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**Allonursing in captive giraffes (*Giraffa camelopardalis*)
- kin selection or milk-theft?**

Diploma Thesis

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Declaration

I declare that this diploma thesis of Allonursing in captive giraffes (*Giraffa camelopardalis*) - kin selection or milk-theft? was elaborated independently and is based on my own knowledge, consultations with my supervisor and literary resources cited in attached bibliography.

In Prague, 18. 4. 2012

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Abstrakt

Allokojení, tedy jev, kdy samice kojí jiná mláďata než svá vlastní, můžeme sledovat u mnoha skupin savců. Toto chování lze pozorovat ze dvou různých perspektiv, a to již ze zmíněné perspektivy samice (kojení cizích mláďat) a nebo z pohledu mláděte, sání od cizích samic = allosání.

Vzhledem k tomu, že laktace a mateřská péče jsou velmi energeticky náročné, není na první pohled zřejmé, proč samice kojí ještě jiné mládě než své vlastní, navíc hrozí přenos patogenů mezi samicí a nevlastním mládětem. Naopak allosání by pro mláďata mohlo být celkem přirozené, neboť mohou získat více energie, větší imunologickou výbavu anebo kompenzovat růstové nedostatky. Allokojení bylo pozorováno častěji u druhů s vícečetnými porody než u druhů, kde se rodí jen jediné mládě. U kopytníků je tedy vzácnější. Nicméně v lidské péči se toto chování vyskytuje více a to i u kopytníků.

Cílem této práce bylo zjistit, zda si samice žiraf při allokojení cizí mláďata vybírají. Pokud ano, předpokládaly jsme, že tomu tak je na základě příbuzenského výběru. Druhá možnost, že si samice cizí mláďata nevybírají, by mohla být vysvětlena hypotézou „krádeže“ mléka. Výzkum probíhal ve čtyřech zoologických zahradách v České republice na celkovém počtu 31 samic a 49 mláďat.

Celkem bylo pozorováno 3543 interakcí. 2673 pokusů a 870 kojení, z nichž v 43,8% šlo o allokojení. Hypotéza příbuzenského výběru potvrzena nebyla. Samice žiraf si nevybíraly při allokojení příbuznější mláďata. Naopak hypotéza „krádeže“ mléka by mohla allokojení vysvětlovat, neboť cizí mláďata sála většinou spolu s vlastním, nebo v pozicích, kde je samice mohla hůře identifikovat (dále od hlavy samice).

Klíčová slova: Allokojení, allosání, žirafa (*Giraffa camelopardalis*), sociální chování, příbuzeský výběr, „krádež“ mléka;

Abstract

Allonursing is a phenomenon of females nursing other calves than their own and can be found in many groups of mammals. It is possible to observe such behaviour from two different perspectives; from the above mentioned female perspective (nursing a non-filial calf) or from the perspective of a young one (sucking from a non-maternal female = allosucking).

Lactating and maternal care are very energy-consuming and it is not obvious, why the female nurses another offspring than her own. Moreover, there is the threat of the transmission of pathogens between female and the non-filial calf. On the other hand, allosucking could be quite understandable. The calves can get more energy, compensate their growth deficiencies or be supplied with a greater immunological equipment. Allonursing was observed more frequently in species with multiple births than in species where only one calf is born. Thus it is rare in ungulates. However, in captivity, the incidence of this behaviour occurs more often even in ungulates.

The aim of this study was to determine if the female giraffes during allonursing choose the non-filial calves. If so, it was presupposed that they do it because of kin selection. Another presumption was that the females do not choose the non-filial calves, and could be explained by the hypothesis of “milk theft”. The research was conducted in four zoos in the Czech Republic, with participation of 31 female and 49 young ones.

The total sum of observed interactions was 3543 out of which there were 2673 attempts and 870 nursing bouts, of which were 43.8% found to be practice allonursing. Kin-selection hypothesis has not been confirmed. The hypothesis of “milk theft” could explain allonursing because most of the non-filial calves suck mostly with the filial one, or in positions where it was more difficult for the female to identify them (further from the female's head).

Keywords: Allonursing, allosuckling, giraffe (*Giraffa camelopardalis*), social behaviour, kin selection, “milk theft”;

Contents

1	Introduction	10
1.1	Aims.....	11
1.2	Hypotheses.....	11
1.2.1	The Kin Selection Hypothesis.....	11
1.2.2	The Milk theft Hypothesis.....	11
2	Bibliographic research.....	13
2.1	Social behaviour.....	13
2.1.1	Altruism.....	13
2.1.2	Cooperation.....	14
2.1.2.1	Kin selection.....	14
2.1.2.2	Mutualism.....	16
2.1.2.3	Reciprocity.....	17
2.1.3	Living in groups.....	17
2.1.3.1	Advantages of social living.....	18
2.1.3.2	Disadvantages of social living.....	18
2.1.4	Parental behaviour.....	19
2.1.4.1	Helpers.....	19
2.2	Allonursing.....	21
2.2.1	What is allonursing.....	21
2.2.2	Why do young ones suck from non-maternal females.....	21
2.2.2.1	The Compensation Hypothesis.....	22
2.2.2.2	The Milk theft Hypothesis.....	22
2.2.3	Why females nurse non-filial juveniles.....	23
2.2.3.1	The Misdirected Parental Care Hypothesis.....	23
2.2.3.2	The Reciprocity Hypothesis.....	24
2.2.3.3	The Kin Selection Hypothesis.....	24
2.2.4	Other Factors influencing suckling behaviour.....	24
2.2.4.1	Age of the juvenile.....	25
2.2.4.2	Sex of the juvenile.....	25
2.2.4.3	Age of the females.....	26
2.2.5	Taxons where allonursing was found.....	26
2.2.5.1	Allonursing in ungulates.....	26
2.3	The Giraffe.....	28
2.3.1	<i>Giraffa camelopardalis</i> (Linnaeus, 1758).....	28
2.3.2	Current giraffe status.....	28
2.3.3	Taxonomy.....	29
2.3.4	Distribution of the giraffe.....	29
2.3.5	Anatomy.....	31
2.3.6	Ecology.....	32
2.3.6.1	Food.....	32
2.3.6.2	Communication.....	33
2.3.6.3	Reproduction.....	33
2.3.6.4	Predators.....	34
2.3.7	Social behaviour of giraffe.....	34
2.3.8	Maternal care of the giraffe.....	35
2.3.8.1	The milk of the giraffe.....	36
3	Material and Methods.....	37

