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Mother-calf interaction and activity synchronization of Eland (*Taurotragus oryx*) under farm conditions

Diploma thesis

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Affirmation

I declare that this diploma thesis of Mother-calf interaction and activity synchronization of Eland (*Taurotragus oryx*) under farm conditions was elaborated independently and is based on my own knowledge, consultations with my supervisor and literary resources cited in attached bibliography.

In Prague, dated 23th of April 2013

Bc. Kateřina Hozdecká

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Abstract

This diploma thesis is focused on social behaviour between females and their offspring in case of Common eland (*Taurotragus oryx*) under farm condition. Objective of this study was to determine mother-offspring interactions in relation to calf age and synchronization of calves in farm condition from birth to weaning. I observed 11 pairs mother-calf during 11 months, totally in 68 observation days (458.2 total hours with 6.7 hours per 1 observation day in average). Females spent in average 25.66 ± 2.42 SE % of 6 hours time budget by foraging, 18.96 ± 1.98 % of daily time by ruminating, 7.45 ± 1.67 % of daily time budget by resting, and 4.18 ± 0.90 % of daily time budget by moving. In contrast with calves which spent 24.35 ± 4.08 % of daily time budget by resting, 13.22 ±2.42 % of daily time budget by foraging, 13.01 ± 2.70 % of daily time budget by ruminating, and 4.33 ± 0.85 % of daily time budget by moving. Other results suggested that mother's behavior was not affected by calf activity, and there were not any significant difference in female behaviour as the calf grew. In general, females spent time by foraging during calf activity in most of cases. Synchronization of calves was high during foraging and resting behaviours in calves with similar age.

Key words

Common eland, social behaviour, ungulates, maternal behaviour, maternal care, mother-calf interaction, antipredator strategy

Anotace

Tato diplomová práce pojednává o sociálním chování mezi matkou a mládětem antilopy losí (*Taurotragus oryx*) v podmínkách farmového chovu. Účelem této studie bylo zjistit interakci mezi matkou a mládětem v závislosti na věku mláděte a synchronizaci mláďat od narození do odstavu. Pozorováno bylo 11 párů matka-mládě během 11 měsíců, 68 pozorovacích dnů (což činilo 458,2 hodin s průměrnou pozorovací dobou 6,7 hodin na jeden pozorovací den). V průměru samice strávily více času žraním 25,66 ± 2,42 SE % za pozorovácí dobu (6 hodin), v 18,96 ± 1,98 SE % ruminovaly, v 7,45 ± 1,67 SE % odpočívaly a v 4,18 ± 0,90 SE % byly v pohybu. Na rozdíl od mláďat, která nejvíce času strávila odpočinkem a to v 24,35 ± 4,08 SE % v průměru za pozorovací den (6 hodin), dále pak v 13,01 ± 2,70 SE % žrala, v 13,01 ± 2,70 SE % ruminovala a v 4,33 ± 0,85 SE % se pohybovala. Chování matek nebylo ovlivněno aktivitou mláďěte and tudíž bylo nezávislé na věku mláďat. V době, kdy bylo mládě aktivní, samice nebyly příliš ostražité a ve většině případech samice žraly během této doby. Mláďata byla nejvíce synchronní v průběhu žraní a odpočívání a to především ta mláďata, která si byla věkově nejblíže.

Klíčová slova

Antilopa losí, sociální chování, kopytníci, mateřské chování, mateřská péče, interakce matka-mládě, antipredační strategie

Content

List of Tables

List of Figures

1. INTRODUCTION

1.1 Parental Care

Parental care is defined as any form of parental care/behaviour which increases of parents' fitness. Parental care contains care before and after parturition (Clutton-Brock, 1991; Baker, 1994). It means preparing the environment for the offspring such as nests and burrows, feeding or suckling of offspring, cleaning of offspring, protection of them against predators and others (Clutton-Brock, 1991).

We can recognize two categorizations of parental care. First is categorization according to care rate.

"Depreciable care" – It means that parents feed their offspring and the benefit from the parental investment is decreasing with and increasing size of progeny.

"Nondepreciable care" – In this case it is parent's vigilance and the benefit is not decreasing with increasing progeny size.

And second categorization is according to sex which takes care of an offspring.

"Biparental care" – Both parents take care of their offspring. They increase their reproductive success and improve the protection against predators. 90% occurrence of biparental care is in birds (Lack, 1968) e.g. in birds Black-legged Kittiwake, *Rissa tridactyla* (Coulson, 1966), Manx Shearwater, *Puffinus puffinus* (Brooke, 1978). Pairs of this two species of birds (male and female) are faithful very long time even for all life (Clutton-Brock, 1991). Pair which stays together have high reproductive success than new pair (Krebs and Davies, 1991).

"Maternal care" – In this case of parental care female is the parent which takes care of offspring. Maternal care is quite common for mammals. Mammalian females have longer gestation period than other species. During this time males ensure feeding for females. The most of mammals are polygynous and monogamy and biparental care occurs in carnivorous (feeding of offspring) or Callitrichidae (taking care on offspring).

"Paternal care" – This type of parental care occurs very rarely and it is mostly used by fish species because of high mortality of newborns. Females take care of progeny only during developmental stage of egg. Even some (79) species of bony fish, *Osteichthyes*, do not take care at all (Gross & Sargent, 1985). In overall this type of care includes care and protection of eggs (Krebs & Davies, 1991). Paternal care occurs also in mammalian species in marmosets and tamarins (Goldizen, 1987). Males do not take care of offspring a much but their role is indispensable for survivorship of descendents (Baker, 1994). Wang & Novak (1994) noticed in prairie voles, *Microtus ochrogaster*, that pups develop faster when the male is present in the pack. In the most cases male's active parental role is playing with offspring (Baker, 1994). Paternal care is absent in ungulates (Evans, 1990).

And finally the last type of parental care is "alloparental care". It is when the parents become unrelated individuals. It could be behaviours as allonursing and allosuckling (chapter 1.3), defense or maintaining the territory in some rodents (Hoogland, 1981), canids (Malcolm & Marten, 1982), bats (McCracken, 1984) and in African lions (Schaller, 1972).

1.1.1 Maternal Care

Maternal care is type of parental care which has evolved in the most of mammalian species. It could be determined as mother's resources of energy which female invests into its offspring and their future reproductive success (Krebs & Davies, 1991; Clutton-Broock, 1991). The pair of mother-offspring is the social complex, which is basic and universal trait for all socially living mammals (Eisenberg, 1981; Crook *et al*., 1976; Hejcmanová *et al*., 2010). Care is influenced by mother's parity, age, social rank (Nash & Wheeler, 1985). Primiparous females defend their offspring more than multiparous in the case of females in primates and dolphins (Altmann, 1980; Amundin, 1986). In contrary Ozoga & Verme (1986), Green (1990), Cameron *et al.* (2000), and Hejcmanová *et al.* (2010) suggested that multiparous females have higher quality of maternal care than the primiparous, due to more experience.

Prenatal mother care includes preparation of nests, burrows and also takes care of itself during the gestation. The mother condition after the parturition is very important for offspring development, its health (before and after birth) and for the quality and quantity of milk (Sadleir, 1967; Oftedal, 1985). In social living animals females separate from the herd and they stays in isolation until the parturition (Baker, 1994).

Parturition is induced by hormones and it is the same with lactation, which starts very early before parturition (Rosenblatt & Siegel, 1981). In these time females may become aggressive besides their offspring and defend it. Ungulates have two strategies (hiding pattern and following pattern) after the parturition (Walther, 1961, 1964, 1965, 1968; Lent, 1974; Fisher *et al*., 2002). Mother-infant bond is very important factor for good maternal care, recognition of offspring and ignorance of non-filial offspring (Lent, 1974). Therefore mothers have to learn how to recognize their infants. Licking of neonates is the most used way how to recognize offspring for lot of terrestrial placental mammals (Ewer, 1968). While pinniped's females use vocalization, smell and separation of mothers and offspring, for learning how to determine their infants (LeBoeuf & Briggs, 1977). Through the licking mother recognizes the infant and also obtains olfactory and gustatory perception and thus mother recognizes offspring easily. It means that the mother aggression against infant is lower because of good ability to identify it (Hepper, 1987; Levy & Poindron, 1987).

Ungulates as bighorn sheep, *Ovis canadensis*, red deer, *Cervus elaphus*, fallow deer, *Dama dama* L., reindeer, *Rangifer tarandus* L., common eland, *Taurotragus oryx*, and giant eland, *Taurotragus derbianus* have only single offspring per one breeding season. On the other hand, there are ungulates which may have twins as roe deer, *Capreolus capreolus* L., saiga, *Saiga tatarica* L., pronghorn, *Antilocapra americana*, white-tailed deer, *Odocoileus virginianus* (Andersen, 2000).

Nursing is declining with growing of offspring (Rubin & Michelson, 1994; Sarno & Franklin, 1999; Cassinello, 2001; Hejcmanová *et al*., 2010), during weaning (chapter 1.4), when the mother-offspring conflict (Trivers, 1974; Gauthier & Barrette, 1985) is appearing and young become independent on milk and reach high condition (Cassinello, 2001). Female becomes aggressive for suckling attempts and isolates its infant from milk intake.

There are two offspring strategies related to mother-infant relationship during the first days or weeks of their lives (Walther, 1961, 1964, 1965, 1968; Lent, 1974; Fisher *et al*., 2002). Infants which lie down and hide after parturition for days or weeks are called "HIDERS" and infants which follow their mothers after the parturition are called "FOLLOWERS". The basic difference between these two strategies is the length and mutual contact among female and infant in the first days and weeks of offspring life (Lent, 1974; Ralls *et al*., 1986).

About 80 % of ungulates are hiders (Estes, 1976). The hiding strategy decrease reduction of predation (Lent, 1974; Estes, 1976; Sekulic, 1978; Fisher *et al*., 2002) of newborn infants, especially in bush type of habitat and also guarding of infants against aggression (Lent, 1974) and competition (Murdock et al., 1983) within the herd. The distance between mother and offspring is highly variable and it depends on species (Lent, 1974). Lot of studies shows that maternal behaviour is stereotypic during the hiding season (Underwood, 1979; Murdock *et al*., 1983) female just watches its offspring lie down and memorizes where it lie and then returns and waits approximately from 10 till 30 meters away from calf. Then mother vocalizes and waits as long as infant goes to its. Another studies show that maternal behaviour is not so stereotypic and there is high degree of interspecific and intraspecific vicissitude of behaviour. It is the same both in captivity and in the wild. For example in white-tailed deer, *Odocioleus virginianus* (White *et al*., 1972), and pronghorn, *Antilocapra americana* (Autenreith & Fischter, 1975) mothers sometimes do not follow and watch their fawns to the hiding site and they have problem when their fawns relocate the site where they were lying. Espmark (1969) described in roe deer, *Capreolus capreolus*, six types of maternal behaviour by used for approche to the fawns. In captive sable antilope, *Hippotragus niger*, females come to the hiding area (Hnida, 1985). And also Autenreith and Fichter (1975) and Hnida (1985) described that in pronghorn and sable antelope females vocalize or they can go through in the silent. Thompson (1996) disagreed with researches of Murdock *et al*. (1983) and Hnida (1985), and says that female sable antelope approaches the hiding area directly to their calves. Primiparous females sometimes have problems with finding and recognition of their infants, as was proved in water buffalo, *Bubals bubalis* (Muurphey *et al*., 1995), Saharan arrui, *Ammotragus lervia* (Cassinello, 1999), and muskox, *Ovibos moschatus* (Tiplady, 1990). Even Johnson (1987) described hiding behaviour in macropods (red-necked wallaby, *Macropus rufogriseus*, and in other different macropods species). Calves of common elands are also (*Taurotragus oryx*) hiders pattern of strategy (Underwood, 1979).

The follower pattern evolved for example in the European bison, *Bison bonasus* (Daleszczyk, 2004). The calf follows its mother after the birth and stays very close to the mother. These animals usually live in open habitats, besides with the hiding type animals which live in forest habitats. Whereas infant stays close to mother, the mother protects it against to predators by maternal defense (Lent, 1974; Caro & FitzGibbon, 1992; Gese, 1999). Again, there is the question of sex-biased maternal care (which sex will be prefered by mother) (Trivers & Willard, 1973; Clark, 1978; Caley & Nudds, 1987; Byers & Moodie, 1990; Kojola 1998; Hewison & Gaillard, 1999). Leuthold (1977) determined that bovids as wildbeests, *Connochaetes* spp., hartbeests, *Alcelaphus* spp., buffaloes, *Syncerus* spp., are ungulates in which use following pattern evolved.

Ralls *et al*. (1986) compared his results with results of earlier studies about mater-offspring relationships in captive ungulates (Tab. 1). According this study equids, tapirs, hippopotamuses are strictly followers and giraffes are strictly hiders. Cervids and Bovids have both type of mother-infant strategy, it depends on species.

Table 1 Comparison of type of mother-young relationships in ungulates in the study of Ralls *et al*. (1986) and earlier reported studies (Ralls *et al*., 1986)

Taxon	Hider / Follower	Old literature	References
Equidae			
Equus burchelli (zebra)	F	F	Kliengel (1969a,b)
Equus hemionus (onager)	F	F?	Kliengel (1977)
Tapiridae			
Tapirus terrestris (tapir)	F	?	Terwilliger (1978)
Hippopotamidae			
Hippopotamus amphibius (Nile hippopotamus)	F	?	Greasley (1973)
Choeropsis liberiensis(pygmy hippopotamus)	F	?	Galat-Luong (1981)
Camelidae			
Camelus bactrianus (bactrian camel)	F	F?	Gauthier-Pilters & Scheel (1980)
Cervidae			
Muntiacus reevesi (muntjac)	H	H	Yahner (1978)
Elaphus davidianus (Père David's deer)	H	F?	Altmann & Scheel (1980)
		H	Wemmer (1983)
Rangifer tarandus (reindeer)	F	F	Espmark (1971)
Giraffidae			
Giraffa camelopardalis (gifaffe)	H	I	Leuthold (1977)
		H	Langmann (1977); Pratt & Anderson (1979)
Bovidae			
Tragelaphus eurycerus (bongo)	H	H	Hamannn (1979)
Bison bison(wood bison)	F	F	McHugh (1958)
Kobus ellipsiprymnus (waterbuck)	H	H	Kiley-Worthington (1965)
Hippotragus niger (sable antelope)	H	H	Grobler (1974)
Oryx dammah (scimitar-horned oryx)	H	H	Walther (1979)
Connochaetes taurinus (wildebeest)	F	F	Estes & Estes (1979)
Madoqua kirki (dik-dik)	H	H	Hendrichs & Hendrichs (1971); Bowker (1977)
Gazella dorcas (Dorcas gazelle)	H	H	Walther (1966, 1979)
Gazella dama (dama gazelle)	H	H	Walther (1979)
Hemitragus jemlahicus (Himalyan tahr)	F	I	Schaller (1977)
Capra ibex (Kuban ibex)	F	I	Schaller (1977)
		F	Walther (1979)
Ammotragus lervia (arrui)	F	I	Schaller (1977)
		F	Haas (1958)

F: follower; H: hider; I: intermediate

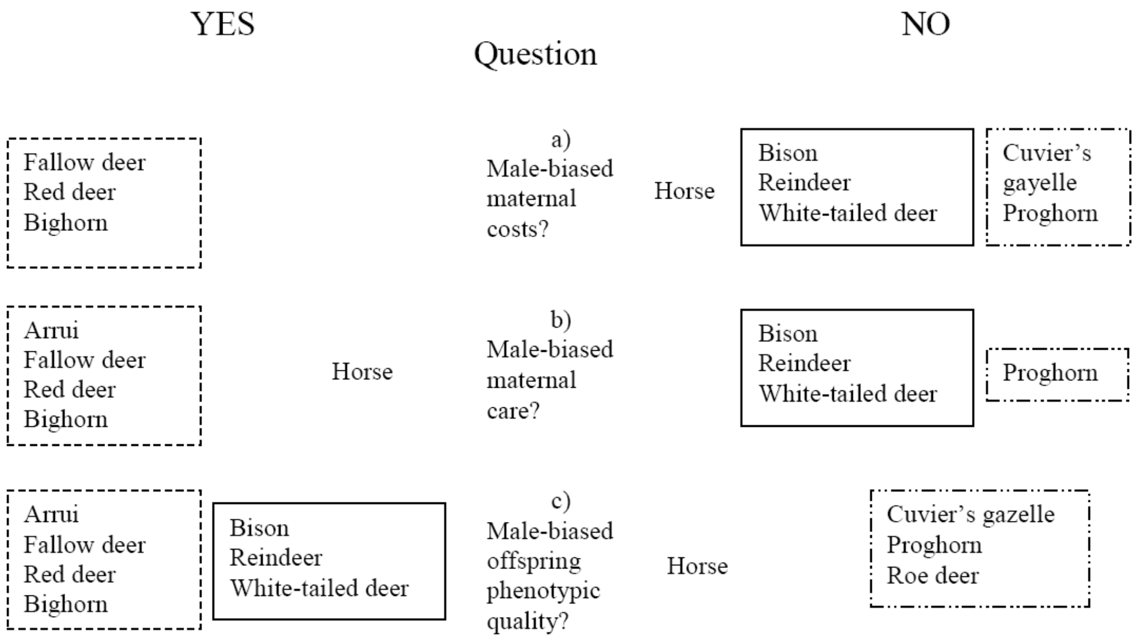
1.1.2 Maternal Investment

In general maternal investment is any behaviour or actions of parents which increase the offspring fitness at the costs of parent's fitness (Krebs & Davies, 1991). Generally males have higher mortality and it means that it is difficult to reach the reproduction age for them (Moss, 2001) and they have higher nutritional requirements for growth (larger body size in adult) (Verne, 1989; Byers & Moodie, 1990; Green & Rothstein, 1991; Hejcmanová *et al*., 2010).

Greater investment in individual sons has been proved in red deer, *Cervus elaphus* (Clutton-Brock *et al.*, 1981, 1982); feral horses, *Equus caballus* (Duncan *et al*., 1984; Berger, 1986), rocky mountain bighorn sheep, *Ovis canadensis* (Hogg *et al.*, 1992), bison, *Bison bison* (Wolff, 1988), African elephants, *Loxodonta africana* (Lee and Moss, 1986), many species of phocid seals (Reiter *et al.*, 1978; Kovacs and Lavigne, 1986; Anderson and Fedak, 1987), coypus, *Myocaster coypus* (Gosling *et al.*, 1984) and Old World rabbits, *Oryctolagus cuniculus* L. (Boyd, 1985), and Saharan arrui, *Ammotragus lervia sahariensis* (Cassinello, 1996). This group of species is polygynous. All of these besides horses and coypus have distinct sexual dimorphism in body size and/or weapon (tusks, antlers, etc.) (Byers & Moodie, 1990).

Other species that do not show differences in maternal investment have apparently equal degrees of polygyny and adult sexual dimorphism: white-tailed deer, *Odocoileus virginianus* (Robbins & Moen, 1975; Gauthier & Barrette, 1985), fallow deer, *Dama dama* (Gauthier & Barrette, 1985), mountain goats, *Oreamnos americanus* (Carl & Robbins, 1988), and black-tailed deer, *Odocoileus hemionus* (Mueller & Sadleir, 1980; Carl & Robbins, 1988; Byers & Moodie, 1990), American bison, *Bison bison* (Rutberg, 1986; Green & Rotstein, 1991), and reindeer, *Rangiffer tarandus* (Hewison & Gaillard, 1999). Also Sarno and Franklin (1999) did not prove the evidence about different maternal investment between males and females offspring, but mothers from males refuse attempts of suckling in Guanaco (*Lama guanicoe*). Hewison and Gaillard (1999) (Fig. 1) shows summary of some species of ungulates as fallow deer, red deer, bighorn, arrui, bison, reindeer, white-tailed deer, horse, roe deer, proghorn and Cuvier's gazelle , which exhibit or do not exhibit male-biased maternal care. Also there is shown question of male-biased maternal cost and offspring phenotypic quality.

Figure 1 Patterns of sex-biased maternal investment in ungulates: evidence for a) male-biased maternal costs (reduced subsequent fecundity or survival of mother), b) male-biased maternal care (higher suckling rate), and c) male-biased offspring phenotypic quality (higher body weight and/or early growth rate), in 11 species in unggulates. The type of rectangles are the groups with the same pattern if response to the three questions (the horse is not associated with any of the three groups) (Hewison and Gaillard, 1999).

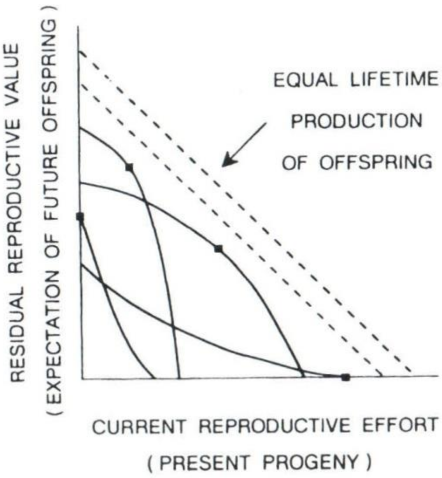


Females which invest more to sons, produce higher and most quality milk in sexually dimorphic and polygynous mammals (Landete-Castillejos *et al*., 2005).

