al., 2006). Hider females, on the other hand, are known to use mostly olfactory verification of fawns for reunion, though acoustic signals may be used to some extent for identity as the fawn ages (Poindron et al., 2007b). Various authors have suggested different interpretations of mother-to-young recognition, such as: ungulate females of both follower and hider species mainly use olfactory cues for recognizing young, even though the ability to identify young through both auditory and visual cues is developed as early as olfactory cues (Poindron et al., 2003); ungulate mothers only need auditory and visual cues to distinguish their own young from aliens, and learning of olfactory cues is not necessary for a mother in early recognition of her fawn (Ferreira et al., 2000). For goats (*Capra hircus*), mothers discriminate their young only on the basis of acoustic (kids' bleats) or visual cues as early as 48 h after birth (Terrazas et al., 2003) and 6–24 h in domestic sheep (*Ovis aries* – Ferreira et al., 2000; Keller et al., 2003), while olfaction cues are not as necessary for recognition, even during the first days postpartum (Terrazas et al., 1999; Ferreira et al., 2000; Sebe et al., 2007). Another point of view is that only young are able to recognize their mothers according to their calls, while adult females cannot distinguish their offspring through their vocalizations (*Dama dama* – Torriani et al., 2006; *Ovis aries* – Searby and Jouventin, 2003; Nowak et al., 2007); and conversely, mothers can also recognize their lambs by their bleats (*Ovis aries* – Shillito-Walser et al., 1982; Searby and Jouventin, 2003). In an attempt to better understand the recognizing process in hider species, this paper will consider the mother-fawn interrelationship of goitered gazelles in the wild, which until now, has not been the subject of specific investigation.

The goitered gazelle is a typical representative of ungulates found in all types of deserts and semi-arid regions of Asia, preferring open habitats in flat or rolling hill areas often along arid foothills and plateaus covered by dry river beds (Kingswood and Blank, 1996). Several weeks prior to giving birth (April-May), most pregnant females separate from their herds to deliver their offspring in isolation – most birth twins, more rarely singletons (Blank, 1990; Blank and Yang, 2013). During their first weeks of life (late-May and early-June), the young stay alone for most of the day (Blank, 1985), with mothers returning every few hours for just a short time (up to 30 min on average) to nurse. As the young grow, the females spend longer periods with their fawns (65 min on average in late June – Blank and Yang, 2015) until they reach the age of two months and begin to follow their mothers continuously (Blank, 1985).

In some ungulate species, olfactory cues are found to play a crucial role for mothers to distinguish their own young (Levy et al., 2004), with auditory and visual cues, providing only a little additional information, considered unnecessary in recognizing their offspring, even though auditory and visual cues are learned as rapidly as the olfactory cues (Keller et al., 2003). According to these observations, we suggested our first hypothesis that goitered gazelle mothers also would recognize their young mainly from olfactory cues and would allow them to suckle only after smelling their anogenital parts, while oral and visual cues would play only a supplementary role in the recognition process.

Licking of newborn animals by their mothers is a very common and important phenomenon in ungulates, having well-known physiological effects – stimulation of breathing and circulation, and reflexive defecation and urination – which are essential for the development of fawns during their initial 1–2 weeks of life (Huegel, 1985; Metz and Metz, 1986; Levy et al., 2004). General licking immediately after birth also helps to dry the newborn's coat, reducing evaporative heat loss (Keyserlingk and Weary, 2007). Furthermore, anogenital licking has been found to have an additional benefit by aiding in the mother-young recognition process. As suggested by Gubernick (1981), selectivity in ungulates may be the result of olfactory labeling of the fawn after birth through licking by the mother; however according to Romeyer et al. (1994) and Poindron et al. (2007b), mothers learn some individual olfactory signatures of their fawns through licking, but licking is more likely a part of the establishment of selective bonding between mother and fawn immediately after birth, followed by a decline thereafter. Based on either of these two observations, we proposed our second hypothesis that goitered gazelle mothers would lick their fawns, not only during the first two weeks after birth – especially immediately after birth, when licking would have mostly a physiological effect, but also until the fawn reached the age of one month, when licking no longer provided a physiological function, but olfactory cues were still important for recognition.

In fallow deer (Vannoni et al., 2005; Torriani et al., 2006), red deer (*Cervus elaphus*) (Vankova et al., 1997), and domestic sheep (*Ovis aries*) (Terrazas et al., 2002; Searby and Jouventin, 2003; Nowak et al., 2007) the young recognized their mothers based on their vocalizations (deer) or behavior (sheep), while the mothers did not rely on either of their fawns' calls or behavior for identification. Therefore, we proposed our third hypothesis that the same identification processes would be found for our wild goitered gazelles, and only the young would respond to their mothers' calls or their behavior, while the mothers would not distinguish the calls or behaviors of their fawns.

2. Materials and methods

We observed the maternal behavior of female goitered gazelles in their natural environment of the Ili Depression (southeastern Kazakhstan) during a 6-year period from 1981 to 1986, when the total population number fluctuated between 1500 and 5000 gazelles. Since we did not collect enough solid data for an analysis of yearly differences, we pooled these data together. For our research, we used the continuous focal animal observation method (Altmann, 1974). All behaviors were recorded by one observer during the entire observation period and were recorded in the order in which they occurred and each time they occurred (all occurrence method). In most cases, gazelles were observed from distances of 100–150 m using binoculars (magnification 8×) or a spotting scope (magnification 30×–60×). Observation posts were usually established on elevations and in different parts