3.1	Material.....	37
3.2	Methodology	38
3.2.1	Identification of the giraffe.....	38
3.2.2	Observation	39
3.2.3	Evaluation.....	40
3.2.3.1	Coefficient of relationship.....	40
3.2.3.2	Statistical analyses.....	41
4	Results.....	42
4.1	Kin Selection.....	44
4.1.1	The frequency and duration of allonursing depend on the coefficient relatedness	44
4.1.2	The female initiates allonursing more often with their filial or related offspring	46
4.1.3	Non-kin offspring and their being driven off more often.....	47
4.2	Milk theft	48
4.2.1	The Frequency and duration of allonursing depend on the mother's parity.....	48
4.2.2	Frequency and duration of allonursing depends on the mother's age	49
4.2.3	Female giraffes sniff (identify) filial calves more frequently.....	51
4.2.4	Does the female reach the calf in position 3?.....	51
4.2.5	The non-filial calves suck more often together with filial calves than alone.	52
5	Discussion	54
5.1	Kin Selection.....	54
5.2	Milk theft	55
6	Conclusion.....	57
7	References	58
8	List of Figures and Tables	67
9	List of the Appendices.....	I

1 Introduction

In many groups of mammals we can get together with the phenomenon of females nursing other offspring than their own. This behaviour is called allosuckling and occurs in many species of mammals in the wild as well as in captivity (Packer et al., 1992; Roulin, 2002). We perceive allonursing as providing milk to a non-filial young (seen from the female point of view), and allosuckling (from the perspective of the offspring) means that the calf receives milk from other females than from their own mothers (Bartoš et al., 2001a, b; Drábková et al., 2008; Zapata et al., 2009b).

The causes of allonursing are not clear at the first sight as lactation is very energy-consuming (Gittleman and Thompson, 1988) and also involves the risk of pathogen transmission between mother and the non-filial calf (Roulin, 2002). On the other hand, causes of allosuckling are quite understandable. The young can get more supply of energy to compensate the growth deficiencies (Bartoš et al., 2001b) or get more immune gear if they suck from more females (Roulin and Heeb, 1999).

Allonursing was observed more frequently in species with multiple births than in species where there is only one young born (Packer et al., 1992). This behaviour is not so common in ungulates, nevertheless, it was recorded at a relatively large number of ungulate species of both Artiodactyla and Perissodactyla.

Allosuckling in Artiodactyla was found in larger or lesser extents for example in red deer (*Cervus elaphus*) (Bartoš et al., 2001a,b); river buffalo (*Bubalus bubalis*) (Murphey et al., 1995); cattle (Víchová and Bartoš, 2005); guanacos (*Lama guanicoe*) (Zapata et al., 2009a); camels (*Camelus bactrianus*) (Miková and Sovják, 2005); pigs (Illmann et al., 2007) and also giraffes (*Giraffa camelopardalis*) (Packer et al., 1992).

This thesis is a further exploration of a previous research (Valdhansová and Koláčková, 2008; Gloneková, 2009) which confirmed the allonursing of giraffes in captivity and tries to find reasons why captive giraffes nurse non-filial calves. At the same time a cooperating research was carried out, detecting why non-filial calves suck from other females.

Giraffes usually live in smaller, little cohesive groups (Dagg and Foster, 1972) in the vast home range. In contrast, the giraffes' space in captivity is limited and this may lead to more frequent interactions among individuals. The social structure of the captive group is influenced by its social relationships, mainly mothers and calves (Bashaw et al., 2007).

We assume that allonursing occurs less often in the wild and is more commonly found by the animals in captivity according to Packer et al. (1992). Pratt and Anderson, pers.com.in Packer (1992) show that allonursing of the giraffes in the wild appears but it is less than 10% of all nursing. Opposed to this, Valdhansová and Koláčková (2008) have shown 45.24% of allonursing in the captive giraffe, with Gloneková (2009) describing 46.7% of allonursing in the captive giraffe.

1.1 Aims

The main aim of the research was to find out why the females in captivity nurse non-filial calves. I predicted two possibilities. The first one was that the females nurse the non-filial calves intentionally (because of kin selection) and the second one that they do it inadvertently (“unknowingly“). For the second prediction I assumed that inexperienced females would nurse non-filial calves more than the females took more experience and that the calves will try to steal the milk from non-maternal females.