1.1.3 Maternal expenditure

Maternal expenditure is energy and time which female spend for benefit of its offspring. The female resources are used for future reproductive success of its offspring and it helps to maximize offspring's fitness. In general, expenditure of parents has two elements (A: survival and success future reproduction of newborns; B: expenditure of parents for next future reproduction in another breeding season). Current and future relation is declining. There are many of factors whitch favor optimal situation (availabilities of parents, amount of parental expenditure on the parent's survival, probability of parent's relatedness to actual and future descendents and the reproductive value (Fig. 2) (Pianka, 1976; Carlisle, 1982; Winkler, 1987; Clutton-Broock, 1991).

Figure 2 Trade-offs between current reproductive expenditure and parent's subsequent reproductive value (Pianka, 1976; Cluttton-Brock, 1991).



Also it is expenditure which parent use for increasing fitness of the relative's offspring (Winkler, 1987; Montgomerie & Weatherhead, 1988; Clutton-Broock, 1991). In this case is included both adoption of unrelated offspring (McKaye, 1981; Andersson, 1984; Constanz, 1985; Thresher, 1985; Thierry & Anderson, 1986; Mrowka, 1987; Clutton-Broock, 1991) and brood parasitism (Andersson, 1984; Gowaty, Plissner, & Williams, 1989; Clutton-Broock, 1991).

1.2 Suckling

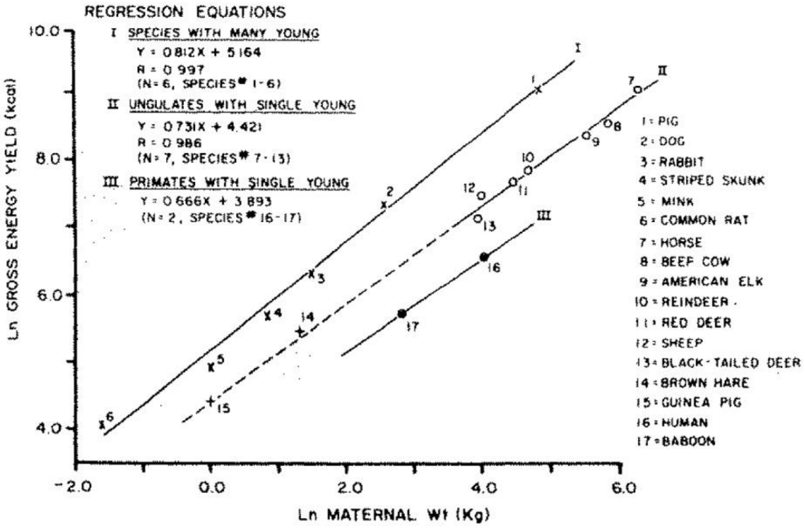
Lactation is biological process which involves production of milk. It means that milk is gathered and released for offspring. This process plays big role in many animal species. It is important for reproduction, maintaining of species and also as intake of feed for offspring and its survival (Clutton-Broock, 1991). Lactation is induced by hormones before the parturition (Rosenblatt & Seigel, 1981).

"Suckling of the milk is basic form of sociobiological behaviour of all mammals" (Wilson, 1975; Gauthier & Barrette, 1985). Milk intake has a basic and universal function for social behaviour of mammals. Suckling behaviour is a form of the relation between mother and offspring (Gauthier & Barrette, 1985). Offspring is often massages udder of mother by butting for better releasing of milk (Lidfors *et al.*, 1994; Haley *et al.*, 1998). By amount of butting could be predict a hunger. Hunger of infants is predicted by amount of attempts and dismissed attempts of suckling (Therrien *et al.*, 2008).

Calves received majority amount of milk during their first month of life (Cassinello, 1996, 2001). Cassinello (1996) suggested that average suckling rate is the highest during the first month of calves life, and decreses with calf's aging such as other studies described in other mammalian species (Gauthier & Barrette, 1985; Birgesson & Ekvall, 1994). A total amount of intake milk during this time is very important for their condition in the future. After parturition suckling is the most intensive and declines with the age of offspring (Rubin & Michelson, 1994; Sarno & Franklin, 1999; Cassinello, 2001, Hejcmanová *et al*., 2010). Gauthier & Barrette (1985) recorded significant high suckling rate in primiparous females than multiparous females in white-tailed deer, *Odocoileus virginianus*, and fallow deer, *Dama dama L*. Male offspring in African elephant suckle more milk and spend more time by suckling than the females (Lee & Moss, 1986). Suckling duration is important factor for calf's nutrition and maternal care (Lee, 1987; French, 1998; Roulin, 2002) and it is may be important factor for indication of milk intake in ungulates (Cameron, 1998). Suckling duration is another important feature of suckling and it is highly variable during the lactation. It depends on lot of factors e.g. situation (stressful situation) (Lee, 1987; French, 1998; Roulin, 2002), age of infant, sex-biased maternal care (Clutton-Brock *et al*., 1982a), parity of mothers (Réale *et al*., 1999). Suckling duration is getting shorter with increasing age of offspring and it is known in red deer, *Cervus elaphus* (Bubenik, 1965), white-tailed deer, *Odocoileus virginianus*, and fallow deer, *Dama dama* (Gauthier & Barrette, 1985), bighorn sheep, *Ovis canadensis californiana* (Shackleton & Haywood, 1985), and cattle (Lidfors *et al*., 1994). On the other hand Hejcmanová *et al*. (2010), and Havlíková (2011)refer about increasing suckling duration with the increasing age of calf in common eland, *Taurotragus oryx*, and western derby eland, *Taurotragus derbianus derbianus*, because of calves increasing nutritional needs for growth (Robbins *et al*., 1981). There is some studies which refer that long duration of suckling could be caused by lack of milk, difficult gaining of milk or non-nutritive suckling (Haley *et al*., 1998). In some cases piglets use non-sucking behaviour (massaging udders) (Fraser, 1980). Short suckling frequency according age exhibits common eland, *Taurotragus oryx*, (Hozdecká, 2011) and it is caused by starting of weaning and receiving of alternative feed (grass, green fodder, silage, etc.) (e.g. in mouflon, *Ovis musinom* (Réale & Bousses, 1995), Saharan arrui, *Ammotragus lervia* (Cassinello, 2001), and red deer, *Cervus elaphus scoticus* (Vasquéz *et al*., 2004).

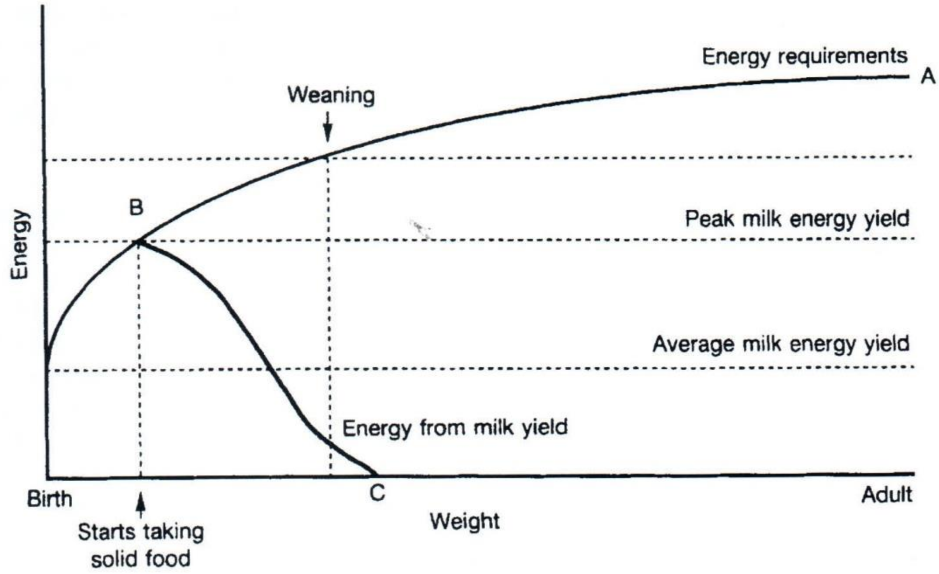
Quality, yield and nutrition components of milk indicate mother's food intake before and during lactation (London, Darroch & Milne, 1984). Daily intake of milk is very various in any species (Oftedal, 1984). It depends on mother weight and its complete condition and daily milk yield and gross energy output is increasing with the female weight (Gordon, 1989; Reiss, 1989; Clutton–Brock, 1991). Daily taken energy, proteins from milk, and calf's growth rate are influenced by body weight of individuals (Oftedal, 1981, 1984; Clutton–Brock, 1991). Pig's production of milk is twice higher than predictable amount from their body size, multiparous females have higher gross energy outputs and protein volume than the primiparous females and ungulates achieved higher values than primates (Fig. 3) (Oftedal, 1981, 1984).

Figure 3 Gross energy yield from milk related to (female) body weight for seventeen mammals (Oftedal, 1981, 1984).



Lactation is for females very energetically demanding biological process which influences their survival, growth and reproduction (Martin, 1984; Loudon, 1985; Oftedal, 1985; Stearns, 1992). Basically, female's overall condition depends on lactation (Rogowitz, 1996; Carlini *et al.*, 2004). The Figure 4 shows the relations between mother's energy input during the lactation and offspring needs for development (start of taking solid food, weaning, energy requirements, energy from milk yield, peak milk energy yield and average milk energy yield) from birth to adult (Lee, Majluf and Gordon, 1991).

Figure 4 Relations between energy supplied by the mother through lactation and offspring requirements for maintenance and growth. Showing the onset of intake of solid food and the relative requirements sustained prior to weaning (Point C) (Lee, Majluf and Gordon, 1991).



Females compensate this high energy losses by increasing foraging to get required nutrients (Ruckstuhl & Festa-Bianchet, 1998; Hamel & Côté, 2008), it might be by longer suckling bouts (Shipley *et al*., 1994). Lactating females spend more time by foraging than non-lactating females as in many studies such as red deer, *Cervus elaphus* (Clutton-Brock *et al*., 1982b), in Columbian ground squirrel, *Spermophilus columbianus* (MacWhirter, 1991), in wood bison, Bison bison athabascae (Komers *et al*., 1993), and in bighorn sheep, *Ovis canadensis* (Ruckstuhl & Festa-Bianchet, 1998).

1.3 Allosuckling

Allosuckling is nursing of non-offspring and it is high expenditure of energy for lactating females (Illmann, Pokorná & Špinka, 2005). This type of nursing has been observed in more than 100 mammals (Packer *et al*., 1992) in many domestic and wild social-living animals (group-living animals) (Newberry &Wood-Gush, 1985; Birgersson *et al*., 1991; Packer *et al*., 1992; König, 1994a, b; Pusey & Packer, 1994; Bartoš *et al*., 2001; Maletínská & Špinka, 2001). Suckling of non-offspring is much more common for species living in roosts (chiroptera) (McCracken, 1984; Wilkinson, 1992) and species with reproduction occurs accordingly such as many carnivores (Hoogland *et al*., 1989), and rodents (Pusey & Packer, 1994). Bartoš *et al*. (2001) in red deer, *Cervus elaphus*, and Víchová and Bartoš (2005) in cattle, *Bos taurus*, supposed that allosuckling is altruistic behaviour of females, which evolved as adaptation for their offspring against insufficiency of milk or nutrition from their mothers (Landete-Castillejos *et al*., 2000) than that the allosuckling is misbehaviour of recognition own offspring (Tiplady, 1990; Cassinello, 1999). Allosucking is quite common in the cases of lost own progeny (Illmann *et al*., 2005). In general, allosuckling is acquirement of extra milk and it is quite common in captive condition (Parker *et al*., 1992; Therrien *et al*., 2008). It was proved that allosuckling duration is shorter than suckling duration of filial offspring in cattle (Waltl *et al*., 1995), in fallow deer, *Dama dama* (Ekvall, 1998), and red deer, *Cervus elaphus scoticus* (Vasquéz *et al*., 2004). Birgesson and Ekvall (1994), Ekvall (1998) and Réale *et al*. (1999) found out that primiparous and young females of fallow deer and mouflon exhibit long suckling duration.

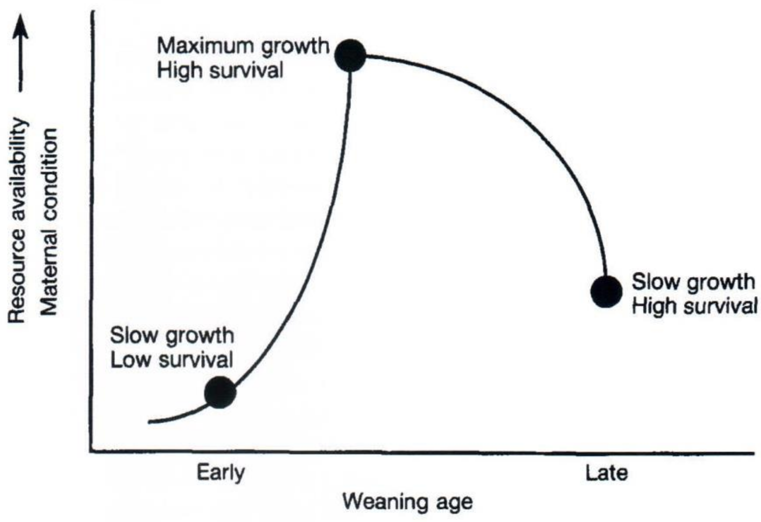
1.4 Weaning

Weaning is the process of gradual rejection of young's suckling attempts and infant become independent to milk nutrition and mother (mother-offspring conflict). In general, it is known that a young which reaches four times weight from its birth weight will be weaned by mother (Lee *et a*l., 1991). Another thesis about weaning's issue is that mother weans its young before next mating season (Moore *et al*., 1985; Pollard & Pearse, 1998; Haigh, 1999). Weaning is also affected by behaviour and immunocompetence (Griffin *et al*., 1988; Pollard *et al*., 1998), weather (Griffin *et al*., 1988; Pollard & Pearse, 1998).

Naturally, every mother has own adaptable weaning strategy depending on concrete conditions of environment e.g. in pinnipeds (Reiter, Stinson & Le Boeuf, 1978; Trillmich, 1986) in elephants (Lee & Moss 1986) in deers (Clutton-Brock, Guinness & Albon, 1983; Gauthier & Barrette, 1985) in bighorn sheeps (Berger, 1979) in domestic sheeps (Arnold, Wallace & Maller, 1979) and in primates (Lee, 1987; Hauser & Fairbanks, 1988). In carnivores mothers decrease the weaning age by mother-offspring sharing food (Doolan & Macdonald, 1999; Courchamp *et al*., 2002).

The Figure 5 displayed relation between weaning age of offspring and maternal condition according growth of offspring. Mortality of descendent is higher with early weaning. It could happen in case of inability of lactation or insufficiency of food. Apprehensible the growth rate will be slowly. Another slow growth rate occurs if the weaning will appear late. Optimal condition for maximum growth and high survival is weaning of offspring somewhere in the middle (Lee, Majluf & Gordon, 1991).

Figure 5 A general model relating the age at weaning to food availability or quality based on the observations that three patterns of weaning appear to exist both within species under different conditions and between species in different habitats (Lee, Majluf & Gordon, 1991).



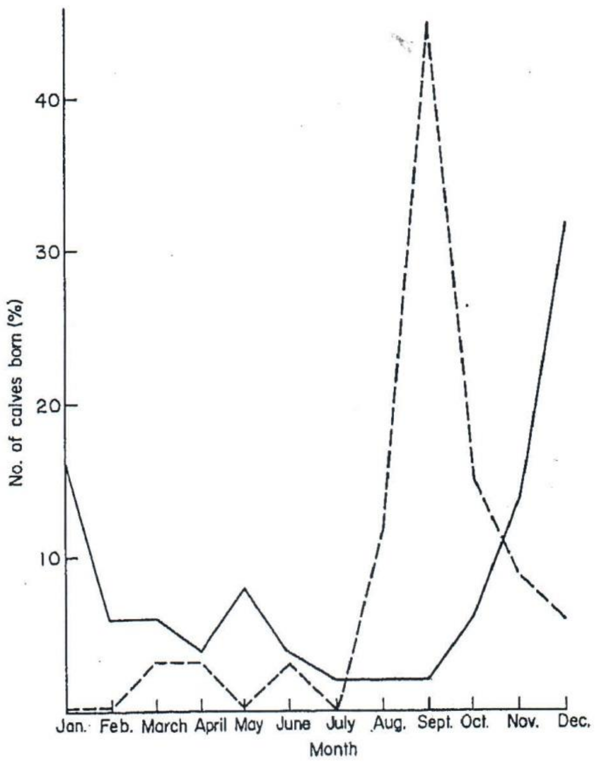
1.5 Behaviour pattern

Behaviour pattern of elands was studied in many studies (Skinner, 1969; Underwood, 1979; Underwood, 1981; Cransac & Aulagnier, 1996; Wallington *et al.*, 2007; Hejcmanová *et al.*, 2010; Jůnková Vymyslická *et al.*, in prep.; Žižková & Kotrba, in prep.).

1.5.1 The calving cycle and the birth process

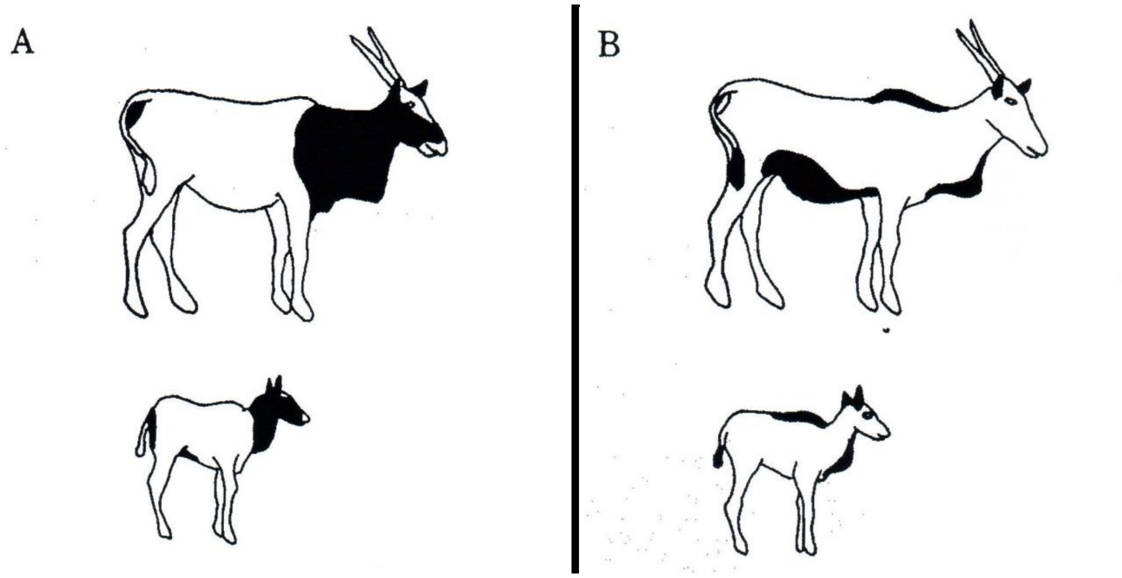
Before parturition cows are restless, they passe here and there, sometimes they are aggressive to subordinates without any reason. Their hindquarters of abdomen fall dowm and vulva becomes enlarged and redness. Underwood (1979) noted that cows give birth between 4 a.m. and 8 a.m. Skinner's (1969) study deals with influence of different habitat to calving season. The peak of highveld's calving was during November and January and females from bushvelt gave births a bit earlier (Fig. 6). Calving time could be managed in captivity according local conditions or needs of breeders.

Figure 6 Calving seasons of eland in two enviroments. Percentage estimated from fifty-one births in the Highveld (—) and from thirty-two births in the Bushveld (- - -) (Skinner *et al*., 1969).



After parturition female frequently vocalizes and calf quickly stands and moves around and the first suckling occurs very soon. During this period cow is grooming, licking and sniffing its calf (Fig. 7) (Underwood, 1979). The duration of first suckling bout influences mother-infant bond. Thereafter the calf walks away (10-40 m) and lay down from the group and waits for mother for next suckling. Female excludes placenta and feeds it (Underwood, 1979; Murdock *et al*., 1983). Eland belongs to animals which use hiding strategy pattern (chapter 1.1.1) (Estes, 1991). It means that at the beginning neonates are laying down in hiding. They prefer stay alone and they do not seek other animals.

Figure 7 Areas involved in social grooming in eland. A: areas groomed by adult females. B: areas groomed by calves. Calf-groomed areas were much more general, and areas of concentration only are shown (Underwood, 1979).