1.2 Hypotheses

1.2.1 The Kin Selection Hypothesis

H1: Females prefer allonursing calves with a higher coefficient of relationship

1. Frequency and duration of allonursing depends on the coefficient of relationship
2. The female is more likely to initiate allonursing to related offspring
3. The female drives off more often the non-kin offspring

1.2.2 The Milk theft Hypothesis

H2: More experienced or older females nurse the non-filial calves less often than the inexperienced and young females

1. Frequency and duration of allonursing depends on the parity of the mother
2. Frequency and duration of allonursing depends on the age of the mother

H3: The non-filial calves suck from the non-maternal females in positions further from the females head or together with filial calf

1. The female sniffs (identifies) filial calves more often than non-filial ones.
2. The non-filial calves suck together with filial calves more often than they do so alone.

2 Bibliographic research

2.1 Social behaviour

Social structure forms an important class of behavioural and ecological relationships among individuals of the same species. It is based on interactions between individuals (Whitehead, 2008) and these interactions can be beneficial for one or both members who are interacting together at a particular moment. It can be labelled agonistic, sexual or parental behaviour (Johnsgard, 1967) and all the interactions among individuals are the results of the animals' sociality (Wilson, 2000).

Social structure synthesizes behavioural and ecological relationships between members of the same species whose ranges overlap. Animals can cooperate in attaining resources or defending resources against conspecifics or themselves against predators (Whitehead, 2008). Alloparental care can also be a way of cooperation when the animals cooperate for mutual upbringing of their descendants (Stiver et al., 2012).

2.1.1 Altruism

Altruism is the phenomena dependent on the existence of sociality (Klopfer, 1967). It is any acting in the interest of others at cost of the individual (Krebs and Davies, 1981; Trivers, 1971) which means a type of behaviour that is beneficial to another organism (Rowthorn, 2006; Trivers, 1971) but is unprofitable (futile) for the donor (Franck, 1996). The animal can offer its safety in order to defend others (Maurice, 1977). Altruistic behaviour increases the direct fitness of the recipient and reduces the direct fitness of the actor (Kappeler, 2010).

Altruism exhibited for example by parents in defending their youngsters (Krebs and Davies, 1981; Maurice, 1977) together with participation in parenting the offspring, sharing food, protecting others or sacrificing one's life to save the family is much more common among relatives (Attenborough, 1990). Such help can be the aim of the direct descendant as well as other relatives (Alcock, 1975). Manning and Dawkins (1998) say that an altruist will help only when it provides its genes to survive. A number of scientists involved in the issue believe, that allonursing is the result of altruism (Packer et al., 1992).

One of the answers why the females nurse the non-filial calf could be the postulate of an inclusive fitness theory where there should be the help to perpetuate the genes of the altruist (Murphey et al., 1991).

2.1.2 Cooperation

Cooperation means that individuals help each other (Nowak, 2006). According to Kappeler (2010) it is the outcome of an interaction (or repeated interactions) where all participants increase their direct fitness. Conversely, Krebs and Davies (1981) believe that cooperation is the act where at least one participating receives some benefit and increases its fitness at another individual's expense and who then becomes manipulated, without being aware of it. A cooperator therefore pays for another one who receives a pure benefit (Nowak, 2006).

The cooperative behaviour in animal societies is often explained as maintaining because of its benefits to groups or populations (Clutton-Brock, 2009b) as it brings the result which gives some advantage to the group members and has been achieved through a collective action (Dugatkin, 1997).

The new theoretical treatments have a basis in Hamilton's models of the evolution of cooperation where there is the concept of inclusive fitness a very important issue (Clutton-Brock, 2010). Cooperation has been observed between relatives but also between unrelated individuals or even between members of different species (Nowak, 2006).

According to Clutton-Brock (2010); Whitehead (2008) and Dugatkin (1997), there are more explanations why animals cooperate. There are kin selection, mutualism and various forms of reciprocity to be named.

2.1.2.1 Kin selection

An individual can help transfer its genetic representation to the future generations by helping close relatives who share its genes (Krebs and Davies, 1981; Nowak, 2006). As a relative carries some of the same genes, the kin-helping behaviour will occur (Kappeler, 2010). It can be found even among quite distant relatives (Eberhard, 1975). Kinship is seen to be one of the key moments in being social. If the genealogy is known, affiliation between any pair of individuals could be calculated (Whitehead, 2008).

What is seen as essential in the kin-selection theory is the concept of inclusive fitness (Oli, 2002), showing how individuals gain inclusive fitness. The procedure is either indirect through related individuals (indirect fitness), or directly by reproducing itself (direct fitness) (Griffin and West, 2002).

2.1.2.1.1 Recognition of relatives

In social groups containing related and unrelated individuals, animals must have some way to recognize who is their relative and who is not (Manning and Dawkins, 1998). Kin recognition is an ability to identify and distinguish kin from non-kin, and may be an important step in the development of social and sexual behaviour (Kappeler, 2010).

Females need to distinguish between filial and non-filial offspring (Pusey and Packer, 1994; Maurice, 1977). Parent-offspring recognition is usually crucial for the survival of the young (Torriani et al., 2006). The animals use the experience of look, sound or smell, which are very important for offspring identification (Maurice, 1977). Manning and Dawkins (1998) have named the above described recognition “phenotype matching”.

2.1.2.1.2 Coefficient of relatedness “r”(Wright, 1992)

We can quantify the likelihood that a parent and an offspring will share a copy of genes identical by descent and also the odds to share the genes with brothers, sisters, cousins and so on (Krebs and Davies, 1981; Barnard, 2004). This probability of sharing genes is called relatedness (Nowak, 2006) and can be quantified by the coefficient of relatedness = r (Krebs and Davies, 1981, Barnard, 2004; Wright, 1992).

It should be mentioned here that siblings and parents together with juveniles have 50% chance to share the genes ($r = 0.5$). Nieces and nephews have 25% chance ($r = 0.25$) (Manning and Dawkins, 1998; Nowak, 2006; Wright, 1992, Barnard, 2004).

2.1.2.1.3 Fitness

Fitness is the survival and fertility success of the organism (Barnard, 2004; Ridley, 1995), and can be divided into two types: **direct fitness** obtained by individual reproduction, meaning production of one's own offspring (Krebs and Davies, 1981). It is an approach centered on the recipient and calculating the fitness effect on the

recipient of the behaviour of several actors (Taylor et al., 2007) whereas **indirect fitness** obtain help to the family member to survive and reproduce. The fitness components are received from the effects on reproduction of relatives (i.g. siblings) (Krebs and Davies, 1981; Foster, 2005).

Inclusive fitness is a process centered on the actor, calculating the fitness effect on a number of recipients of the single actor behaviour (Taylor et al., 2007). Inclusive fitness shows the importance of genetic transmission through non-descendent relatives (Queller, 1992) and is measured by Hamilton's rule (Krebs and Davies, 1981).

2.1.2.1.4 Hamilton's rule

Hamilton's rule is the relationship of benefit, cost and relatedness necessary for advantageous altruism (Queller, 1992, Barnard, 2004), evaluates the advantages and disadvantages related to the participation in upbringing of the juveniles. This model explains the selfless act of closest relatives (Veselovský, 2005; Barnard, 2004) and can be used for altruism by descendents as well as for any member of a population (Queller, 1992).

$C > r \times B$

It is a formula where $r \times B$ includes the indirect fitness component, composed of the fitness benefit for the recipient (B) multiplied by the coefficient of relatedness between actor and recipient (r). C is the direct fitness component measuring the actor's direct fitness component (Kappeler, 2010; Dugatkin, 1997; Nowak, 2006).

2.1.2.2 Mutualism

Mutualism has been described as the simplest of all the cooperative mechanisms. Animals help others because their behaviour at this point helps themselves, too (Whitehead, 2008). Cooperators benefit immediately and suffer no temporary reduction in their fitness (Avital and Jablonka, 2000). Two or more animals cooperate to gain survival or reproductive benefits (Krebs and Davies, 1981). If the individual profits from

cooperation and is not dependent on the partner's action, the cooperation can evolve despite the existence of some associated costs (Sumpter, 2010).

Grouping is a good example of mutualism. Animals form groups to profit from joining a group and also other group members are benefited (Whitehead, 2008). The golden jackal increase hunting success by hunting in pairs rather than alone (Kappeler, 2010).

2.1.2.3 Reciprocity

Reciprocity is based on the theory that the rate of individuals' interactions with another individual depends on previous interactions in the community (Whitehead, 2008). The benefit of such altruistic behaviour to the recipient is greater than its costs to the participant as long as help is reciprocated (Krebs and Davies, 1981). The cooperator's fitness is temporarily reduced, but such reduction is later compensated for by an overall increase in fitness (Avital and Jablonka, 2000).

The explanation of cooperation among non-relatives often proves, that individuals' exchange resources or services (Barnard, 2004). The above described procedure suggests that cooperation is maintained by reciprocity. The obvious existence of reciprocity in animal societies is rare and many examples of cooperation among non-relatives possibly represent cases of intra-specific mutualism or manipulation (Clutton-Brock, 2010).

2.1.3 Living in groups

It often occurs that all individuals within the “group” are associated with each other. Animals make clusters to localize sources of food or shelter. These aggregations and groups are elements of social structure (Whitehead, 2008). Traditional interpretations of the evolution in animal societies have suggested that the society structure is an attempt to maximize an individual's inclusive fitness (Clutton-Brock, 2009a). Individuals may actively seek or maintain proximity with other individuals because there are benefits from grouping with others (Whitehead, 2008).

Mammalian societies are complex systems influenced and modified by interactions of a lot of external factors and internal constraints. Individuals do not distract or relate to each other randomly; they are found in characteristic patterns of population dispersion, grouping

and ranging and form relationships varying in number, complexity and duration (Crook et al., 1976).

2.1.3.1 Advantages of social living

Sociality brings advantages to animals (Klopfer, 1967) and is often very beneficial to them (Manning and Dawkins, 1998). To be a group member is important for many kinds of animal species. It is believed that living in a group helps an individual survive more easily than if they lived on their own or in couples (Allman, 2010). The greatest of advantages is likely to be the protection against predators (Attenborough, 1990; Klopfer, 1967; Manning and Dawkins, 1998; Maurice, 1977).

Living in a group lessens the probability of an individual being attacked as the predator has more animals to choose from (Molvar and Bowyer, 1994). According to Many Eyes theory, if more animals watch out for danger, that expected danger will be found. Many Eyes is also a more effective way to find food (Allman, 2010). Each individual benefits when one animal traces food (plants, berries, or prey) and living in groups is also helpful in protection of their food supply (Barnard, 2004; Allman, 2010). Habitat protection can also be mentioned. Groups can defend a territory against other groups of their species (Klopfer, 1967).