Neonates react to external stimuli by orientation, following, nose-trusting, licking and chewing. Vocal exchanges between mother and offspring also increase mother-infant bond. There is the lot of vocal signals which pair can use for communication. Underwood (1979) described this signal in his study (Fig. 8).

1.5.2 Early social behaviour of infants

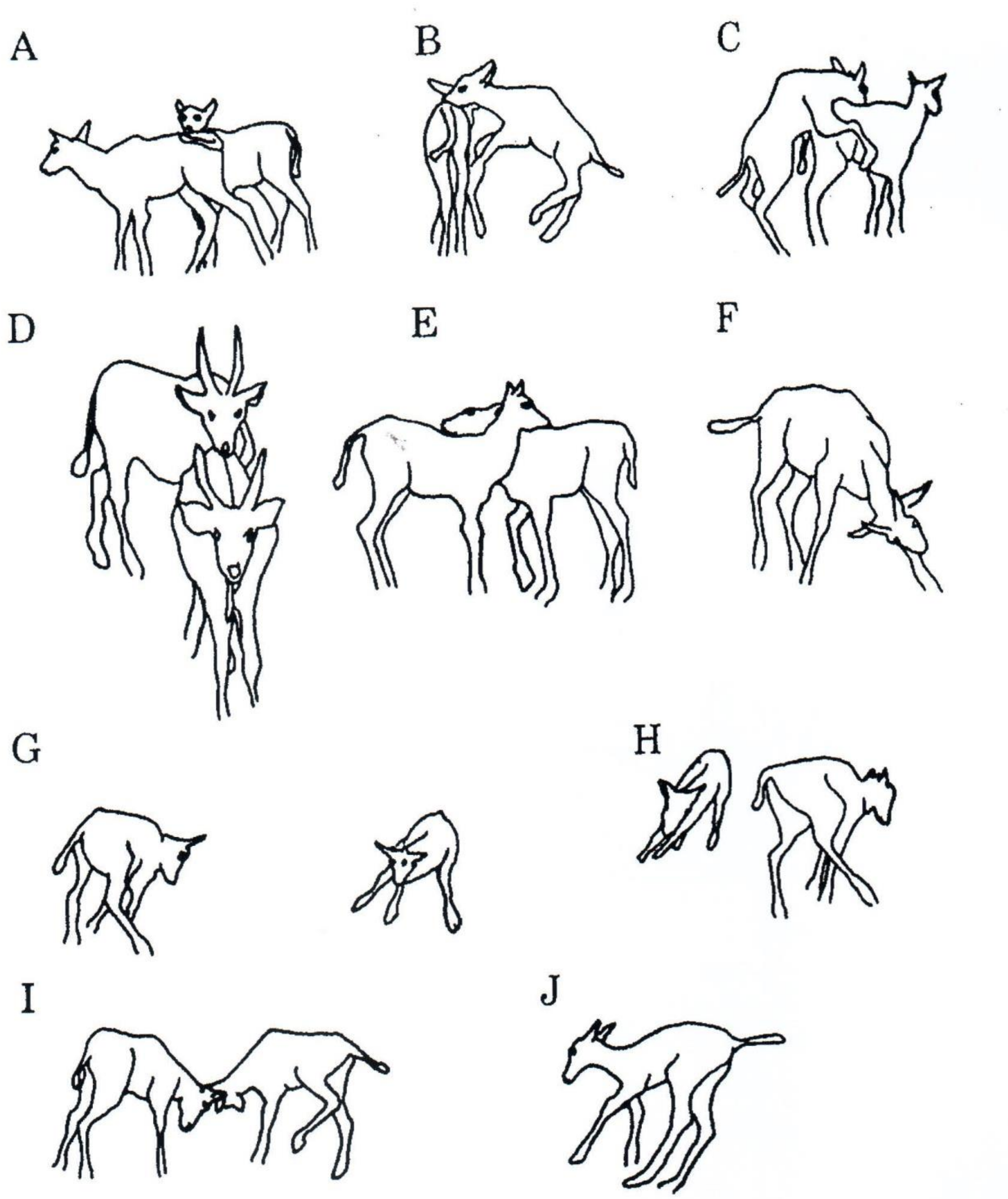
Development of social behaviour arises in juveniles very early such as mounting, chinning, flemen (urine lapping) or aggression. Calfs imitate behaviour of adult individuals (Fig. 9).

Chinnig is when one calf lays its chin to the body of second calf. Calves use this motion for chase away the second calf or calves use it to put chin to the dam's flank after rejection during the weaning time. Adults, especially males use chining as preparation of females for mating. Mounting occurs in the similar situation as chinning, but with higher excitement. Aggressive behaviour is developed in the first few days of calf live. By head lowering, tossing, nodding and violent looping actions calf threatens to other calf. After one week calf begins scrape and rub its horns against a tree or other member's horns. This behavour is modified to coordinated fights betwen calves and it is a part of play behaviours as spoutaneous running, jumping (Underwood, 1979).

Figure 8 Vocal communication between eland dam and calf (Underwood, 1979)

Signal	Situation	Sender and recipient	Message	Response
'Whimper'	In a neonate calf, spontaneous at first, then connected with rising and suckling attempts	Calf to dam?	That the calf lacks certain stimuli, e.g. physical contact?	Dam eventually approaches and licks the calf or stands nearby to facilitate suckling. Dam may also give grunts or similar low volume calls
	As the neonate calf is separated from other eland, especially its dam	Calf to all classes especially the dam	Same, except that the stimuli are probably those associated with proximity rather than contact	Often none apparent. A lactating cow, particularly the dam, may approach or call
	As a calf approaches the dam after a bout of contact calling	Calf to dam	That it is the calf which has been calling which is approaching? Anticipation? Decreasingly unpleasant stimulus contrast?	Dam sniffs at and usually stands to allow suckling
	As a calf approaches strange calves	Calf to calves	That the calf wishes to approach and make social and/or physical contact?	The strange calves may whimper. They will usually investigate the approaching calf
'Moan'-'wail'	Spontaneously after a long separation from the dam. The louder, open mouthed sections of the spectrum are usually preceded by the more muted calls	Calf to dam	Calf wishes contact with the dam; in particular to suckle	Dam calls, approaches. Duet follows. Suckling eventually results
'Click'-'moo'	As the dam licks the neonate calf (and almost continually immediately post-partum)	Dam to calf	Assuring the calf of the dam's presence and position? Giving the calf an auditory 'imprint' of the dam?	The calf may orient itself towards the call, or stop its movements, depending on the situation
	As the neonate calf begins to move with some degree of coordination away from the dam	Dam to calf	Locating the dam for the calf?	The calf may stop its movements away and orient itself towards the dam if she continues calling. It may also call
	As the cow returns to the lying out place or the creche after some hours. Early elements of the call lost as the bout proceeds	Dam to calf	Alerting the calf and giving the cow's location	The calf calls and the two converge. Suckling follows

Figure 9 Some early social behaviour patterns seen in the eland calf. A: Chinning. B: Misdirected mounting attempt in a 12 hour old calf. C: 'Correct' orientation for mounting in a two week old calf. D: Chinning used to drive a subordinate animal towards a point of interest (the observer).E: Mutual chining (neck-wrestling?). F: Spontaneous horn sweep in a five month old calf. G, H: sparring actions. I: Forehead rubbing/play fighting. J: 'Goose-step' (Underwood, 1979).



1.5.3 Social behaviours

Elands are social living animals. They can form very numerous herds (100-500 individuals). This antelopes are very well adapted for habitats and other animals. In some cases they are mixed with other antelope species or zebras. Common eland is nonterritorial, nomadic and gregarious antelope and its social behaviour could be determined by communication, sexual behaviour, fighting behaviour, social organisation. Herd is formed by one dominat male which claims pretension to mating with all females. Calves form a nursery group, which means that all infants are together. They play, lick, and groom with each other, and build very strong bond between them. Subadult males become a solitery during the time (Estes, 1991).

(a) Communication

Communication within the herd is based on tactile channel, vocal channel, olfactory and visual channel. Tactaile communication is not common for Tragelaphinae, but it is seen in this species. Usually calves lick other calves or subordinates want to propitiate the dominant individuals. Vocal communication is also not common for elands. Some sounds are not audible to human ears. Females use vocal signals for communication with their infants (chapter 1.6.2) during lactation. Olfactoric and visual communication is used by older or dominant males for demostration of their strength. They soak and bump by their heads and horns to the mud, clay or small trees. Typical olfactoric and also sexual behaviour is flemen. It is usually used by males for detection oestrus stage of females (Underwood, 1979; Estes, 1991).

(b) Fight behaviour

Through the fights males consolidate the position in hierarchy within the herd (in mating season or foraging hebaviour). Fighting is very rare in elands. Fistly male demostrates challenge by feigned attack, tossing by head, and flapping by horns to the ground. Low rank individuals show their subordination by appeasement behaviour, head-shaking or head-low posture. For fighting males use front-pressing (Fig. 10), ramming, neck-wrestling, and horn-tangling (Estes, 1991).

Figure 10 Fighting males © Kateřina Hozdecká

(c) Social organisation

The social structure inside the herds was studied in many ungulates (e.g. red deer, *Cervus elaphus* (Appleby, 1983; Hall, 1983), American bison, *Bison bison* (Ruthberg, 1983; Lott & Galland, 1987), scimitar-horned oryx, *Oryx dammah* (Pfeifer, 1985), bighorn sheep, *Ovis canadensis* (Bennett, 1986; Hass & Jenni, 1991), domestic cattle, *Bos taurus* (Hall, 1986), addax, *Addax nasomaculatus* (Reason & Laird, 1988), chamois, *Rupicapra pyrenaica* (Locati & Lovari, 1991), Cuvier's gazelle, *Gazella cuvieri*, and dama gazelle, *Gazella dama* (Alados & Escos, 1992), sable antelope, *Hippotragus niger* (Thompson, 1993), reindeer, *Rangifer tarandus* (Kumpula *et al*., 1993), and Western Derby eland, *Taurotragus derbianus derbianus* (Jůnková Vymyslická *et al*., in prep.). Usually high rank animals are older, have more experiences, larger body mass and size, bigger weapons (tusks, hornes, etc.) than other individuals which are subordinates. But Jůnková Vymyslická *et al*. (in prep.) suggested that not always the older individuals have high rank in herd. Cheney (1977) noted that social rank of mother could be influence rank of infant, but it was not prove (Clutton-Brock *et al*., 1986; Craig, 1986; Jůnková Vymyslická *et al*., (in prep.)). Capitanio (1991, 1993) recorded that dominance is not hereditary. Moore (1990) and Drews (1993) remarked that infants can inherit only the aggressive disposition from their mother or Mosley (1999) noticed that infants can learn this aggressive behaviour from their mother.

(d) Foraging behaviour

Studies about composition of eland's diet are very variable. Common elands are classified as graser, mixed feeder and also as browser. Lamprey (1963), Underwood (1975), and Nge'the & Box (1976) found out that eland are strictly grassers. Watson & Owen-Smith (2000), Wallington *et al*. (2007) suggested that eland are almost browsers. Watson & Owen-Smith (2000) recorded 94.3 % of diet from browsing. Animals are active during morning and the late evening time because of high day temperatures. This diurnal strategy is beneficial for their water balance (Cain *et al*., 2006). It is quite common for animals as buffalo (Lewis, 1977), wildebeest (Twine, 2002), impala, *Aepyceros melampus* (du Toit & Yetman, 2005), mountain reedbuck, *Redunca fulvorufula* (Taylor, Skinner & Krecek, 2006), and Swayne's Hartebeest, *Alcelaphus buselaphus swaynei* (Vymyslická *et al*., 2010).

During the lactation females substitute their higher energy losses increasing foraging hehaviour (Clutton-Brock *et al*., 1982b; MacWhirter, 1991; Komers *et al*., 1993; Ruckstuhl & Festa-Bianchet, 1998; Neuhaus & Ruckstuhl, 2002; Hamel & Côté, 2008). Ruminating and lying are other behaviours which have increasing trend during the lactation (Hamel & Côté, 2008) (Fig. 11, 12). Foraging behaviour decrease during the warm seasons (Belovsky & Slade, 1986; du Toit & Yetman, 2005).

Figure 11 Percentage of time spent foraging (a), lying (b), ruminating (c), and ruminating while lying (d), in relation to date during the summer in adult mountain goats, at Caw Ridge Alberta (2002-2005). For the presentation, data are means (±SE) of time spent in each behaviour for individual females observed at the same date during the same year, and regression lines represent a quadratic fit of these data points (Hamel & Côté, 2008).

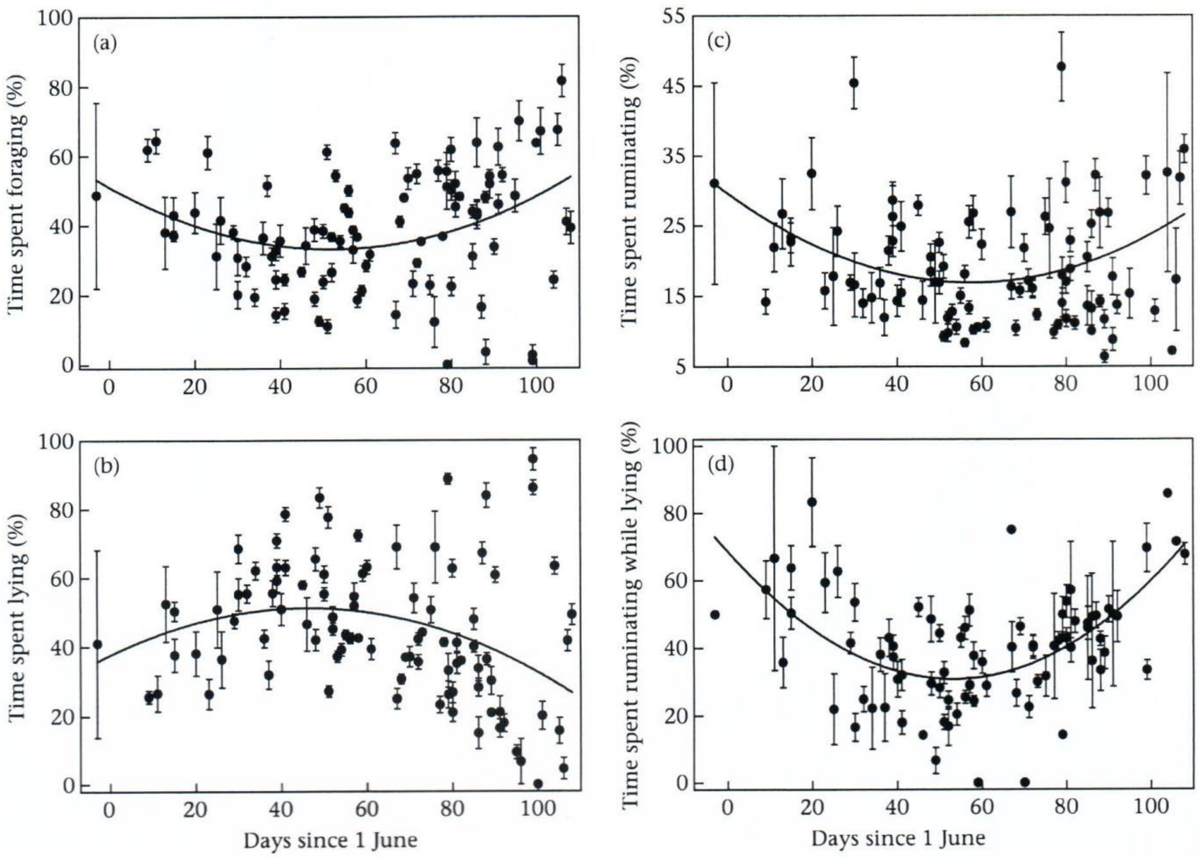
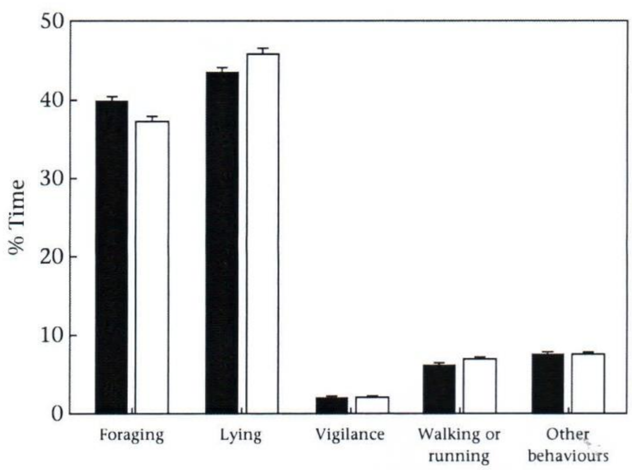


Figure 12 Percentage of time spent in each behaviour (±SE) in relation to female reproductive status in mountain goats. Female activity budgets (N=74 females) were collected between 2002 and 2005 at Caw Ridge, Alberta. The figure illustrates 1513 and 1235 female-budgets of lactating and nonlactating females, respectively. Black: lactating; White: nonlactating (Hamel & Côté, 2008).



1.6 Antipredator behavior

Antipredator's strategies are very diverse among animals. These behaviours include visual and acoustic signals, special gaits in flight, unique ways how to escape and attacking of predator in some cases (Hamilton, 1971; Edmunds, 1974; Sherman, 1977; Bertram, 1978; Elgar, 1989). Antipredator behaviour pattern could be divided into acoustic and visual signals, defense behaviour and attack to predator.

(a) Visual signals

In this group of behaviours includes tail flicking, tail flagging, bounding, leaping and stotting, zigzagging and tacking, prancing, and foot stamping. Tail flicking is used for intraspecific communication among individuals living in large group of artiodaytyls (Caro *et al*., 2004). Thomson's gazelles use tail flicking when they are in danger (Stuart & Stuart, 1997). In contrary, white-tailed deer (LaGory, 1981), and fallow deer (Alvarez *et al*., 1993) use tail flicking during foraging in bushy habitats when the predator is not present. Even the tail flicking is used for shooing of flies (Mooring &Hart, 1992). Tail flagging is warning signal and belongs to intraspecific communication in species which live in intermediate-sized group and open habitats artiodactyls (e.g. white-tailed deer) (Caro *et al*., 1995). In some cases is type of communication among infant and mother. Offspring hold tail in vertical position and it belongs also to alarm signals in fallow deer (Alvarez *et al*., 1976), white-tailed deer (Hirth & McCullough, 1977). Behaviours as bounding, leaping and stotting are used by animals living in rocky areas with conspicuous colour coats or patches. Bounding is used by African bovids to jump over barriers as escaping from predator (Caro, 1994). Stotting function is a signal for predator that animal knows about it (Caro, 1986a, b). Hunting dogs, *Lycaon pictus* prefer gazelles which do not stotting, because there is higher chance to be successful and catch the prey. Stotting gazelles are in higher condition and they have better ability to escape a predator (FitzGibbon & Fanshawe, 1989). Impalas, *Aepyceros melampus* use leaping for showing how they are healthy and in good condition to predators (Caro, 1994, 1995). Ziggzagging is rapidly changing of direction movements of prey during flight against predator for example in case of Thomson's gazelles and cheetahs, *Acinonyx jubatus* (FitzGibbon, 1990a). Escape Zigzag pattern use also suni, *Neotragus moschatus* (Stuart & Stuart, 1997). Prancing and foot stamping are intraspecific alarm signals in group living animals with white marking on legs (Caro *et al*., 2004).

(b) Acoustic signals

Ungulates use snorting and whistling as acoustic alarm calls. Bushbucks, *Tragelaphus scriptus* (Kingdon, 1997), Nile hippopotamuses, *Hippopotamus amphibious* (Stuart & Stuart, 1997), white-tailed deer (LaGory, 1987), Thomson's gazelles, *Gazella thomsoni* (Hasson, 1991), topis *Damaliscus korrigum* (Caro, 1994) snort in danger or when they behold or smell the predator and thereby alert other members of herd. Likewise muntjacs, *Muniaucs reevesi* (Yahner, 1980), and roe deer, *Capreolus capreolus* (Reby *et al*., 1999) snort and bark in danger. Whistling is typical for African bovids (e.g. oribis, *Ourebia ourebi* (Kingdon, 1997), klipspringer, *Oreotragus oreotragus* (Tilson and Norton, 1981)) has some principle as snorting and barking (intra- or interspecific alarm calls) and it could be used to confuse a predator.

(c) Defence

Among defensive behaviours belong inspection, freezing, refuge in cliffs or burrows, entering water. Inspection means that animal prefers approaching and following a predator than escaping. This defensive strategy is very dangerous, but the advantage is that it can monitor and learning something about the predator. This defense antipredator strategy use Thomson's gazelles in presence of cheetahs (FitzGibbon, 1994). When animal does not make any movements when the predator is aproching, it is called freezing. Freezing is typical for animals which are cryptic in rocks or dense vegetation because of their spotted or stripped coats (Smythe, 1977; Wood, 1992; Caro & FitzGibbon, 1992; FitzGibbon, 1994; Kingdom, 1997; Stoner *et al*., 2003). Common warthogs, *Phacochoerus africanus* (Nowak, 1999), escape to their burrows and klipspringers, *Oreotragu oreotragus* (Tilson and Norton, 1981), run away to the rocky slopes. Some sort of animals uses the running to the water as antipredator strategy. Chital, *Axis axis* (Johnsingh, 1983), and lechwes, *Kobus leche* (Stuart & Stuart, 1997), flee into or across the shallow pools or water when they are in danger. Also moose, *Alces alces* (Fuller & Keith, 1980), sometimes run away into water against the wolf, *Canis lupus*.

(d) Attack

Attacking of predators is common for mothers which defend its offspring. Usually it occurs in large body size animals. Gese (1999) described attack hebaviour towards coyote, *Canis latrans* in North American ruminants as elk, *Cervus elaphus*, American bison, *Bison bison*, and pronghorn antelope, *Antilocapra americana*. Even wildebeest females, *Connochaetes taurinus* (Caro, 1994), and common eland females, *Taurotragus oryx* (Estes, 1991) defend their offspring by attacking of predators.

(e) Antipredator behaviour of social animals living in the group

It was described three types of antipredator behaviours in group living animals (scattering, bunching and group attack). Scattering is simultaneously fleeing in many directions of all herd members (Lingle, 2001). Chitals, *Axis axis* (Johnsingh, 1983), bunch together when dholes, *Cuon alpinus* appear. It is the same in the case of mule deer, *Odocoileus hemionus*, and coyotes (Lingle, 2001). Some species of social living large artiodactyls attack a predator as African buffaloes, *Syncerus cafer* (Caro & FitzGibbon 1992) and white-lipped peccaries, *Tayassu pecari* (Nowak, 1999), roe deer, *Capreolus capreolus* (Jarnemo, 2004), mule deer, *Odocoileus hemionus*, and white-tailed deer, *Odocoileus virginianus* (Lingle *et al*., 2005).

Another very common antipredator behaviour of social living animals is vigilance of each individual. Alertness of individuals declines with increased number of group members (Elgar, 1989; Quenette, 1990). This was studied in mammals (Underwood, 1982; Burger & Gochfeld, 1992; Illius & FitzGibbon, 1994; Childress & Lung, 2003), and in macropods (Jarman, 1987; Blumstein *et al*., 1999). Individuals reduce scanning of surroundings with increasing number of herd's members. It is beneficial for individuals, they can spent less time by scanning and more by foraging (Pulliam, 1973). In the other hand, with higher number of members is decling a probability to be catched by predator, because of high variability of preys (neighbours) (Quenette & Gerard, 1992). This claim was studied in macropodid marsupial, the quoka, *Setonix brachyurus* (Blumstein *et al*., 2001), in black howler monkey, *Alouatta pigra* (Treves *et al*., 2001), and giraffe, *Giraffa camelopardalis* (Cameron & du Toit, 2005).

1.7 Synchronization

Synchronization of individuals is very important for social living animals specially for the herd/flock/roost cohesion (Ruckstuhl, 1999).

1.7.1 Behaviour synchronization

High rate of activity synchronization is mostly during forage behaviour and individuals are more synchronized if they have similar or same activity budget (Ruckstuhl & Neuhaus, 2001). Synchronization of herd's members is a fundamental factor of group cohesion (Jarman, 1974; Krause & Ruxton, 2002), it decrease risk of predation (Krause & Ruxton, 2002), and also decrease a number of insect attacks (Hart, 1992).

Ruckstuhl & Neuhaus (2001) found out that synchronization of ibex group depends on external factors such as changing type of groups, habitat (e.g. open terrain for escaping vs. grassy slopes), and predation risk and their synchronization rate is very variable. Females and males which belong to sexually dimorphic ungulate species are separated into different groups because of their different activity budgets. Activity budget is very important factor which influence the synchronization and segregation of herd (Ruckstuhl, 1998). Group of animals are much more synchronized when they contain individuals with the same body-size than in mixed group (Conradt, 1998; Ruckstuhl, 1998, 1999; Ruckstuhl & Neuhaus, 2001). This segregation of individuals is also depends on age of herd's members (e.g. sub-adult males forms group (bachelor group) which is much more easy to synchronized because similar activity budget (Ruckstuhl, 1999; Ruckstuhl & Neuhaus, 2001; Ruckstuhl & Festa-Bianchet, 2001)). Research of segregation of individuals according age was observed in Nubian Ibex, *Capra nubiana* (Gross *et al*., 1995), mouflon, *Ovis gmelini* (Cransac *et al*., 1998), and other social ungulates (Estes, 1991). And also according the age the bachelor group has higher synchrony than the mixed group of individuals with the same age (Ruckstuhl & Neuhaus, 2001). Ruckstuhl (1998) suggested that sex of individuals is another factor which influences the synchronization. During the breeding season males and females are separated to different groups in sexually size-dimorphic social ungulates (Main *et al*., 1996).

1.7.2 Nursing synchronization

This type of synchronization is used for breeding of pigs in captivity. Nursing synchronization decrease allosuckling attempts of calves (Illmann *et al*., 2005). Šárová *et al*. (2007) did not prove different degree of synchronization in lactating and non-lactating females in cattle. Murdock *et al*. (1983) found out that cows of sable antilope, *Hippotragus niger*, nurse in synchrony in captivity condition (New York Zoological Society's captive breeding program on St. Catherine's Island, Georgia).

2. AIMS OF THE THESIS

The main objective of this thesis was to determine mother–offspring and calf-calf interactions in Common elands (*Taurotragus oryx*) under farm conditions. First aim was to record time patterns of mothers and calves and then I explored whether selected activities of calves and mothers were mutually associated.

1. What is the activity pattern of mother and calves behaviours?
2. Is activity of mother influenced by calf behaviour?
3. Are there any changes in mother behaviour in relation to calf age?
4. Is there any synchronization among calves?

Hypotheses

H1: We hypothesized that mother will behave differently in farm condition without predators than mothers in the wild with potential predator presence which were vigilant over their calves and consequently their behaviours were influenced by calf activity as revealed by White & Berger (2001) in Alaskan moose females.

H2: If mother activity is affected by calf activity, there will be also changes related to calf age.

H3: Considering that calves constitute a nursery group we hypothesized that calves will synchronize their activities among individuals of similar age (Ruckstuhl, 1998, 1999; Ruckstuhl & Festa-Bianchet, 2001).

3. MATERIALS AND METODS

3.1 Farm locality and breeding management

The study was conducted on a group of Common elands (*Taurotragus oryx* PALLAS 1766) on Czech University of Life Sciences Farm Estate in Lány (50° 07’ N, 13° 57’ E), situated 35 km from Prague in temperate climate (mean annual temperature 8.86 °C, mean annual precipitation 487.74 mm) and 421 meters above the sea level.

The animals were fed twice a day. During the vegetation season (from May until October) daily feed ration was composed of alfalfa hay and concentrate fodder (corn silage) and the open access to pasture. Synchronization of reproduction was managed to be achieve parturition during winter time without access to pasture in order to ensure better veterinary manipulation with newborns during winter and spring time. In 2010 females gave birth during spring months from 13th of March to 11th of May.

The group of 51 Common elands was housed in a stable (Fig. 13, 14) with a pasture area of 2.5 ha (Fig. 15). This 51 animals were bred into two herds separated by fences (first: 5 males, 11 females, 4 calves and second: 3 males, 11 females, 7 calves, respectively) and there were two separated blocks with 8 males on each side, bred for meat production in the stable (Annex 5). Both herds had one adult breeding male and other males in herd were sub-adult males.

Figure 13 Stable on Czech University of Life Sciences Farm Estate in Lány (outside) © Kateřina Hozdecká

Figure 14 Stable on Czech University of Life Sciences Farm Estate in Lány (inside) © Kateřina Hozdecká

Figure 15 Enclosures for herds of elands © Kateřina Hozdecká

3.2 Investigated animals

All eleven pairs of mothers and calves born in 2010 were included in the study. They were divided into two groups according to their herds (Tab. 2).

Table 2 Basic information about mother-calf pairs (Havlíková, 2011; Hozdecká, 2011)

FEMALE	CALF	SEX	HERD/SIGN	BIRTH	WEANING (day)	N
Eliška	Ellien	♂	1/83 red	23.3.2010	147	254
Tora	Tembi	♂	1/86 blue	4.4.2010	179	226
Dulu	Daren	♂	1/ 93blue	14.4.2010	153	203
Lina	Lungy	♂	1/95 blue	27.4.2010	227	145
Katka	Kayin	♂	2/82 red	19.3.2010	224	307
Glory	Ghana	♀	2/84 green	28.3.2010	168	285
Lesana	Lenny	♂	2/85 yellow	30.3.2010	210	298
Staple	Simba	♂	2/87 green	5.4.2010	194	278
Nassay	Nuru	♂	2/91 green	10.4.2010	243	234
Lydie	Leon	♂	2/92 blue	12.4.2010	187	246
Viktorie	Vorik	♂	2/96 red	11.5.2010	175	157

SIGN: ear mark N: number of recorded pair activities

3.3 Definition of observed behaviours

I recorded every 10 minutes each behaviours of observed animals (Tab. 3).

Table 3 List and definition of recorded activities

Activity	**Abbreviation**	**Definition**
Aggressive behaviour	AG	Aggressive behaviour is psycho-social behaviour. In animals, the mean digging, butting, and marginalization of second animal. This behaviour is quite common during suckling or allosuckling when mother chases away filial or non-filial calf, and/or in very close contact between adult animals.
Allosuckling	ALSUCK	Allosuckling is nursing of non-offspring (chapter 1.3).
Allosuckling attempt	TALSUCK	Allosuckling attempt means that calf sucked shorter than 5 seconds, or wanted to suck demonstrably.
Browsing	BROW	Browsing occurs when animal is not fed and only moves at rest (walking).
Calling	CALL	Vocalization used by female or calf for mutual communication, generally for finding each other or for suckling.
Comfort behaviour	KO	Behaviour which an animal does well for itself: cleaning of fur, scratching, get rid of insects, etc.
Drinking	DRI	Whenever animal goes to drink from water pump or puddle in the pasture.
Excretion	EXC	This behaviour has two sub-behaviours (defecation and urinating). Defecation is a biological process of excretion or emptying of intestinal contents by rectum. Urination is a biological process that separates waste products from the body.
Foraging	FOR	Searching for feed of prepared fodder, forage intake and grazing on pasture.
Grooming	GRO	Interaction between animals for mutual comfort, mother-calf relationship, social relationship, and appeasement of low rank animals to high rank animal.
Feeder comes to the stable	MAN	Every time when the feeder came to the stable for feeding.
Moving	MO	Moving is any movements which animal does.
Nursing	NURS	Mothers perform this activity which is a part of calf's suckling. During this time mother licks and sniffs their infants.
Play	GAME	Typical behaviour for juveniles, which is imitated behaviour of adult's individuals.
Resting	REST	Idling of an animal without movements as simply staying, lying or sleeping.
Ruminating	RUM	Rumination is a typical process of dilution and swallowing of food for ruminats. First individual grayes and rips and then swallows all. During resting phase regurgitates food into the oral cavity where food this further dilutes (with the help of their forestomachs and

		stomach -rumen, book, cap, and mallow). I recorded this behaviour during staying, moving and lying.
Shock	SHOCK	Animals were frightened by disturbing, sound or smell.
Suckling	SUCK	Calf's suckling occurs when contact with teat of mother and baby's mouth is longer than 5 seconds. End of suckling occurs until the baby is separated from the mother for a period of ten minutes.
Suckling attempt	TSUCK	Suckling attempt means that calf sucked shorter than 5 seconds, or wanted to suck demonstrably.
Vigilance	OBS	Observing behaviour of the surroundings as a defensive mechanism when an animal was afraid of unusual sounds or movements.
Weaning		Total weaning of calves was determined when was not detect suckling in 3 consecutive observations.

3.4 Data collection

I recorded eleven mother-calf pairs during the period from 25th of March 2010 (the date of birth of the first calf) till 9th of January 2011 (the date of last calf was weaned (Tab. 3). The animals were observed three or four times per week during first two weeks after each calf's birth, and then once or twice a week until the weaning. The weaning of calves was at 192 day of age in average. The data were collected mostly between 8 a.m. and 3 p.m.; 6.7 hours per observation session in average. For the data collection was used scan sampling (Altmann, 1974; Martin & Bateson, 1992; Cassinello, 1996) with the 10 minutes interval. The interaction between mothers and calves and other all activities of all twenty two animals was recorded and I recorded the position of each animal in the herd also (in the centre of the herd, at the edge /margin of the herd and outside the herd). I recorded the activity of calf as first and then the activity of mother. A total of 458.2 hours within 68 observation days were completed. Number of activity record of each mother-calf pair given in Table 2.

3.5 Statistical data analyses

Statistical data analyses were done in software STATISTICA 9.1 (StatSoft, Tulsa).

In order to examine the activity pattern of mother and calf in pair and difference among individual mother-calf pairs, general linear model (GLM) with repeated measures was used. Dependent variables were total time of mother and total time of calf for each activity within daily observation session, all standardized to 6.7 hours.Categorical predictor were each activity and individual mother – calf pair. Calf age was used as continuous independent co-variate in the analysis.

In order to evaluate the dynamics of behavior in response to calf age, foraging and resting were selected as appropriate type of activity because they were the most frequent behavior. For both activities (foraging and resting separately) general linear mixed model (GLM) with mother – calf pair as random factor was used for analyses. Dependent variable was the average time spent by foraging and resting (separately) of mother and calf (time spent within 6h of observation session). Predictor:In both analyses were the age of calf (measured in weeks).

Mother response to calf activity was tested by sequential analyses. Calf activity was assigned as "body" (initial stimuli) and mother activity as "head" (response to stimuli, it means to calf activity) in the STATISTICA terminology. "Support", the probability of occurrence of repeating of both activities, was fixed to 5% as minimal value to display. "Confidence", the conditional probability indicating the strength of influence of activity of calf to mother's activity, was fixed to 10% as minimal value and maximal size of an itemset 10 to display.

Synchronization of calves was examined by association rules, using 20.0 % as minimal support and minimal 10.0 % and maximal size of an itemset 2 for confidence (terminology is the same as in sequential analysis described above).

4. RESULTS

The most common behaviours were resting with 42 % records in mothers and calves activities, foraging with 22 % records in both categories, ruminating with 21 % records and moving with 7 % records. Other activities had lower occurrence e.g. observing had 2.5 % records, comfort behaviour had 1.6 % records, calves were gaming in 1.2 % records and suckling occurred in 1.1 %records, grooming had 1.0 % records and calling had 0.6 % records.

In the Table 4 displayed time budget for each activity of mother-calf per 6 hour per day.

Table 4 Time budget (in %) for all recorded activities of mothers and calves during 6 hours of observations during the daylight. For abbreviation see Table 3

Activity	**Mother activity**		**Calf activity**	
	mean (%)	**±SE**	**mean (%)**	**±SE**
AG	0.04	0.08	0.04	0.09
ALSUCK	0.00	0.00	0.12	0.12
BROW	0.05	0.15	0.03	0.08
CALL	0.10	0.20	0.04	0.07
DRI	0.09	0.09	0.15	0.13
EXC	0.12	0.11	0.06	0.08
FOR	25.66	2.42	13.22	2.42
GRO	0.27	0.21	0.50	0.26
KO	0.42	0.21	0.93	0.33
MAN	0.14	0.13	0.12	0.12
MO	4.18	0.90	4.33	0.85
NURS	0.53	0.22	0.003	0.02
OBS	2.07	0.77	1.64	0.73
PLAY	0.03	0.07	0.67	0.34
REST	7.45	1.67	24.35	4.08
RUM	18.96	1.98	13.01	2.70
SCHOCK	0.002	0.01	0.05	0.07
SUCK	0.005	0.02	0.53	0.22
TALSUCK	0.00	0.00	0.003	0.02
TSUCK	0.02	0.05	0.07	0.09
not visible	6.29	0.44	0.93	0.45

4.1 Activity pattern of mother and calf in pair

There were significant differences among activities mothers and calves (Fig. 16) ($F(20.13796)=574.64$; $p<0.001$) The daily time budget of activities was changing between mothers and calves. The most of activities were not different, but activities as resting, foraging, ruminating and moving behaviours appeared more and different rates. Females spent more time by foraging than calves. On the other hand, calves spent more time by resting and ruminating than mother. Both mothers and calves moved in similar rate (Tab. 4).

Significant differences were proved among individual mothers during 6 hours time budget of foraging ($F(10.646)=3.563$; $p<0.0001$) (Fig. 17) and there are not any significant differences among calves. Lesana, Tora, and Dulu spent less time by foraging than Steaple and Nassay. Other females spent time by foraging relatively similar times. This activity was affected by age of calves and individuality of each pairs ($F(1.646)=625.969$; $p<0.0001$).

Foraging pattern showed antagonistic trend during first 24 weeks of calf life and after that the total daily time of foraging was quite similar trend in mothers and calves ($F(43.604)=22.345$; $p<0.001$) (Fig. 18).

There were significant differences for resting daily total time among mothers and calves. Calves rested more during the first 24 week of their life. Since 24^{th} week they had similar trend total daily time of resting as mothers ($F(43.604)=41.742$; $p<0.001$) (Fig. 19).