2.1.3.2 Disadvantages of social living

There are disadvantages to living in a group to be mentioned, too. No animal gets all of the food resources, food must be shared and there is always the possibility of a particular member being left with an insufficient amount of food (Krebs and Davies, 1981). If there is a group, there may also be fights over food and water (Whitehead, 2008). Animals must often be submissive to dominant leaders or alpha animals. If a hierarchy exist in groups and each animal has a strict place there (Beacham, 2003), it must submit to any animal with a higher status, must be ready to give up of food, water, or a prized resting place when a dominant animal is interested (Allman, 2010). This may prove to be a serious con to grouping. It has also been discovered that conspicuousness may increase (Krebs and Davies, 1981). A single animal can hide from predators, but it may not be true if a whole

group is considered (Barnard, 2004; Roberts, 1996). Individuals are attacked by hungry predators more easily due to a better visibility of a whole group (Allman, 2010).

2.1.4 Parental behaviour

Parental care is the basic way to transmit genetic information. The parental information is essential for the survival and reproduction of the offspring (Avital and Jablonka, 2000). Any care could lead to improving the condition of the juvenile. Mammals show extensive inter-specific variation in the form of maternal care (Fisher et al., 2002). We may observe largely different parental care patterns in related species. The benefits consist of preservation of the genus and growth (Clutton-Brock, 1991). Parental behaviour includes feeding and looking after the young (Klopfer, 1967) and reduces parents' freedom and exposes them to danger (Attenborough, 1990).

The onset of maternal care is a complex process in which the mother defends the newborn against any unknown stimuli (Kappeler, 2010). Males of many species do not participate nearly at all (Klopfer, 1967; Maurice, 1977).

Speaking strictly of ungulates, there are two main strategies between species in which an offspring follows the mother ("following" strategy) or species in which offspring remain covert ("hiding" strategy) (Fisher et al., 2002). According to Langman (1977) giraffe belongs to the group of hidiers.

Alloparental care means that a female provides nourishment, protection, or other forms of care to a non-filial offspring. It can be very costly in terms of the mother's energy (Maniscalco et al., 2006, Trivers, 1974).

2.1.4.1 Helpers

Several studies of the evolution of helping have been realized to explain the reciprocity and altruism towards relatives (Leimar, 2010). Helping is a behaviour increasing a recipient's direct fitness and the recipient is affected positively. Helping comprises of altruistic and cooperative behaviour (Kappeler, 2010). The described behaviour appears to be altruistic since the helpers offer benefit to others (Krebs and Davies, 1981).

Direct parental care is not necessarily the only strategy to pass the genes to the future. Helping a brother, sister, aunts or grandmothers can also be a way of keeping the gender

(Krebs and Davies, 1981; Manning and Dawkins, 1998). With a number of species, a phenomenon of relatives helping with the brood's upbringing has been described. Animals being active in taking care of other family members are called “helpers” (Veselovský, 2005). Close social interaction can occur between the young and the aunt or grandmother in cases of lowering the helper's fertility (Franck, 1996). Some studies have shown that mammalian fathers, brothers and even unrelated males may contribute significantly to the care of the young (Woodroffe, 1994).

Franck (1996) and also Krebs and Davies (1981) prefaced that helpers are often not related or are of distant relation only (Clutton-Brock, 2002; Avital and Jablonka, 2000). An explanation suggests that allofeeding promotes a social bond with non-relatives (Connor and Curry, 1995). The benefits of helping may be sufficient to maintain cooperative societies (Clutton-Brock, 2002). One of the direct and most obvious benefits of helping is that a young helper acquires information that will make it a better parent (Avital and Jablonka, 2000).

Helping is found in many different species and in various ecological and social situations (Avital and Jablonka, 2000). Most of the detailed studies of alloparental behaviour have dealt with the behaviour of birds as their society allows the currently non-breeding “helpers” to assist others to rear their young ones without taking the full parental responsibility (Cockburn, 1998; Avital and Jablonka, 2000).

2.2 Allonursing

2.2.1 What is allonursing

Mammalian juveniles need their mother's milk to grow up and some of them are able to suck for years (Attenborough, 1990). But not always the juvenile sucks from its own mother only. The term allosuckling is used to describe a calf receiving milk from other females than their own mothers. We perceive allonursing to be feeding non-filial calves (Bartoš et al., 2001a, b, Drábková et al., 2008, Zapata et al., 2009b). Non-offspring nursing is found to be a greatly extreme form of communal parenting (Cameron et al., 1999).

Although allonursing is considered to be a costly behaviour, it has been found in quite a lot of mammals (Packer, 1992). It is very energy-consuming (Illman et al., 2005), involves the risk of pathogen transmission between mother and the non-filial calf (Roulin, 2002) and is not utterly clarified.

In monotocous species such as ungulates this behaviour occurs less frequently than in polytocous species. Most cases have been reported among captive animals (Packer et al., 1992; Zapata et al., 2009b).

Cows and calves of the river buffalo have different motives to practice allonursing (Murphey et al., 1991). Allonursing can be intentional, when a female knows who is suckling. Or it can be a mistake when the female does not recognize the young one, she does not know who is suckling (Roulin, 2002). It can be caused by position of the calf, when it suck further from the mothers head and the female can not identify it (Zapata et al., 2010). The non-filial calf sucking together with her own offspring may well be possible, too. The described behaviour was observed in camels (Miková and Sovják, 2005), and buffalo cows were found nursing up to 4 calves (Murphey et al., 1991). Multiple nursing was noticed also in giraffes (Valdhansová and Koláčková, 2008; Gloneková, 2009).

Allosuckling has also been understood with parasitic behaviour of calves or connected with mothers who have lost their own offspring (Zapata et al., 2009a).

2.2.2 Why do young ones suck from non-maternal females

Allosuckling is a young animal feeding on milk from non-maternal females. The animal may choose to behave like if its own mother does not have enough milk to cover its energetic requirements (Roulin, 2002). This behaviour represents opportunism by the calf

(Zapata et al., 2009b). It is an advantage to get as much milk as possible whenever they can and from whatever source they are able to (Murphey et al., 1991). The milk intake from a non-maternal female is believed to be beneficial for the allosucking infant (Víchová and Bartoš, 2005). Young mammals do not have sufficient immunity against pathogens until their immune system will not support the mothers who transmitted immunological compounds to the young during lactation (Brambell, 2010). It is assumed that young mammals can get some advantage by sucking from more females than their own mothers only (allosuckling) and therefore they get more varied immunity (Roulin and Heeb, 1999). They can get more supply of energy to compensate the growth deficiencies (Bartoš et al., 2001b).

2.2.2.1 The Compensation Hypothesis

Allosucking of calves can improve their weight gain compared to non-allosucking calves (Roulin and Heeb, 1999). Higher growth gain of the allosucking calves can indicate that the calves receive extra milk from other females, meaning that together with maternal milk there is surplus of the nutritious liquid (Víchová and Bartoš, 2005).

The second prediction is that calves attempt to compensate previous deficiencies in maternal milk (Zapata et al., 2010) or they are calves with lower birth weight. In this case the growth of the allosucking calves will be more or less equal to that of calves sucking exclusively from their mothers (Víchová and Bartoš, 2005). With guanacos where there were found similar gain rates in body weight between allosuckling calves and filial sucking calves and because of that it has been thought that guanaco calves are allosucking to compensate for previous deficiencies in maternal milk (Zapata et al., 2010). Packer et al. (1992) and also Víchová and Bartoš (2005) indicate that calves allosucking most frequently tended to grow less and had lower weaning weights than calves sucking non-maternal dams occasionally or sucked maternal dams exclusively.

2.2.2.2 The Milk theft Hypothesis

Allonursing in ungulates is associated with high level of “milk theft” by parasitic infants. That means the young steal the milk of non-maternal females (Packer et al., 1992). Milk theft or “parasitism” is most widespread in monotocous taxa (Murphey et al., 1995, Packer et al., 1992). It is assumed that the more the juveniles sucks, the more milk they

will receive (Cameron, 1998). The calves can steal milk from the females which fail to discriminate their own calves and suck in positions where it could be difficult to identify them (Zapata et al., 2009a). Non-filial calves may suck together with the filial calf (Miková and Sovják, 2005). Allosuckling observed in water buffalos was caused by lack of maternal experience in young cows and this provoked milk theft by hungry calves (Murphey et al., 1995). Also allosuckling observed in guanacos represents opportunistic behaviour of the calf, supporting the milk theft hypothesis (Zapata et al., 2009b).

2.2.3 Why females nurse non-filial juveniles

It is difficult to determine factors facilitating evolution of allonursing (Cameron et al., 1999). Allonursing is a costly behaviour as lactation is very energetically demanding (Packer et al., 1992) and when an allosuckling steals milk from the female there would not be enough for her own young (Miková and Sovják, 2005). Mothers provide energy to offspring but also have maternal requirements (Rogowitz, 1996). If a mother exports too much energy to any offspring (nursing), her weight loss may be excessive and that puts her at risk (Barnard, 2004). This may not be true in the captivity where the females do not have limited access to food (Packer et al., 1992). Allonursing also elevates the risk of pathogens between mothers and non-filial offspring being transferred (Roulin and Heeb, 1999).

Females sometimes knowingly nurse a non-filial calf. The behaviour has to bring some benefit for the female (Miková and Sovják, 2005). The consequences, costs and benefits of this behaviour in ungulates are still not fully understood (Víchová and Bartoš, 2005; Maniscalco et al., 2006).

Quite a lot of hypotheses why female nurse non-filial offspring have been postulated but the real reasons remain obscure (Roulin, 2002). Some hypotheses suggest that allosuckling is a result of misguided parental behaviour, females reciprocate by nursing each other's offspring, they nurse preferentially related offspring for inclusive fitness benefits, female involve in allonursing evacuate extra milk or improve their maternal skills (Roulin, 2003).

2.2.3.1 The Misdirected Parental Care Hypothesis

The misdirected parental care hypothesis proposes that a mother transfers milk to a non-filial calf unintentionally (Roulin, 2002), meaning she misdirects maternal care. A

female would allonurse because she did not notice whom she is nursing (Packer et al., 1992). It is usually related to lack of experience of the mother, e.g. with primiparous females of Steller sea lions (*Eumetopias jubatus*), who spend a significant amount of time nursing non-filial individuals. These results are consistent with the hypothesis that primiparous (presumably younger) females nurse non-filial pups due to inexperience, compared to multiparous females (presumably older) (Maniscalco et al., 2006).

2.2.3.2 The Reciprocity Hypothesis

The reciprocity hypothesis assumes that one animal helps another and it expects the recipient to help back (Manning and Dawkins, 1998). Females in our case reciprocate by nursing each other's offspring (Roulin, 2003). According to Pusey and Packer (1994), two females raise a higher fitness when nursing each other's offspring to a similar extent than when they do not share milk. A female's youngster could obtain milk from the female of reciprocal relationship when the mammary glands of mothers are momentarily depleted of milk. Roulin (2002) states that the benefits for a female whose calf is allonursed by other females should be valuable and it is the reason that she agrees to reciprocate by nursing other juveniles. The members of her group will probably continue to nurse her offspring.