Figure 16 Activity pattern of mothers and calves. For abbreviations see Table 3

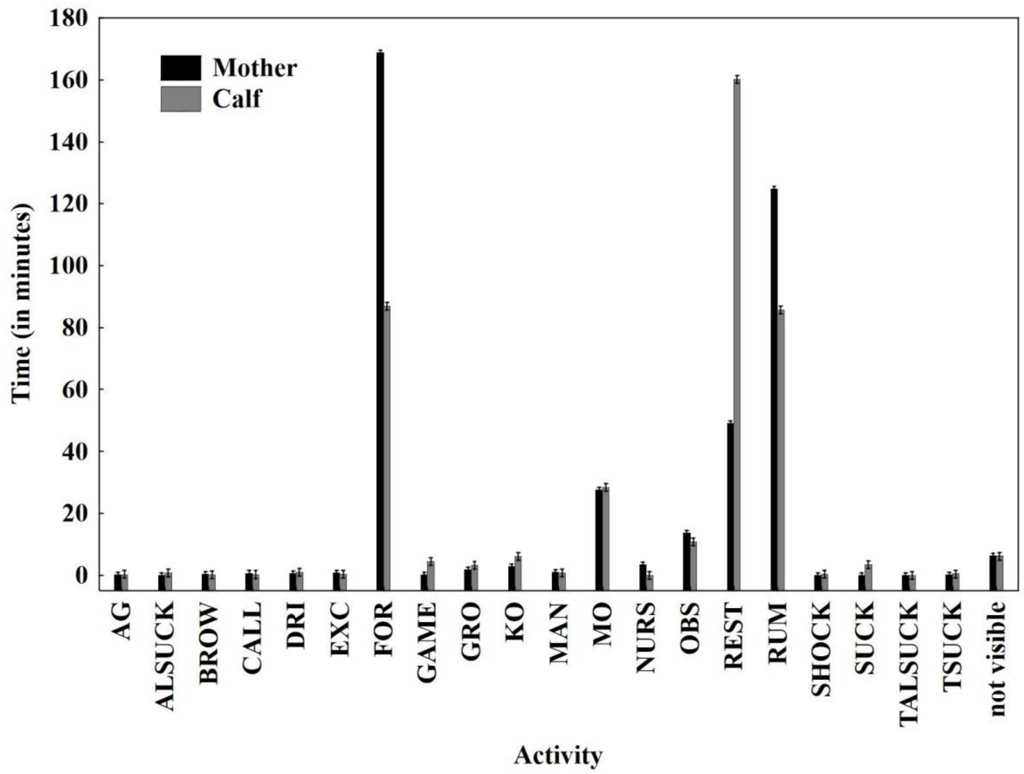


Figure 17 Foraging dynamic among mothers and calves in 6 hours time budget

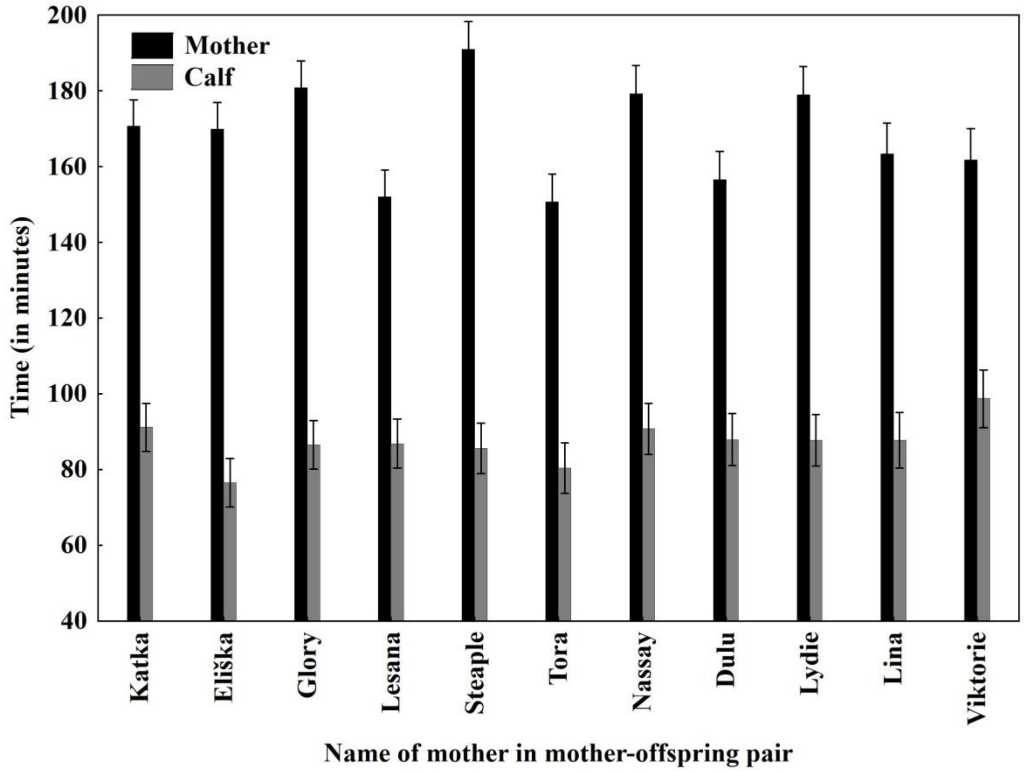


Figure 18 Influence of age of calves to dynamics of foraging

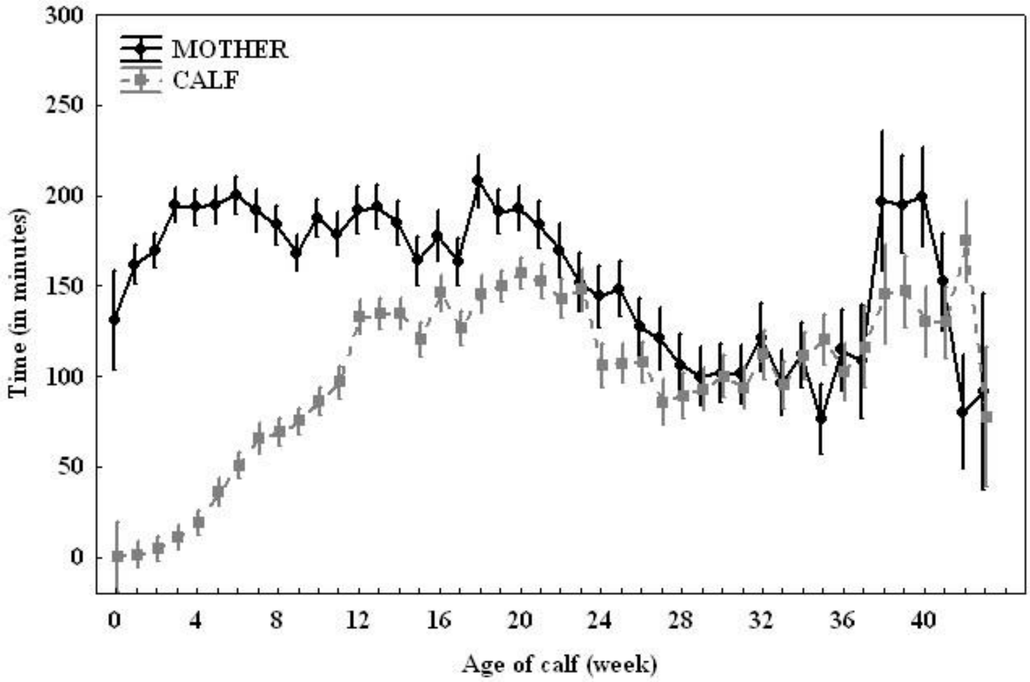
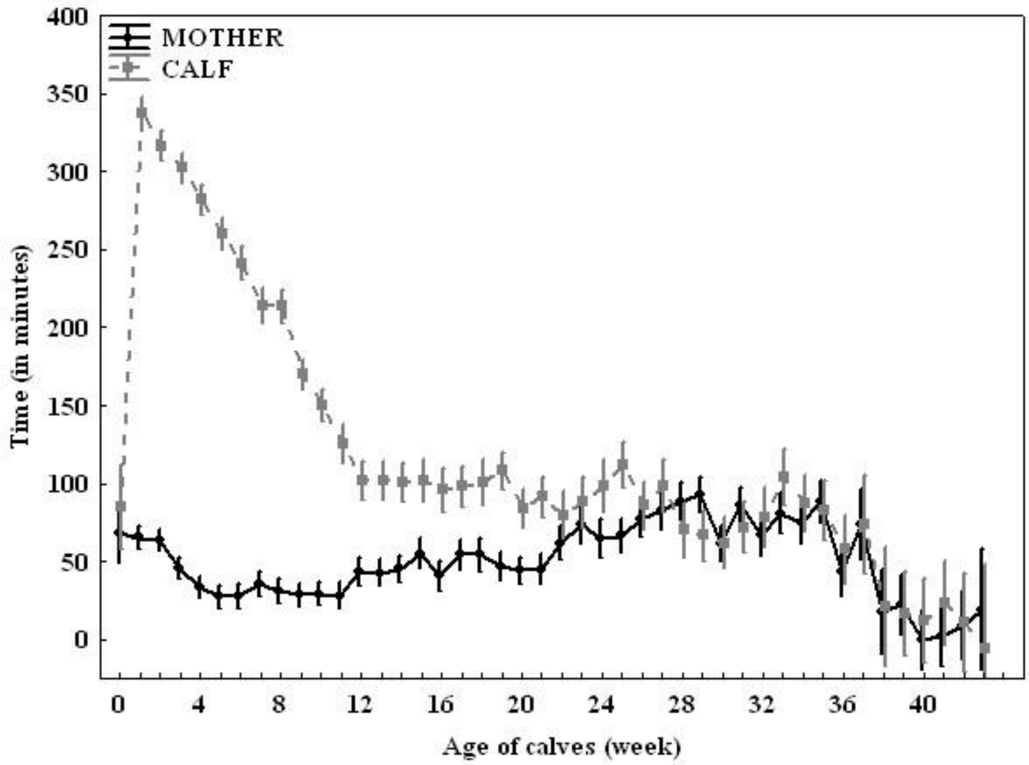


Figure 19 Influence of age of calves to dynamics of resting



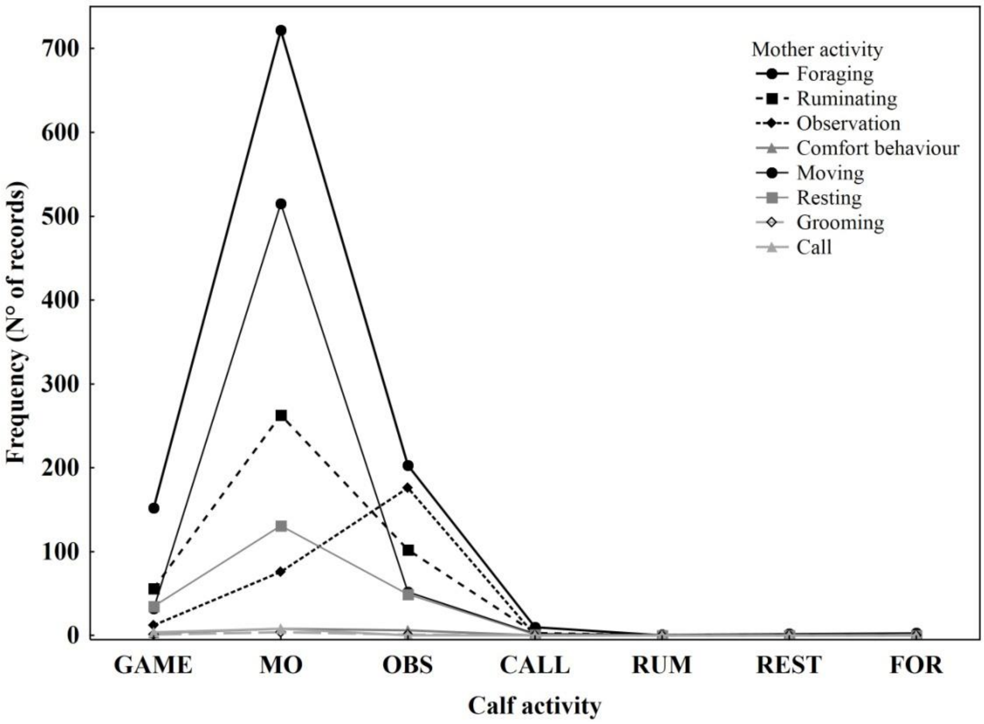
4.2 Do mothers respond to calves activities?

Frequencies of all combined paired activities of mothers and calves are given in Table 5 and graphically illustrated in Figure 20. The basic question is what mother did when the calf was active. When calf was playing, mother mostly foraged in 51.53 %, ruminated in 18.98 %, rested in 11.86 %, moved in 10.85 %, and was vigilant in 4.07 % of cases. Mother foraged in 41.81 %, moved in 29.82 %, ruminated in 15.23 %, rested in 7.59 %, and was vigilant in 4.40 % during the time when calf was moving. In the event that calf was vigilant, mother foraged in 34.47 %, was vigilant in 29.88 %, ruminated in 17.32 %, moved in 8.83 %, and rested in 8.32 %. Mother was foraging in 62.50 %, ruminating in 18.75 %, moved in 12.50 %, and 6.25 %, when calf called. In time when calf ruminated, rested and foraged, mother was moving in 100 % of cases, however these records were not too numerous (all less than 10).

Table 5 Contingency table of paired activities of calf and mother (values with more than 10 records are highlighted in red colour). For abbreviation see Table 3

	Activity of calf							
Activity of mother	**GAME**	**MO**	**OBS**	**CALL**	**RUM**	**REST**	**FOR**	**SUM**
FOR	51.53%	41.81%	34.47%	62.50%	0.00%	0.00%	0.00%	41.28%
RUM	18.98%	15.23%	17.32%	18.75%	0.00%	0.00%	0.00%	16.10%
OBS	4.07%	4.40%	29.88%	0.00%	0.00%	0.00%	0.00%	10.03%
KO	1.02%	0.46%	1.02%	0.00%	0.00%	0.00%	0.00%	0.65%
MO	10.85%	29.82%	8.83%	12.50%	100.00%	100.00%	100.00%	23.05%
REST	11.86%	7.59%	8.32%	6.25%	0.00%	0.00%	0.00%	8.20%
GRO	0.34%	0.23%	0.17%	0.00%	0.00%	0.00%	0.00%	0.23%
CALL	1.36%	0.46%	0.00%	0.00%	0.00%	0.00%	0.00%	0.46%
SUM	11.20%	65.59%	22.37%	0.61%	0.04%	0.08%	0.11%	100.00%

Figure 20 Frequency of paired mother andcalf activities



The probability of occurrence of pair activity foraging (mother) - playing (calf) was in 6 % cases with 51% probability of occurrence. For mother-calf pair behaviour foraging (mother) - moving (calf) was occurrence 27 % with 41% of probability, for ruminating (mother) - moving (calf) was 10 % of occurrence and 15% of probability, and for moving (mother) - moving (calf) was 19 % of occurrence and 30% of probability. In the cases when calf was vigilant and mother behaviour was foraging, the occurrence was 7 % and 34% of probability. In 7 % of occurrence both were vigilant with 30% of probability (Fig. 21, 22). It means that there wasn't confirmed any influence of calf activities to mother behaviour. In the most of cases mothers spent more time by foraging and moving during any calf activities.

Figure 21 Occurrence of chosen mother-calf activities. For abbreviations m: behaviour of mother, MO: moving, OBS: vigilance, RUM: ruminating, FOR: foraging, GAME: play

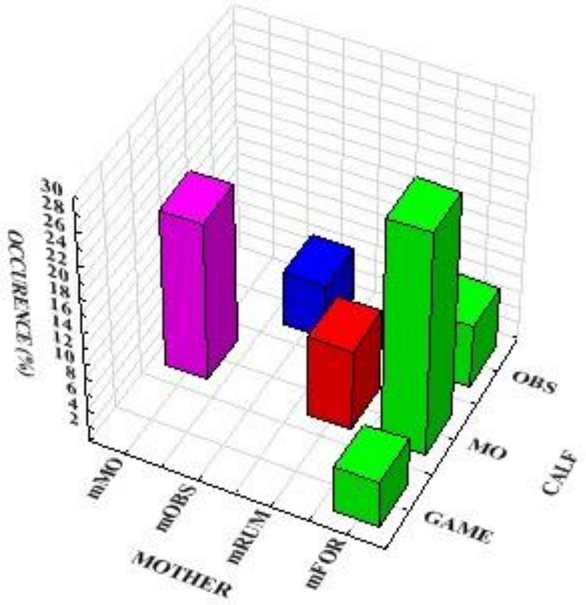
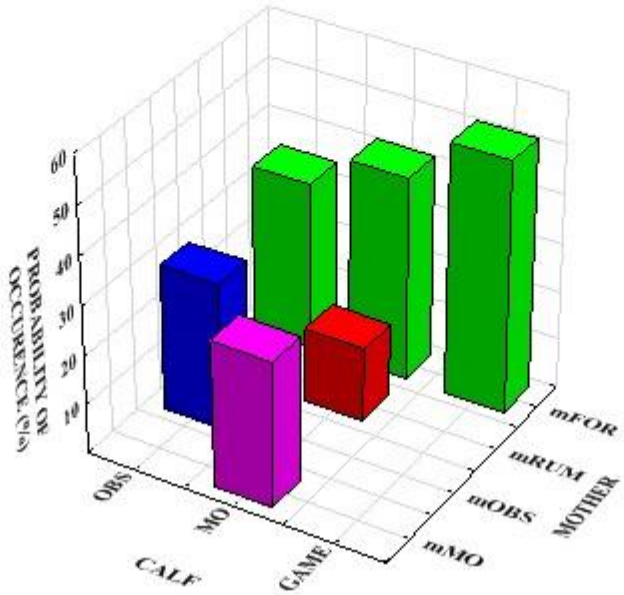


Figure 22 Probability of occurrence of chosen mother-calf pair activities. For abbreviations m: behaviour of mother, MO: moving, OBS: vigilance, RUM: ruminating, FOR: foraging, GAME: play



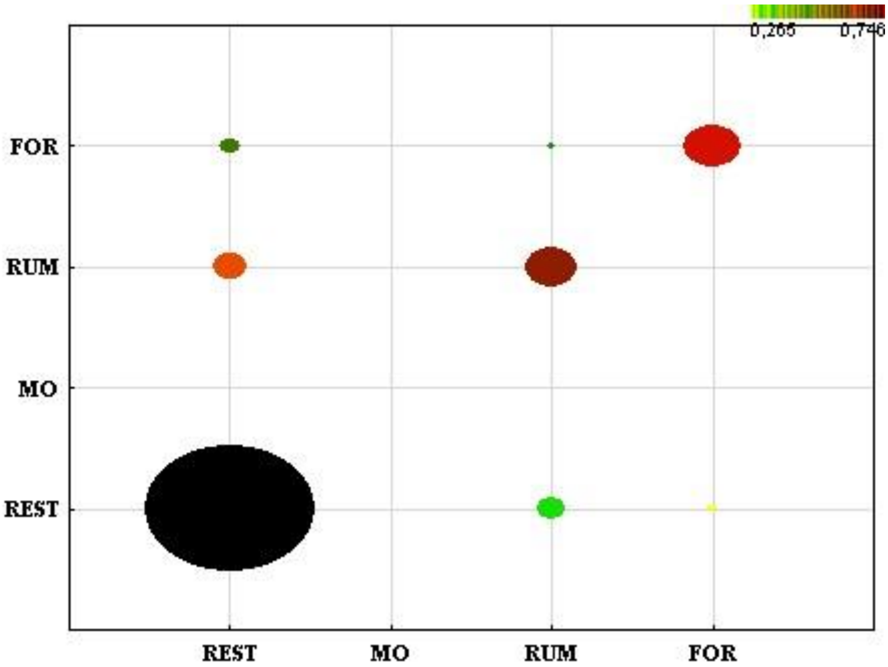
4.3 Change of mother behaviour in relation to calf age

There were no evident changes in associations of paired mother – calf activities related to calf age. Interesting was only occurrence of pair activities foraging (mother) – moving (calf) and moving(mother) -moving (calf) which occurred with higher numbers of occurrence all the time, and observing-observing with high occurence (48 % in average)and probability of occurrence in 9^{th}, 10^{th} , and 11^{th} month of calf age (complete results in Annex 1).

4.4 Synchronization among calves

I chose the three activities of calves which had the most frequent occurrence (REST, RUM, FOR, and MO). There were association among resting and resting by the 58 % of cases and with the 75% probability of occurrence. Association of resting and ruminating appeared in 25 % of cases with 32% of probability and for association of resting and foraging was frequency of appearance 21 % with 26% probability. Association of ruminating and resting was in 27 % of cases with 60% probability and ruminating-ruminating had 31 % of cases of these two activities with 69% probability of appearance. I recorded associations of foraging and foraging in 32 % of cases with 71% probability of occurrence, than for foraging and resting in 23 % of cases with 52% probability of occurrence and for foraging and ruminating association in 20 % cases with 46% probability of appearance (Fig. 23).

Figure 23 Synchronization of calves (REST, FOR, RUM and MO). For abbreviation REST: resting, FOR: foraging, RUM: ruminating, MO: moving



There were only four calves which were in synchrony during resting (Fig. 24) in 30 % of cases even with 74% of probability of occurrence (Annex 3). These four calves were born in March (Tab. 2). Ellien was low synchronized than Kayin, Ghana and Lenny.

In Figure 25 synchronization between three calves during foraging time is displayed in 11 % cases and even with 63% of probability of occurrence (Annex 4). These three individuals were of the same age. They were born in April during one week (Tab. 2).