2.2.3.3 The Kin Selection Hypothesis

The kin selection hypothesis proposes that a mother nurses a non-filial calf on condition they share genes. It means that she invests her energy to spread those genes in her population (Packer et al., 1992). This hypothesis predicts that females preferentially nurse closely over distantly than unrelated offspring (Roulin, 2002) when their own mother does not provide them with sufficient high-quality milk (Manning et al., 1992). In many mammals, females form close social bonds with members of their group, usually among kin (Cameron, 2009). With lions, for example their non-offspring nursing is far more common among close kin (Pusey and Packer, 1987).

2.2.4 Other Factors influencing suckling behaviour

Of course, allonursing can be affected by the same influences as filial nursing and parental care in general like: age of the calf (Lidfors, 1994), sex of the calf (Trivers and

Willard, 1973), environment (Becker and Ginsberg, 1990), social organisation (Tyler, 1972), to name but a few. I do present the factors most often discussed.

2.2.4.1 Age of the juvenile

Whereas the length (Drábková et al., 2008) and also frequency (Pusey and Packer, 1994) of nursing usually decreases with the increasing age of the calf, we assume the declining occurrence of allonursing too. The frequency of nursing declines with the increasing age, for example in *Babryrousa babryrussa* (MacLaughlin, 2000) or cattle (Lidfors et al., 2010). The sucking duration decreased with the increasing age of the red deer calf (Drábková et al., 2008). However, suckling duration by the eland antelopes (*Taurotragus spp.*) increased continuously, it was up to the age of 3 months (Hejcmanová et al., 2010). The reduced incidence of sucking frequency can be caused by the beginning of grazing, like in the red deer (Bartoš et al. 2001).

The frequency of allonursing may conversely increase with increasing age of the filial calf which is sucking less. The mother could nurse the non-filial offspring more; such behaviour was observed for example in lions (Pusey and Packer, 1994).

Víchová and Bartoš (2005) notice the effect of the calves' age on the frequency of allosucking in cattle was not statistically significant. Nevertheless the calves tended to decrease their allosucking with increasing age.

2.2.4.2 Sex of the juvenile

Although mammal mothers usually take care of their daughters and sons in the same way in terms of food, larger juveniles (often the males) suckle more persistently (Avital and Jablonka, 2000). According to Trivers (1972), the mothers prefer males because they lead to higher reproductive success. Another Trivers-Willards hypothesis says that mothers of polygynous species in good condition or higher-ranking should invest more in sons, than mothers in poor condition and in poor hierarchical positions, who should instead invest more in daughters (Trivers and Williards, 1973).

The difference between sexes was significant with red deer. The sucking duration of female calves was shorter than the sucking duration of male calves (Drábková et al., 2008). Male calves of the Derby elands on average suckled significantly longer than female calves

(Hejcmanová et al., 2010). Conversely, the horse (*Equus caballus*) female foals tended to suck for longer than males (Cameron et al., 1998). Paranhos da Costa et al. (2000) found in the river buffalo that the cows' milk production was not affected by the calves' sex. However, bull-calves presented greater mean weight gain, and that means they had to spend more time by suckling during the first 4 months of life.

2.2.4.3 Age of the females

Suckling behaviour can closely depend on the age and parity of the mother. Young mothers can have insufficient maternal experience in terms of allonursing as seen in the river buffalo (Murphey et al., 1995). Parental care of ewes (*Ovis gmelini musimon*) decreased with the increasing age of the female, leading to decline in suckling frequency and suckle duration (Re´ale et al., 1999). Allosuckling was positively correlated with age of the females in wild fallow deer (Ekvall, 1998).

2.2.5 Taxons where allonursing was found

Allonursing has been reported in several species across the wide range of mammalian orders (Zapata et al., 2009b). Packer et al. (1992) indicates alloursing was observed in 100 species of mammals in 14 orders.

We can mention ungulates (Packer et al., 1992), primates (Perry, 1996), carnivores (Pusey and Packer, 1994), rodents (Hager and Johnstone, 2007), chiroptera (Kunz et al., 1994), cetaceans (Maniscalco et al., 2006) and even marsupialia (Packer et al., 1992).

2.2.5.1 Allonursing in ungulates

This behaviour was recorded at a relatively large number of ungulate species of both Artiodactyla and Perissodactyla.

Allosuckling in Artiodactyla was found in larger or lesser extents in red deer (*Cervus elaphus*) (Bartoš et al., 2001a, b); river buffalo (*Bubalus bubalis*) (Murphey et al., 1995); cattle (Víchová and Bartoš, 2005); mouflon (*Ovis gmelini musimon*) (Re´ale et at.,1999); guanacos (*Lama guanicoe*) (Zapata et al., 2009a); camels (*Camelus bactrianus*) (Miková and Sovják, 2005); pigs (Illmann et al., 2007), giraffes (Packer et al., 1992) and others.

Of Perissodactyla we can mention for example plains zebra (*Equus burchellii*) (Pluháček et al., 2010) or feral horses (Cameron et al., 1999).