Figure 24 Synchronization of resting and foraging among all calves individually. For abbreviation REST: resting, FOR: foraging

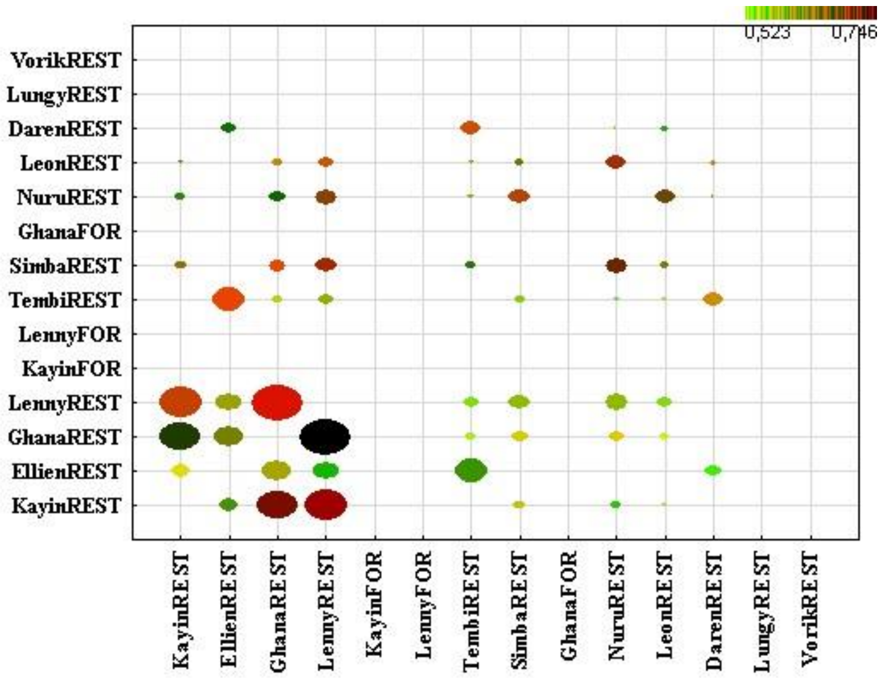
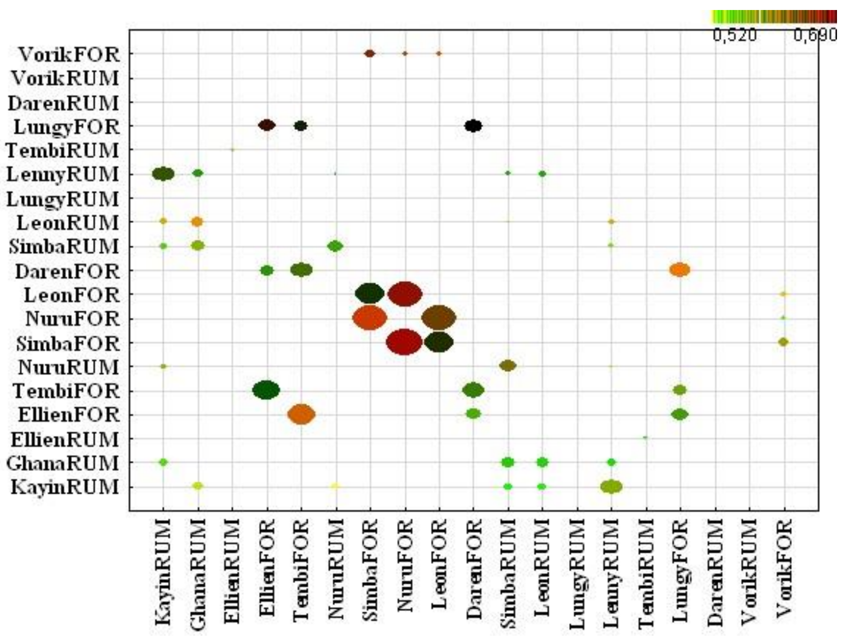


Figure 25 Synchronization of foraging and ruminating For abbreviation FOR: foraging, RUM: ruminating



5. DISCUSSION

In most of ungulates were recorded daily activity budget mainly composed of foraging, ruminating, resting and moving, e.g. in heifer (Hejcmanová *et al*., 2009). It is the same also in Swayne's hartebeest, which spend 26.4 % of time by standing, 24.6 % of its time by foraging, 15.6 % of time by lying, 14.3 % of time by ruminating and 7.1 % of its time by moving (Vymyslická *et al*., 2010). In my investigation, activity budget of lactating females mostly consisted of foraging, ruminating, resting and moving behaviour. Females spent by foraging the most of their time. It was a same as Hamel & Côté (2008) investigated in their study in mountain goats. Lactating females spent more time by foraging because of lactating, which is very energetically costly biological process (Oftedal, 1985). They have higher energetic requirements, so they compensate it by higher forage intake (Ginnett & Demment, 1997; Hamel & Côté, 2008). Lactating females spent more time by foraging than the nonlactating females (Clutton-Brock *et al*., 1982; MacWhirter, 1991; Komers *et al*., 1993; Ruckstuhl & Festa-Bianchet, 1998; Neuhaus & Ruckstuhl, 2002; Hamel & Côté, 2008), but this was not tested in this study. Also Hamel & Côté (2008) found out that females nursing sons had high forage intake than females nursing daughters. Mother's higher investment to sons was proved in many studies in polygynous ungulates (Trivers & Willard, 1973), in red deer, *Cervus elaphus* (Clutton-Brock, *et al*. 1981, 1982), feral horses, *Equus caballus* (Duncan *et al*., 1984; Berger, 1986), rocky mountain bighorn sheep, *Ovis canadensis* (Hogg *et al*., 1992), bison, *Bison bison* (Wolff, 1988), African elephants, *Loxodonta africana* (Lee & Moss, 1986), coypus, *Myocaster coypus* (Gosling *et al*., 1984), Saharan arrui, *Ammotragus lervia sahariensis* (Cassinello, 1996), and other species. It is caused by higher nutrients requirement for development and growth of male infants and it corresponding with larger body mass in adult (Verne, 1989; Byers & Moodie, 1990; Green & Rothstein, 1991; Hejcmanová *et al*., 2010). Results of this study show significant differencies between lactating females and their foraging rate, but I can not supposed that it was affected of sex of calves caused by non-balanced sex ratio of newborns (1 female and 10 males).

Our results shown that the second used female's activity was ruminating. Ruminating is a second important behaviour for all ruminats (Realini *et al*., 1999). This result is natural according foraging rate and maternal behaviour (Ginnette & Demment, 1997; du Toit & Yetman, 2005). Time spent by ruminating and ruminating rate is influenced by diet. In cattle ruminating increases with increasing fibre content and dereses with decreasing forage particle size (Albright, 1993). So, if females forage higher content of feed, naturally they will ruminating more, because of digestion process (Hamel & Côté, 2008). Hamel & Côté (2008) descriebed that lactating females spent more time by ruminating than nonlactating females.

Third very important behaviour for ruminats is lying. It is same in this observation. In this study was assigned to classification of resting behaviours (lying, standing, sleeping). Hamel & Côté (2008), whom suggested that lacking females spent more time by ruminanting than lying, this was also similar in this case. Females spent more time by ruminating than resting. In the previous Hamel & Côté's study was tested differnces between lying rates of lactating and nonlactating females. Nonlacting females spent more time by lying than lacktating females, which replaced lying by spending more time by ruminating.

Activity budget of calves was represented by resting, foraging, ruminating and moving, respectively. Calves spent more time by resting during first two months of their life. This result could be influenced by hiding strategy pattern of elands (Lent, 1974; Ralls *et al.*, 1986). Calves lay in corners or by walls of the stable or somewhere in the pasture separated from herd in farm condition. It could be adaptation of hiding strategy to captive condition. Foraging rate of calves is very low at the beggining. It is caused by milk intake from their mothers. In this study foraging rate had increasing trend until 24th week of their age and than became relatively similar. Calves spent more time by suckling than foraging at the begging (from first to second month of their life) and then they start to compensate by foraging on grass, green fodder etc., because of weaning process. Clutton-Brock (1991), and Cassinello (1996) observed that calves spend more time by suckling than foraging in the first months on their life and when suckling begin decreasing, calves exhibit higher foraging rate.

Life of offspring is very valuable for females due to high energetic and nutrient costs and mother's antipredative protection of infants. White & Berger (2001) suggested that females adapt their behavour according rate of calf's activity and its vulnerability. It means that there exists a compromise between foraging and vigilance (predation risk) of females with calves. Lactating females need more nutrients because of lactation costs, therefore spent more time by foraging. Mother increases antipredator vigilance with increasing calf's activity. On the other hand, when young decreases its activities, female decreases antipredator vigilance and begins with forage intake until the calf becomes active (FitzGibbon, 1990b; Illius & FitzGibbon, 1994; White & Berger, 2001). This trade-off between foraging and pradation risk is quit common for non-precocious infants, which use hiding strategy (Lent, 1974). Our results did not show this tradeoff and females was foraging during calves activities. This result could be affected by captive condition and long-term living in farm without any predators. As Blumstein & Daniel (2005) found out that some antipredator's behaviours disappear after isolation on islands. This indicates that exists some antipredator behaviours and strategies which are hereditary (Riechert & Hedrick, 1990; Cousyn *et al.*, 2001) and some of them are phenotypic origin. In this study was stested dependency mother's response to calf's activity on age of calf, but there was not find out any significant differencies with calf's aging. During 11 months of research females was mostly foraging during calf's activity, but I suggest that in nature condition it could has a different results.

As Conradt (1998), Ruckstuhl (1998, 1999), and Ruckstuhl & Festa-Bianchet (2001) suggested that synchronization depend on age, body size mass and sex (Ruckstuhl & Neuhaus, 2001). Bachelor group of subadult males are much more synchronized than mix-group (females and males) of same aged animals. Individuals of same age, similar body mass and sex have same or similar activity budgets. Segregation according same age were described in Nubian ibex, *Capra nubiana* (Gross *et al.*, 1995), Alpine ibex, *Capra ibex* (Ruckstuhl & Neuhaus, 2001), mouflon, *Ovis gmelini* (Cransac *et al.*, 1998). Also type of habitat affects synchronization of group (Ruckstuhl & Neuhaus, 2001). In this study calves were highly synchronized during resting, foraging, Kayin, Ghana, Ellien and Lenny were highly synchronized during resting behaviour. They were similar age, so I assume that they have similar activity budget and influence of sex were very low because of non-balanced sex ratio of calves (1 female and 10 males). Ellien was low synchronized than other three calves, due to separation by the fences. I recorded synchronization during foraging in other group of calves (Simba, Nuru, Leon), which were also similar date of birth. Synchronization could be influence by segregation of calves to nursing group, it means that they are a lot of time together and imitate behaviours of other calves and adults. In the previous study of Makovcová (2005) was recorded high synchronization in three yearlings of common elands in this farm.

6. CONCLUSION

Mother-offspring interaction is very important factor for maintenance and survival of species and social structure of herd. As we hypothesized, females behaved differently in farm condition than in the wildlife. Females did not show higher vigilance behaviour during calf's activity and spent more time by foraging, ruminating, resting and moving during this time. So, I suggest that this antipredative behaviour disappeared due to long-term living without predators and low predation pressure, and lactating females now invest more to foraging due to lactation energetic and nutritional costs. Naturally mother's responses to calf's activity was not affect by aging of calves in this case. So, I supposed that mothers do not response to calf behaviour in captive condition.

Results of this observation supported the third hypotheses about synchronization of calves according same age. I recorded high synchronization during foraging and resting of same age calves as in previous studies about synchronization. Individuals of same age have a similar activity budget, so it is quit easy to synchronize a group, especially infants which associate all to the nursery group.

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List of Annexes

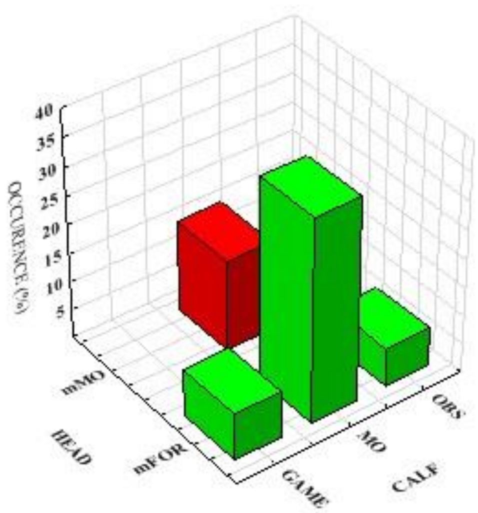
ANNEX 1 Results of sequence analyses of effect of calf activity on mother activity relative to calf age. For

These results have min. support 5.0 %, confidence 10.0 % and max. size of itemset 10.

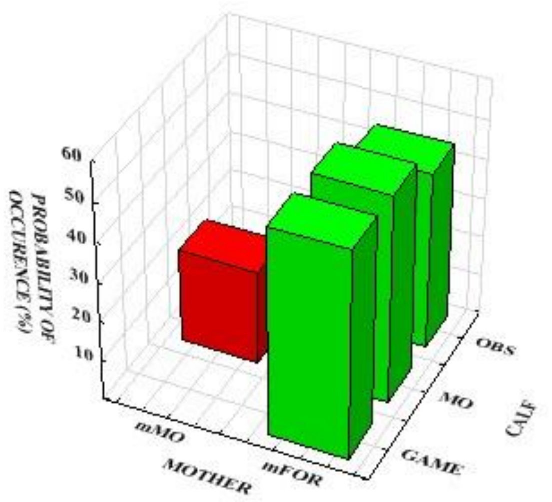
1st month of calf's age

CALF	MOTHER	OCCURENCE (%)	PROBABILITY OF OCCURENCE (%)
GAME	FOR	8.21705	53.00000
MO	FOR	35.50388	52.52294
MO	MO	16.12403	23.85321
OBS	FOR	6.66667	44.79167

Occurrence of mother-calf pair activities for 1st month of calf's age



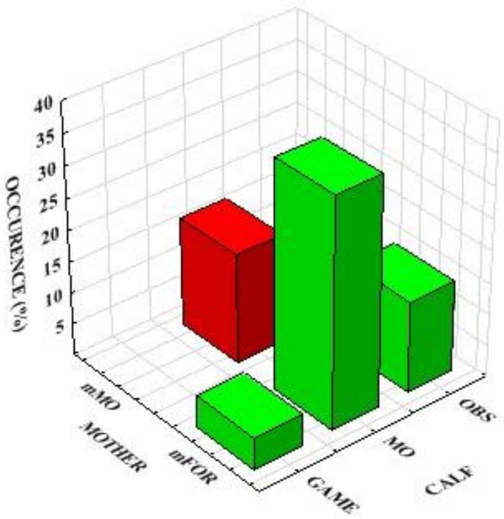
Probability of occurrence of mother-calf pair activities for 1st month of calf's age



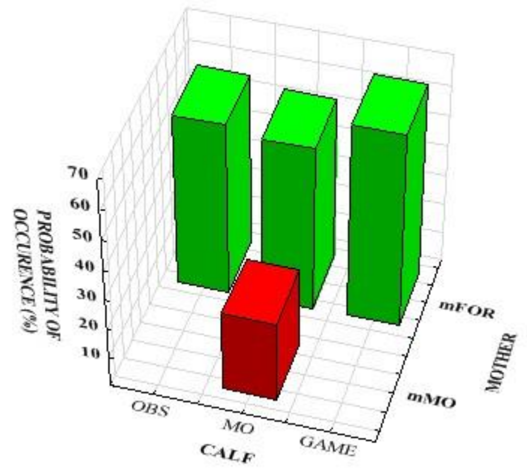
2nd month of calf's age

CALF	MOTHER	OCCURENCE (%)	PROBABILITY OF OCCURENCE (%)
GAME	FOR	5.07400	64.86489
MO	FOR	36.36364	54.95208
MO	MO	17.54757	26.51757
OBS	FOR	14.58774	57.50000

Occurrence of mother-calf pair activities for 2nd month of calf's age



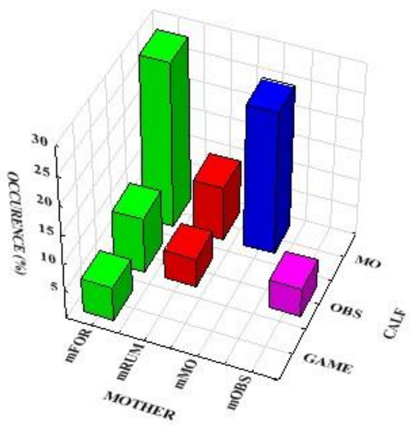
Probability of occurrence of mother-calf pair activities for 2nd month of calf's age



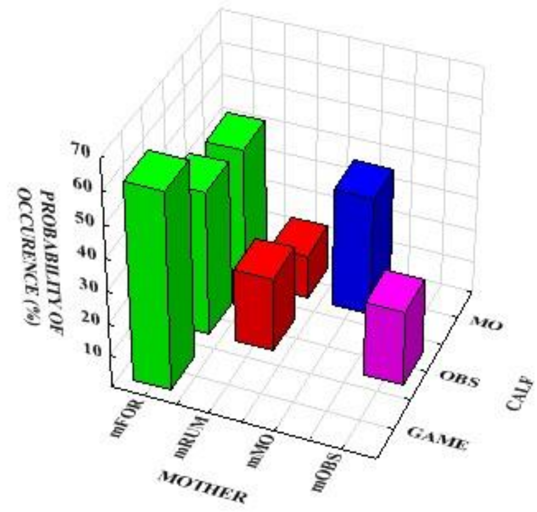
3rd month of calf's age

CALF	MOTHER	OCCURENCE (%)	PROBABILITY OF OCCURENCE (%)
MO	FOR	28.73900	42.06009
MO	RUM	9.38416	13.73391
MO	MO	24.92669	36.48069
OBS	FOR	9.67742	44.59459
OBS	RUM	4.98534	22.97297
OBS	OBS	4.98534	22.97297
GAME	FOR	5.86510	60.60606

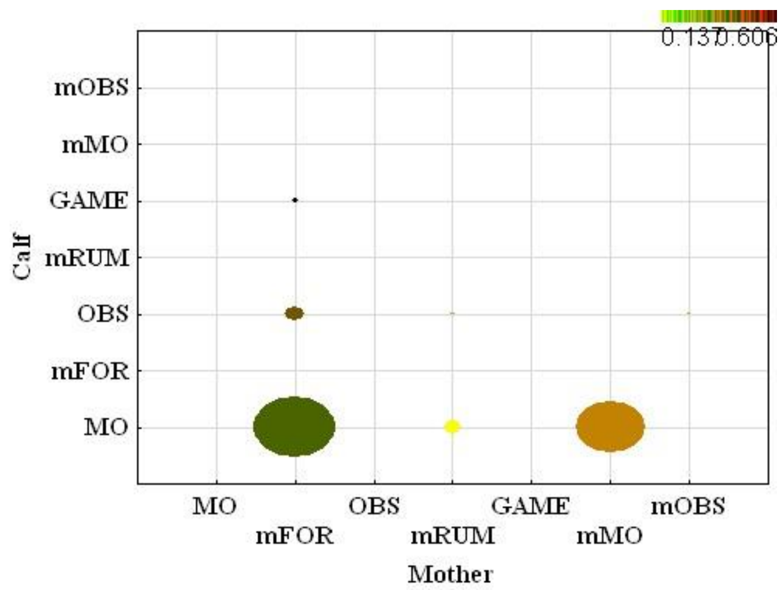
Occurrence of mother-calf pair activities for 3rd month of calf's age



Probability of occurrence of mother-calf pair activities for 3rd month of calf's age



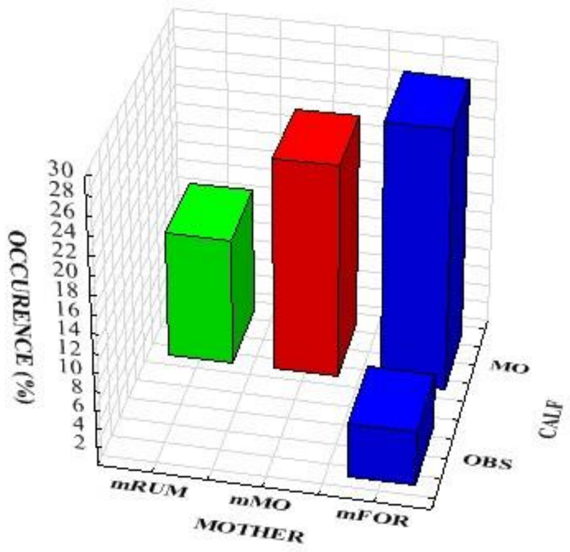
Graph of Synchronization for 3rd month of calf's age



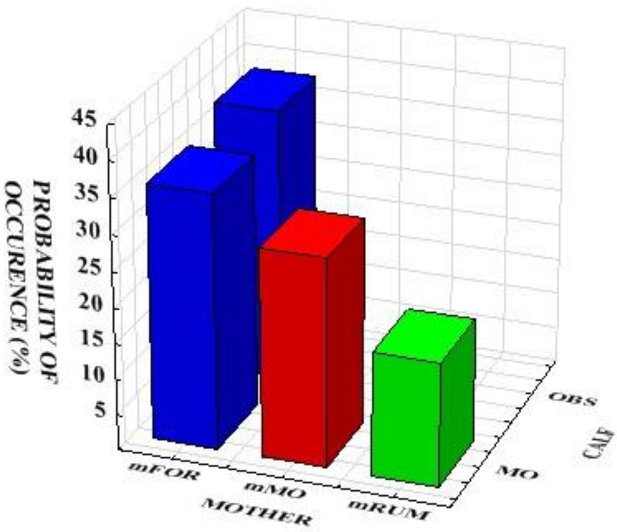
4th month of calf's age

CALF	MOTHER	OCCURENCE (%)	PROBABILITY OF OCCURENCE (%)
MO	RUM	13.40996	17.32673
MO	MO	22.60536	29.20792
MO	FOR	27.58621	35.64356
OBS	FOR	5.74713	38.46154

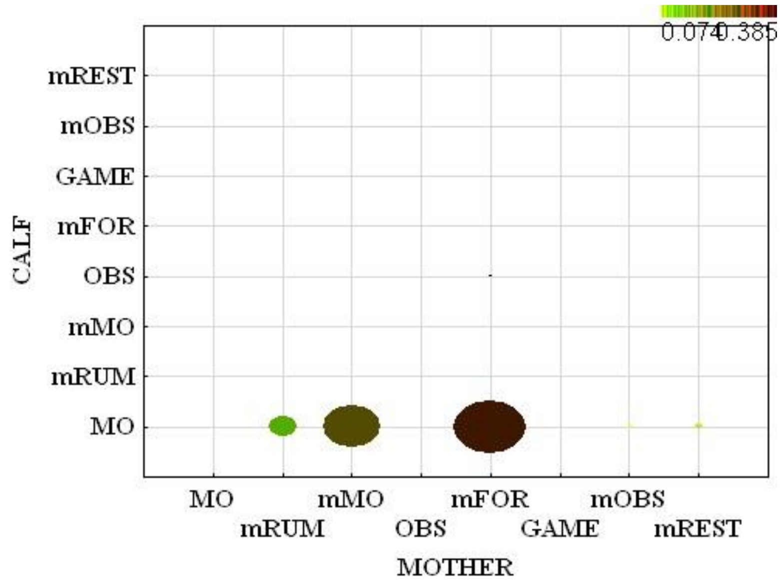
Occurrence of mother-calf pair activities for 4th month of calf's age



Probability of occurrence of mother-calf pair activities for 4th month of calf's age



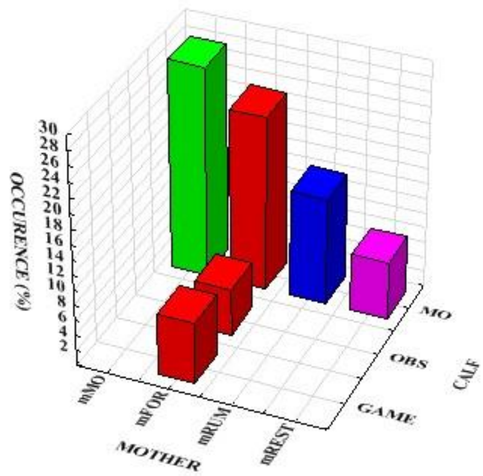
Graph of Synchronization for 4th month of calf's age



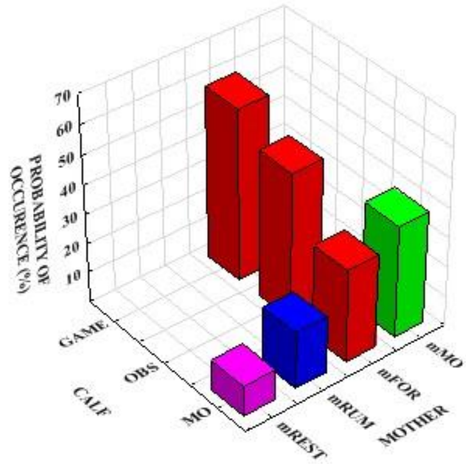
5th month of calf's age

CALF	MOTHER	OCCURENCE (%)	PROBABILITY OF OCCURENCE (%)
MO	MO	27.96209	38.06452
MO	FOR	23.22275	31.61290
MO	RUM	14.21801	19.35484
MO	REST	7.58294	10.32258
OBS	FOR	6.16114	50.00000
GAME	FOR	8.05687	58.62069

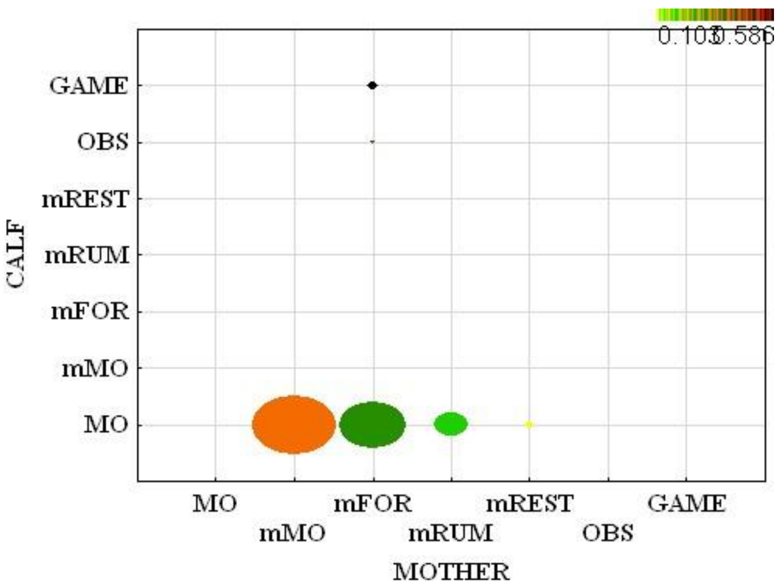
Occurrence of mother-calf pair activities for 5th month of calf's age



Probability of occurrence of mother-calf pair activities for 5th month of calf's age



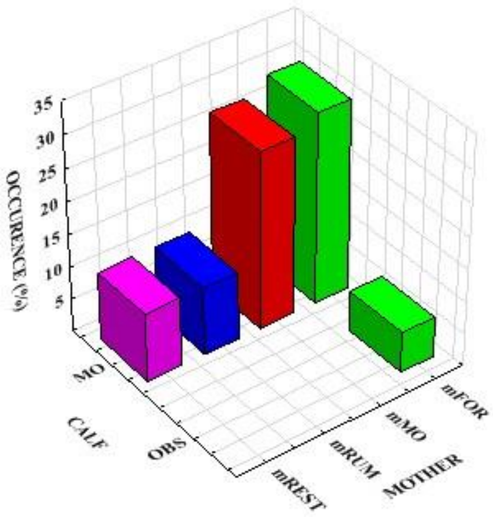
Graph of Synchronization for 5th month of calf's age



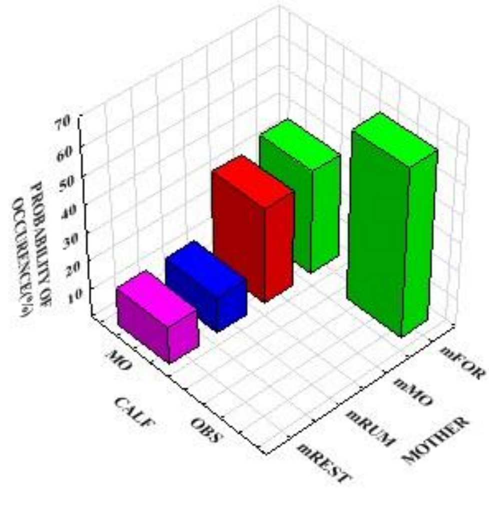
6th month of calf's age

CALF	MOTHER	OCCURENCE (%)	PROBABILITY OF OCCURENCE (%)
OBS	FOR	6.31579	60.00000
MO	FOR	29.47368	36.84211
MO	MO	27.36842	34.21053
MO	RUM	10.52632	13.15789
MO	REST	10.52632	13.15789

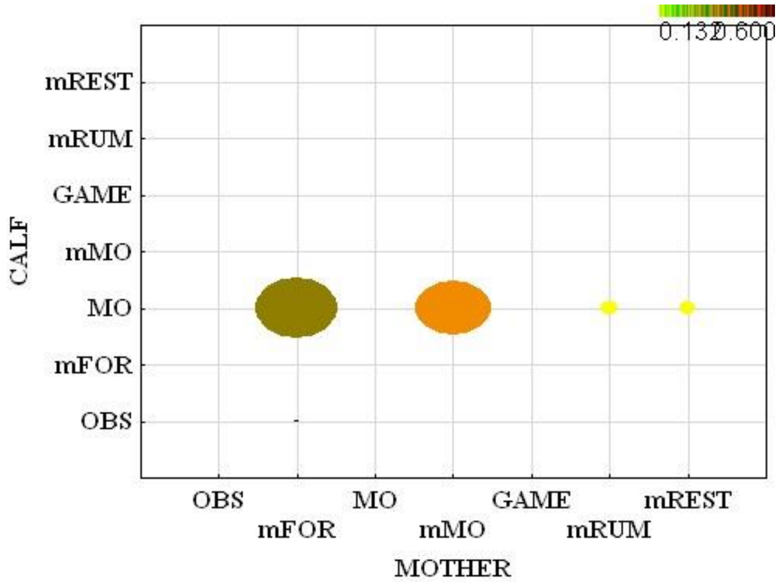
Occurrence of mother-calf pair activities for 6th month of calf's age



Probability of occurrence of mother-calf pair activities for 6th month of calf's age



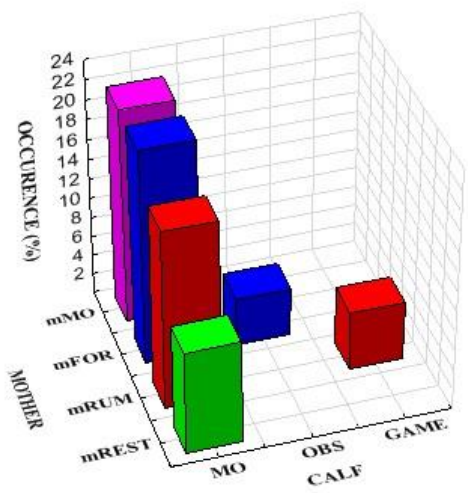
Graph of Synchronization for 6th month of calf's age



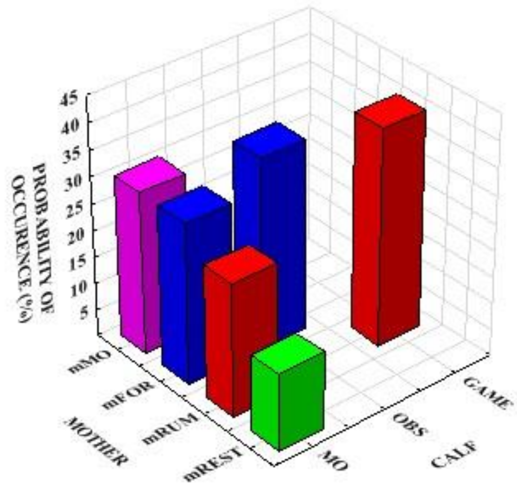
7th month of calf's age

CALF	MOTHER	OCCURENCE (%)	PROBABILITY OF OCCURENCE (%)
MO	REST	10.32609	14.39394
MO	RUM	17.93478	25.00000
MO	FOR	21.73913	30.30303
MO	MO	21.73913	30.30303
OBS	FOR	4.89130	36.00000
GAME	RUM	5.97826	40.74074

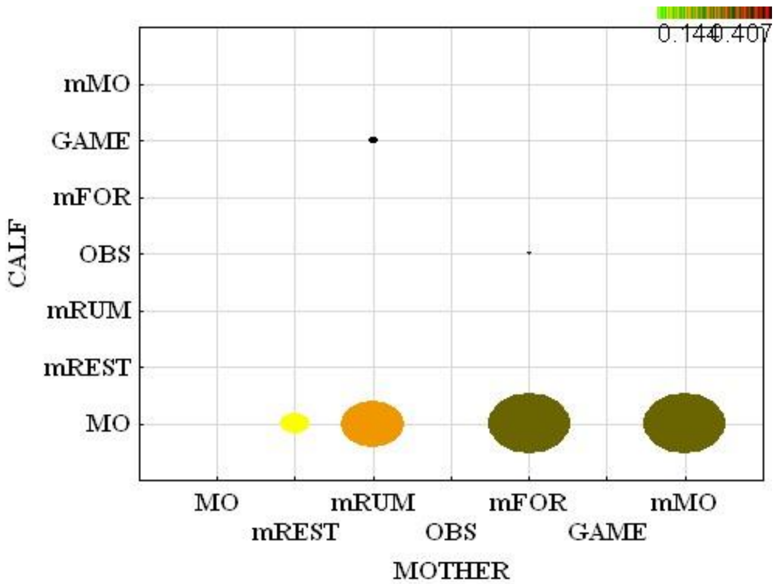
Occurrence of mother-calf pair activities for 7th month of calf's age



Probability of occurrence of mother-calf pair activities for 7th month of calf's age



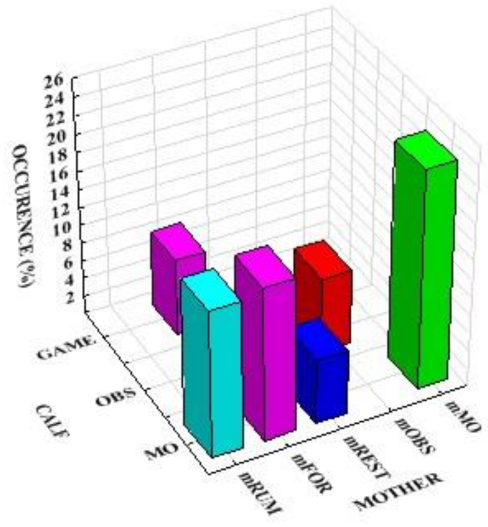
Graph of Synchronization for 7th month of calf's age



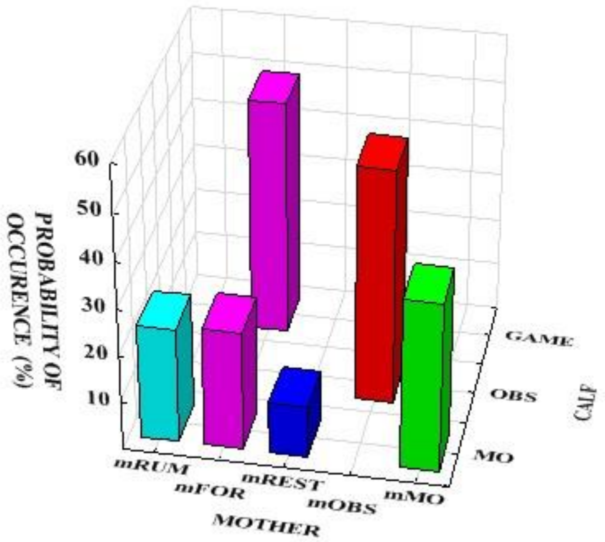
8th month of calf's age

CALF	MOTHER	OCCURENCE (%)	PROBABILITY OF OCCURENCE (%)
MO	MO	23.87097	35.92233
MO	REST	7.09677	10.67961
MO	FOR	16.77419	25.24272
MO	RUM	16.12903	24.27184
OBS	OBS	8.38710	50.00000
GAME	FOR	8.38710	50.00000

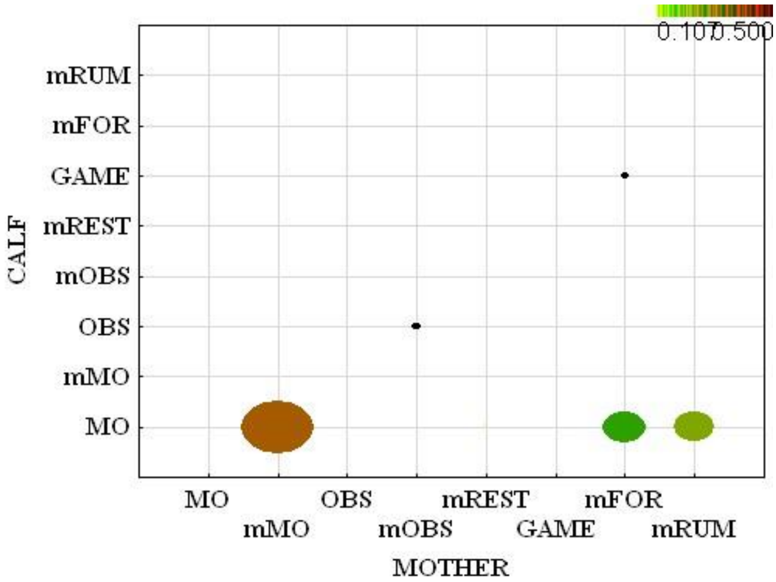
Occurrence of mother-calf pair activities for 8th month of calf's age



Probability of occurrence of mother-calf pair activities for 8th month of calf's age



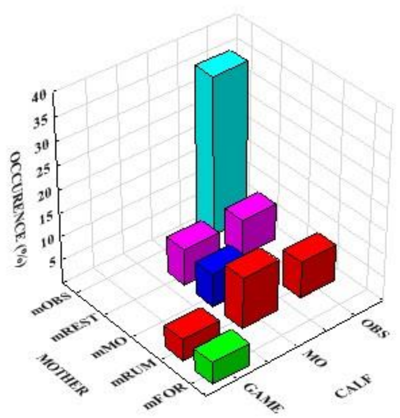
Graph of Synchronization for 8th month of calf's age



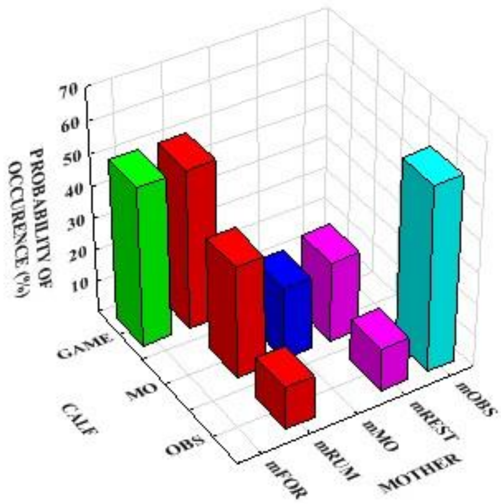
9th month of calf's age

CALF	MOTHER	OCCURENCE (%)	PROBABILITY OF OCCURENCE (%)
GAME	FOR	4.68750	50.00000
GAME	RUM	4.68750	50.00000
MO	RUM	10.93750	35.00000
MO	MO	7.03125	22.50000
MO	REST	7.81250	25.00000
OBS	RUM	7.81250	13.15789
OBS	REST	7.81250	13.15789
OBS	OBS	34.37500	57.89474

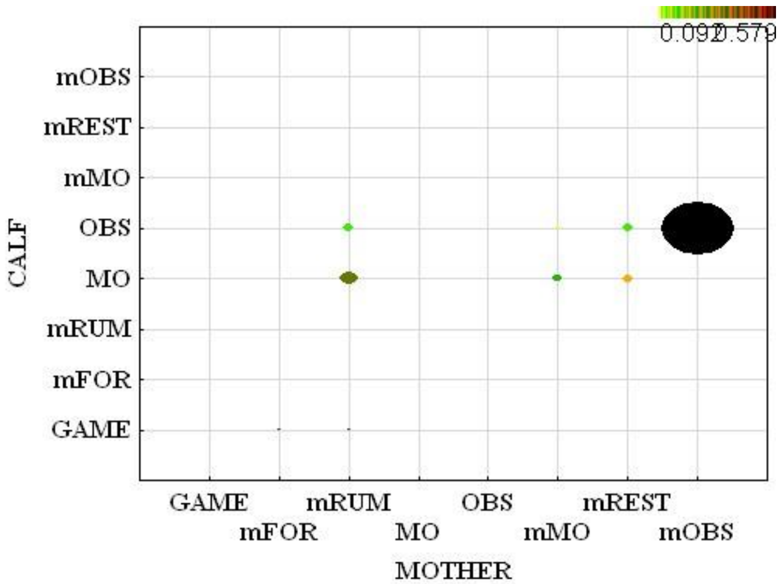
Occurrence of mother-calf pair activities for 9th month of calf's age



Probability of occurrence of mother-calf pair activities for 9th month of calf's age



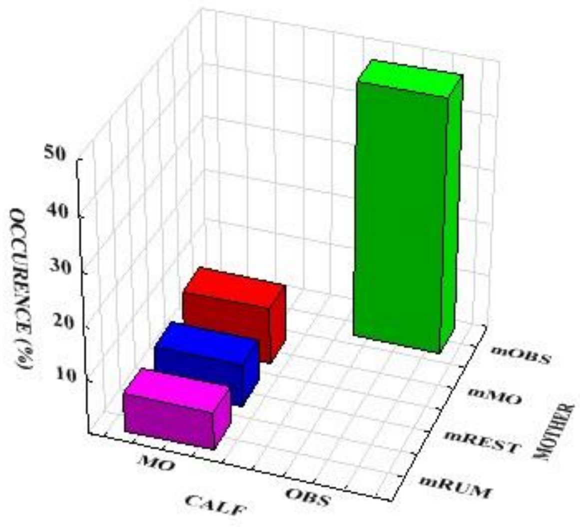
Graph of Synchronization for 9th month of calf's age



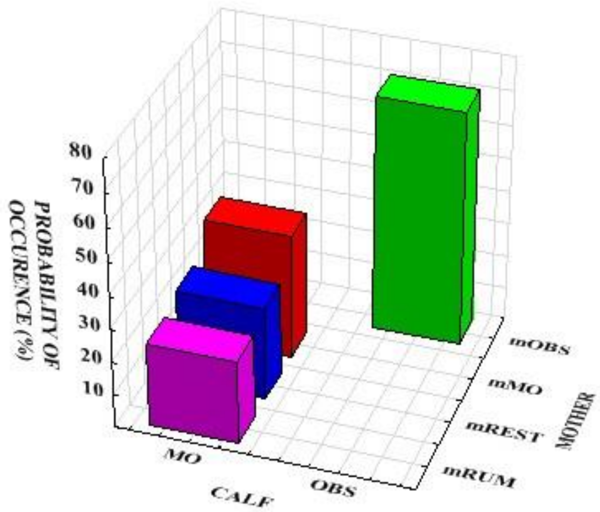
10th month of calf's age

CALF	MOTHER	OCCURENCE (%)	PROBABILITY OF OCCURENCE (%)
OBS	OBS	47.78761	71.05263
MO	MO	10.61947	37.50000
MO	REST	7.96460	28.12500
MO	RUM	7.07965	25.00000

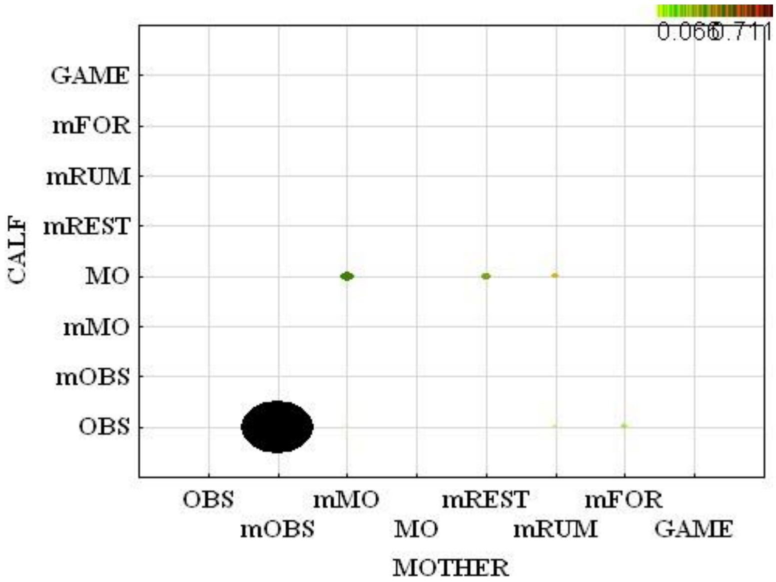
Occurrence of mother-calf pair activities for 10^{th} month of calf's age



Probability of occurrence of mother-calf pair activities for 10^{th} month of calf's age



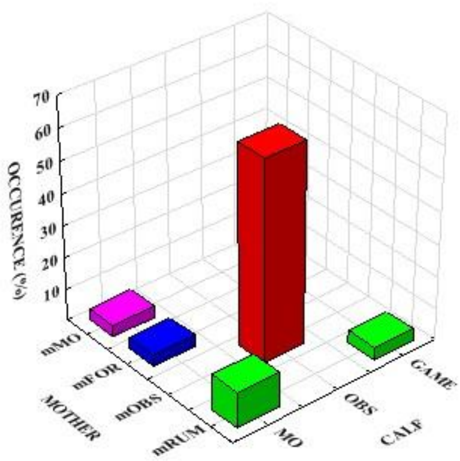
Graph of Synchronization for 10th month of calf's age



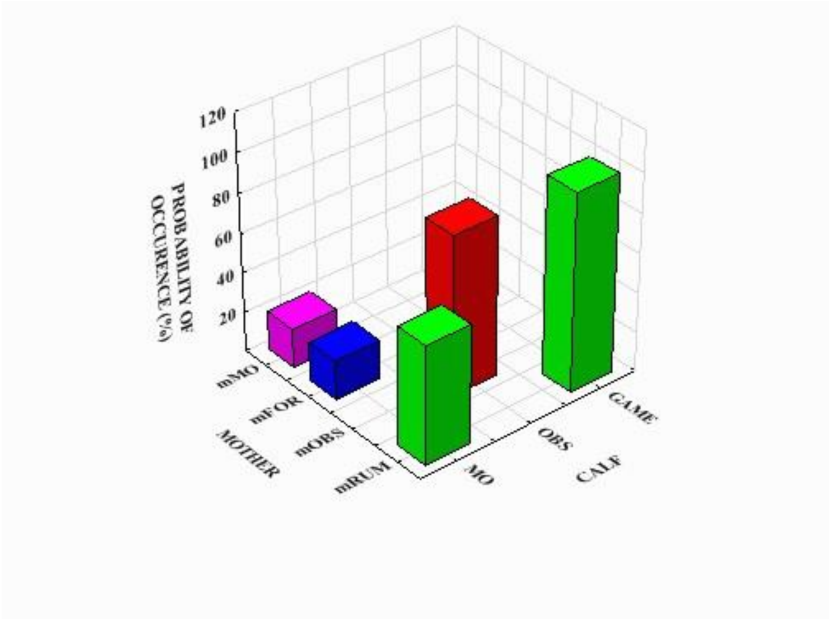
11th month of calf's age

CALF	MOTHER	OCCURENCE (%)	PROBABILITY OF OCCURENCE (%)
MO	RUM	11.11111	60.00000
MO	FOR	3.70370	20.00000
MO	MO	3.70370	20.00000
OBS	OBS	62.96296	80.95240
GAME	RUM	3.70370	100.00000

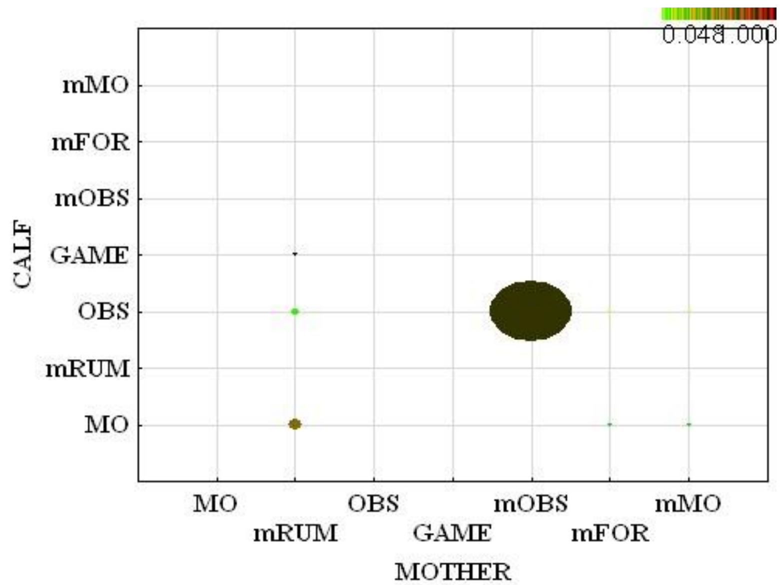
Occurrence of mother-calf pair activities for 11th month of calf's age



Probability of occurrence of mother-calf pair activities for 11th month of calf's age



Graph of Synchronization for 11th month of calf's age



ANNEX 2 Contingency table of chosen calf activities contra mother behaviours

Calf activity	Mother activity	Katka	Eliška	Glory	Lesana	Tora	Staple	Nassay	Lydie	Dulu	Lina	Viktorka	Sum
GAME	FOR	25	16	28	21	13	21	10	9	3	4	2	152
GAME	RUM	6	7	5	11	2	8	4	3	4	5	1	56
GAME	OBS	2	2	3	2	1	2	0	0	0	0	0	12
GAME	KO	0	0	0	1	1	0	0	0	0	1	0	3
GAME	MO	6	4	2	7	0	4	1	3	3	0	2	32
GAME	REST	5	5	5	6	1	4	6	0	1	2	0	35
GAME	GRO	0	0	1	0	0	0	0	0	0	0	0	1
GAME	CALL	0	4	0	0	0	0	0	0	0	0	0	4
	Sum	44	38	44	48	18	39	21	15	11	12	5	295
MO	FOR	78	71	76	76	51	83	73	77	52	41	44	722
MO	RUM	30	20	19	20	38	30	14	30	29	25	8	263
MO	OBS	13	2	8	13	5	13	5	10	5	1	1	76
MO	KO	2	0	1	1	0	0	0	1	1	0	2	8
MO	MO	68	45	55	65	28	60	53	43	28	30	40	515
MO	REST	11	18	11	12	19	9	7	9	15	3	17	131
MO	GRO	0	0	0	1	1	1	0	0	1	0	0	4
MO	CALL	1	3	1	1	1	0	0	0	1	0	0	8
	Sum	203	159	171	189	143	196	152	170	132	100	112	1727
OBS	FOR	24	15	22	19	24	14	24	24	17	12	8	203
OBS	RUM	6	10	10	9	15	6	12	11	12	5	6	102
OBS	OBS	13	16	16	20	16	14	15	14	21	14	17	176
OBS	KO	1	2	1	2	0	0	0	0	0	0	0	6
OBS	MO	10	2	5	5	3	3	6	8	4	2	4	52
OBS	REST	4	4	9	6	6	3	4	3	6	0	4	49
OBS	GRO	0	1	0	0	0	0	0	0	0	0	0	1

OBS	CALL	0	0	0	0	0	0	0	0	0	0	0	0
	Sum	58	50	63	61	64	40	61	60	60	33	39	589
CALL	FOR	1	4	1	0	1	2	0	0	0	0	1	10
CALL	RUM	0	2	0	0	0	1	0	0	0	0	0	3
CALL	OBS	0	0	0	0	0	0	0	0	0	0	0	0
CALL	KO	0	0	0	0	0	0	0	0	0	0	0	0
CALL	MO	1	0	0	0	0	0	0	1	0	0	0	2
CALL	REST	0	1	0	0	0	0	0	0	0	0	0	1
CALL	GRO	0	0	0	0	0	0	0	0	0	0	0	0
CALL	CALL	0	0	0	0	0	0	0	0	0	0	0	0
	Sum	2	7	1	0	1	3	0	1	0	0	1	16
RUM	FOR	0	0	0	0	0	0	0	0	0	0	0	0
RUM	RUM	0	0	0	0	0	0	0	0	0	0	0	0
RUM	OBS	0	0	0	0	0	0	0	0	0	0	0	0
RUM	KO	0	0	0	0	0	0	0	0	0	0	0	0
RUM	MO	0	0	1	0	0	0	0	0	0	0	0	1
RUM	REST	0	0	0	0	0	0	0	0	0	0	0	0
RUM	GRO	0	0	0	0	0	0	0	0	0	0	0	0
RUM	CALL	0	0	0	0	0	0	0	0	0	0	0	0
	Sum	0	0	1	0	0	0	0	0	0	0	0	0
REST	FOR	0	0	0	0	0	0	0	0	0	0	0	0
REST	RUM	0	0	0	0	0	0	0	0	0	0	0	0
REST	OBS	0	0	0	0	0	0	0	0	0	0	0	0
REST	KO	0	0	0	0	0	0	0	0	0	0	0	0
REST	MO	0	0	2	0	0	0	0	0	0	0	0	2
REST	REST	0	0	0	0	0	0	0	0	0	0	0	0
REST	GRO	0	0	0	0	0	0	0	0	0	0	0	0
REST	CALL	0	0	0	0	0	0	0	0	0	0	0	0

	Sum	0	0	2	0	0	0	0	0	0	0	0	2
FOR	FOR	0	0	0	0	0	0	0	0	0	0	0	0
FOR	RUM	0	0	0	0	0	0	0	0	0	0	0	0
FOR	OBS	0	0	0	0	0	0	0	0	0	0	0	0
FOR	KO	0	0	0	0	0	0	0	0	0	0	0	0
FOR	MO	0	0	3	0	0	0	0	0	0	0	0	3
FOR	REST	0	0	0	0	0	0	0	0	0	0	0	0
FOR	GRO	0	0	0	0	0	0	0	0	0	0	0	0
FOR	CALL	0	0	0	0	0	0	0	0	0	0	0	0
	Sum	0	0	3	0	0	0	0	0	0	0	0	3

ANNEX 3 Table of occurence and probability of occurence for synchronization of calf-calf activities - resting

These results have min. occurence 20.0 %, probability of occurence 10.0 % and max. size of itemset 2.

CALF	→	CALF	OCCURENCE (%)	PROBABILITY OF OCCURENCE (%)
Ghana	→	Lenny	30.35328	74.57927
Lenny	→	Ghana	30. 35328	73.02689
Kayin	→	Lenny	28.65898	74.43820
Lenny	→	Kayin	28.65898	68.95056
Kayin	→	Ghana	28.26244	73.40824
Ghana	→	Kayin	28.26244	69.44198
Tembi	→	Ellien	26.42394	68.50467
Ellien	→	Tembi	26.42394	61.70034
Ghana	→	Ellien	25.77505	63.33038
Ellien	→	Ghana	25.77505	60.18519
Lenny	→	Ellien	25.09012	60.36427
Ellien	→	Lenny	25.09012	58.58586
Nuru	→	Lenny	24.26099	68.88434
Lenny	→	Nuru	24.26099	58.36947
Simba	→	Nuru	24.22495	71.41339
Nuru	→	Simba	24.22495	68.78199
Simba	→	Lenny	24.18890	71.30712
Lenny	→	Simba	24.18890	58.19601
Leon	→	Nuru	24.08075	70.61311
Nuru	→	Leon	24.08075	68.37257
Daren	→	Tembi	24.08075	67.81726
Tembi	→	Daren	24.08075	62.42991
Kayin	→	Ellien	23.72026	61.61049
Ellien	→	Kayin	23.72026	55.38721
Simba	→	Ghana	23.17952	68.33156
Ghana	→	Simba	23.17952	56.95306
Nuru	→	Ghana	23.14348	65.71136
Ghana	→	Nuru	23.14348	56.86448
Daren	→	Ellien	22.96323	64.67005
Ellien	→	Daren	22.96323	53.61953
Leon	→	Lenny	22.89113	67.12474
Lenny	→	Leon	22.89113	55.07372
Tembi	→	Lenny	22.78298	59.06542
Lenny	→	Tembi	22.78298	54.81353
Simba	→	Kayin	22.09805	65.14346
Kayin	→	Simba	22.09805	57.39700
Nuru	→	Kayin	21.91781	62.23132

Kayin	→	Nuru	21.91781	56.92884
Simba	→	Tembi	21.84571	64.39957
Tembi	→	Simba	21.84571	56.63551
Tembi	→	Ghana	21.73756	56.35514
Ghana	→	Tembi	21.73756	53.41010
Simba	→	Leon	21.62942	63.76196
Leon	→	Simba	21.62942	63.42495
Leon	→	Ghana	21.55732	63.21353
Ghana	→	Leon	21.55732	52.96723
Leon	→	Daren	21.23288	62.26216
Daren	→	Leon	21.23288	59.79695
Nuru	→	Tembi	21.01658	59.67247
Tembi	→	Nuru	21.01658	54.48598
Leon	→	Tembi	20.90844	61.31078
Tembi	→	Leon	20.90844	54.20561
Leon	→	Kayin	20.80029	60.99366
Kayin	→	Leon	20.80029	54.02622
Nuru	→	Daren	20.47585	58.13715
Daren	→	Nuru	20.47585	57.66497
Kayin	→	Tembi	20.18745	52.43446
Tembi	→	Kayin	20.18745	52.33645

ANNEX 4 Table of occurence and probability of occurence for synchronization of calf-calf activities - ruminating

These results have min. occurence 10.0 %, probability of occurence 10.0 % and max. size of itemset 2.

CALF	→	CALF	OCCURENCE (%)	PROBABILITY OF OCCURENCE (%)
Lenny	→	Kayin	11.46359	63.34661
Kayin	→	Lenny	11.46359	57.60870
Simba	→	Nuru	11.10310	57.89474
Nuru	→	Simba	11.10310	61.60000
Lenny	→	Nuru	10.95890	55.77689
Nuru	→	Lenny	10.95890	56.00000
Tembi	→	Ellein	10.81471	57.20081
Ellien	→	Tembi	10.81471	53.71429
Lenny	→	Simba	10.70656	56.97211
Simba	→	Lenny	10.70656	53.75940
Nuru	→	Kayin	10.67051	57.40000
Kayin	→	Nuru	10.67051	51.99275
Lenny	→	Leon	10.49027	57.56972
Leon	→	Lenny	10.49027	57.45527
Leon	→	Kayin	10.49027	57.85288
Kayin	→	Leon	10.49027	52.71739
Simba	→	Kayin	10.41817	54.69925
Kayin	→	Simba	10.41817	52.71739
Lenny	→	Ghana	10.34607	58.96414
Ghana	→	Lenny	10.34607	53.91621
Ghana	→	Kayin	10.31002	54.09836
Kayin	→	Ghana	10.31002	53.80435
Leon	→	Ghana	10.16583	59.64215
Ghana	→	Leon	10.16583	54.64481
Simba	→	Ghana	10.09373	57.14286
Ghana	→	Simba	10.09373	55.37341
Leon	→	Simba	9.98558	55.06958
Simba	→	Leon	9.98558	52.06767

ANNEX 5 Table of occurence and probability of occurence for synchronization of calf-calf activities - foraging

These results have min. occurence 10.0 %, probability of occurence 10.0 % and max. size of itemset 2.

CALF	→	CALF	OCCURENCE (%)	PROBABILITY OF OCCURENCE (%)
Nuru	→	Simba	12.54506	65.16854
Simba	→	Nuru	12.54506	68.50394
Leon	→	Nuru	12.47296	67.97642
Nuru	→	Leon	12.47296	64.79401
Leon	→	Simba	12.07642	65.81532
Simba	→	Leon	12.07642	65.94488
Tembi	→	Ellien	11.96828	63.35878
Ellien	→	Tembi	11.96828	62.64151
Daren	→	Tembi	11.46359	61.74757
Tembi	→	Daren	11.46359	60.68702
Lungy	→	Daren	11.31939	69.01099
Daren	→	Lungy	11.31939	60.97087
Lungy	→	Ellien	11.17520	68.13187
Ellien	→	Lungy	11.17520	58.49057
Daren	→	Ellien	10.95890	59.02913
Ellien	→	Daren	10.95890	57.35849
Lungy	→	Tembi	10.95890	66.81319
Tembi	→	Lungy	10.95890	58.01527
Vorik	→	Simba	10.67051	66.51685
Simba	→	Vorik	10.67051	58.26772
Vorik	→	Leon	10.34607	64.49438
Leon	→	Vorik	10.34607	56.38507
Vorik	→	Nuru	10.27397	64.04494
Nuru	→	Vorik	10.27397	53.37079

ANNEX 6 List of Animals in farm (2010)

NAME	SEX	HERD/SING	DATE OF THE BIRTH
Krul	♂	1/14 orange	17.12.2003
Lojza	♂	1/15 green	20.12.2003
Pipin	♂	1/43 green	9.4.2007
Lome	♂	1/37 yellow	11.5.2007
Varna	♀	1/55 red	22.3.2007
Eliška	♀	1/57 red	9.4.2007
Čudlík	♂	1/49 blue	13.3.2007
Dulu	♀	1/35 blue	28.4.2007
Lorie	♀	1/61 blue	16.2.2007
Simir	♂	1/62 blue	29.1.2008
Velvet	♂	1/64 orange	8.2.2008
Cavalia	♀	1/66 red	20.4.2008
Tora	♀	1/56 blue	20.2.2007
Lina	♀	1/36 blue	8.5.2007
Drak	♂	1/45 blue	8.2.2008
Luboš	♂	1/54 yellow	31.1.2008
Singi	♂	1/60 green	21.10.2008
Dajan	♂	1/70 bue	26.4.2009
Lubumba	♀	1/81 blue	29.11.2009
Viktorka	♀	2/63 orange	2.2.2008
Glory	♀	2/ green sign	3.4.2006
Viktorie	♀	2/48 red	10.3.2007
Lydie	♀	2/4 blue	16.5.1997
Dakarka	♀	2/12 blue	16.10.2003
Katka	♀	2/7 red	27.12.2002
Staple	♀	2/11 green	17.8.2003
Lia	♀	2/16 yellow	22.5.2004
Lindi	♀	2/21 orange	5.4.2005
Nassay	♀	2/ no sign	25.5.2005
Sydney	♀	2/41 green	19.12.2007
Lejdy	♀	2/46 yellow	24.2.2008
Lutu	♂	2/47 blue	5.3.2008
Leanka	♀	2/52 yellow	11.4.2008
Lesana	♀	2/53 yellow	26.11.2004
Toulavka	♀	2/58 orange	15.6.2008
Gingo	♂	2/59 green	29.8.2008
Lumo	♂	2/75 yellow	4.5.2009
Noni	♂	2/77 green	6.5.2009
Latif	♂	2/78 yellow	10.5.2009
Gimbya	♀	2/ no sign	11.6.2009

ANNEX 7 Synchronization of REST, RUM and FOR. For abbreviation REST: resting, RUM: ruminating, FOR: foraging

These results have min. occurence 10.0 %, probability of occurence 10.0 % and max. size of itemset 10.

CALF	→	CALF	OCCURENCE (%)	PROBABILITY OF OCCURENCE (%)
REST	→	REST	57.82264	74.56997
REST	→	REST, REST	42.21341	54.43980
REST, REST	→	REST	42.21341	73.00499
REST	→	REST, REST, REST	31.25451	40.30683
REST, REST	→	REST, REST	31.25451	54.05237
REST, REST, REST	→	REST	31.25451	74.03928
REST	→	REST, REST, REST, REST	20.83634	26.87122
REST, REST	→	REST, REST, REST	20.83634	36.03491
REST, REST, REST	→	REST, REST	20.83634	49.35952
REST, REST, REST, REST	→	REST	20.83634	66.66667
REST	→	RUM	25.16222	32.45002
REST	→	FOR	20.51190	26.45281
RUM	→	REST	26.78443	60.11327
RUM	→	RUM	30.74982	69.01294
RUM	→	RUM, RUM	20.51190	46.03560
RUM, RUM	→	RUM	20.51190	66.70574
FOR	→	REST	23.35977	60.11327
FOR	→	RUM	20.43980	52.34249
FOR	→	FOR	31.86734	45.79968
FOR	→	FOR, FOR	21.01658	71.40549
FOR, FOR	→	FOR	21.01658	65.95023