2.2.5.1.1 Allonursing in giraffes

Allonursing was confirmed in the captive giraffes (Valdhansová and Koláčková, 2008; Gloneková, 2009) and Pratt and Anderson, pers.com.in Packer (1992) in their research of alloparental behaviour they discovered allonursing of giraffes in the wild. Allosuckling represented less than 10% of all nursing and was limited to young animals closely related to the lactating females.

2.3 The Giraffe

2.3.1 *Giraffa camelopardalis* (Linnaeus, 1758)

The giraffe (*Giraffa camelopardalis*) is the biggest ruminant and the tallest animal in the world (Estes, 1993). With Okapi (*Okapia johnstoni*), living in the lowland forest of East Africa and the Democratic Republic of Congo, the giraffe is the only representative of the order Giraffidae (Dagg and Foster, 1982; Skinner and Chimimba, 2005).

The giraffe gets its name from the Roman name “Orafus” or from the Arabic “xirapha” which means “one who walks swiftly” (Stuart and Stuart, 2001a; Skinner and Chimimba, 2005). The specific name *camelopardalis* refers to their size and marking: big as camel and spotted like leopard (Skinner and Chimimba, 2005).

2.3.2 Current giraffe status

This African mammal is as the species declared the “Least Concern” by IUCN (the International Union for the Conservation of Nature) and its population trend is “decreasing”.

According to Fennessy and Brown (2010) and giraffe conservation foundation (GCF) (2012) the giraffe has more subspecies of which two are listed as “Endangered”. *G.c. peralta* (West African or Nigerian giraffe) and *G.c. rothschildi* (Rothschild's or Baringo giraffe), of whom the population is potentially close to meeting the population threshold for the “Critically Endangered”. They are not listed in CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) (Fennessy and Brown, 2010).

IUCN estimated the total number of giraffes in Africa in 1999 to exceed 140,000. Current GCF estimation declares the population of fewer than 80,000 individuals across all subspecies. That means decrease of 60,000 animals in 12 years. Most reductions occur within northern populations. Poaching, human population growth, habitat loss, habitat fragmentation and habitat degradation have had an immense impact on the giraffes' distribution (GCF, 2012; Dagg and Foster, 1982).

2.3.3 Taxonomy

The giraffe is considered to represent a single species classified into multiple subspecies (Brown et al., 2007). See the Fig. 1.

Kingdom: Animalia

Phylum: Chordata

Class: Mammalia

Order: Artiodactyla

Family: Giraffidae

Genus: *Giraffa*

Species: *G. Camelopardalis*

Binomial Name: *Giraffa camelopardalis* (Linnaeus, 1758)

Subspecies: *G. c. angolensis*

G. c. antiquorum

G. c. camelopardalis

G. c. giraffa

G. c. peralta

G. c. reticulata

G. c. rothschildi

G. c. thornicrofti

G. c. tippelskirchi

(Fennessy and Brown, 2010, Dagg and Foster, 1982)

Fig. 1: Taxonomy of the giraffe

2.3.4 Distribution of the giraffe

This animal lives in arid and dry savannah zones south of the Sahara Desert where trees occur (Estes, 1992). They inhabit relatively open woodlands, wooded grasslands and seasonal floodplains (Kingdon, 2007; Kingdon, 1979; Dagg and Foster, 1982). Giraffes tend to avoid areas where the tree canopy is closed and take advantage of grassland for

travelling only (Skinner and Chimimba, 2005), therefore we are scarcely able to find them on grassy plains (Dagg and Foster, 1982).

There are four major populations into which the aforementioned subspecies are divided (Kingdon, 2007). Here we speak of **somalid arid** population which includes the Nubian giraffe (*G. c. camelopardalis*) < 250 animals occur in north-eastern Congo and eastern Sudan; Reticulated giraffe (*G. c. reticulata*) < 5,000 animals occurs in Somalia, Ethiopia and north-east Kenya. **Saharan** population involves only West African giraffe (*G. c. peralta*) < 250 animals to be found in Chad. The third population to list is the **northern savannah** population. This group covers Kordofan giraffe (*G. c. antiquorum*) < 3,000 animals living in Sudan and Rothschild's giraffe (*G. c. rothschildi*) < 670 animals to be found in Uganda and north Central Kenya. The last **southern savannah** contains four subspecies. Masai giraffe (*G. c. tippelschircki*) < 40,000 animals inhabiting central to southern Kenya and Tanzania; Thornicroft's giraffe (*G. c. thornicrofti*) < 1,500 animals occur in eastern Zambia; Angolan giraffe (*G. c. angolensis*) < 20,000 animals to be found in Angola as well as western Zambia and South African giraffe (*G. c. giraffa*) < 12,000 animals living in areas of South Africa, Mozambique, Zimbabwe, Botswana, Namibia and Swaziland (GCF, 2012; Carnaby, 2008). See the Fig. 2.

The new taxonomy of Groves and Groob, 2011, separated giraffes within the Northern and Southern groups and assigned them to the endangered subspecies of giraffe *G. c. rothschildi* to *G. c. camelopardalis* subspecies. **Northern giraffes** group includes *Giraffa camelopardalis* (Nubian giraffe, Rothschild's giraffe), *Giraffa reticulata* (Reticulated giraffe), *Giraffa antiquorum* (Kordofan giraffe), *Giraffa peralta* (West African giraffe). To the **Southern giraffe** group belongs *Giraffe tippelskirchi* (Maasai giraffe, vine-leaf giraffe), *Giraffa thornicrofti* (Luangwa giraffe), *Giraffa giraffa* (Cape giraffe), *Giraffa angolensis* (Angolan giraffe).

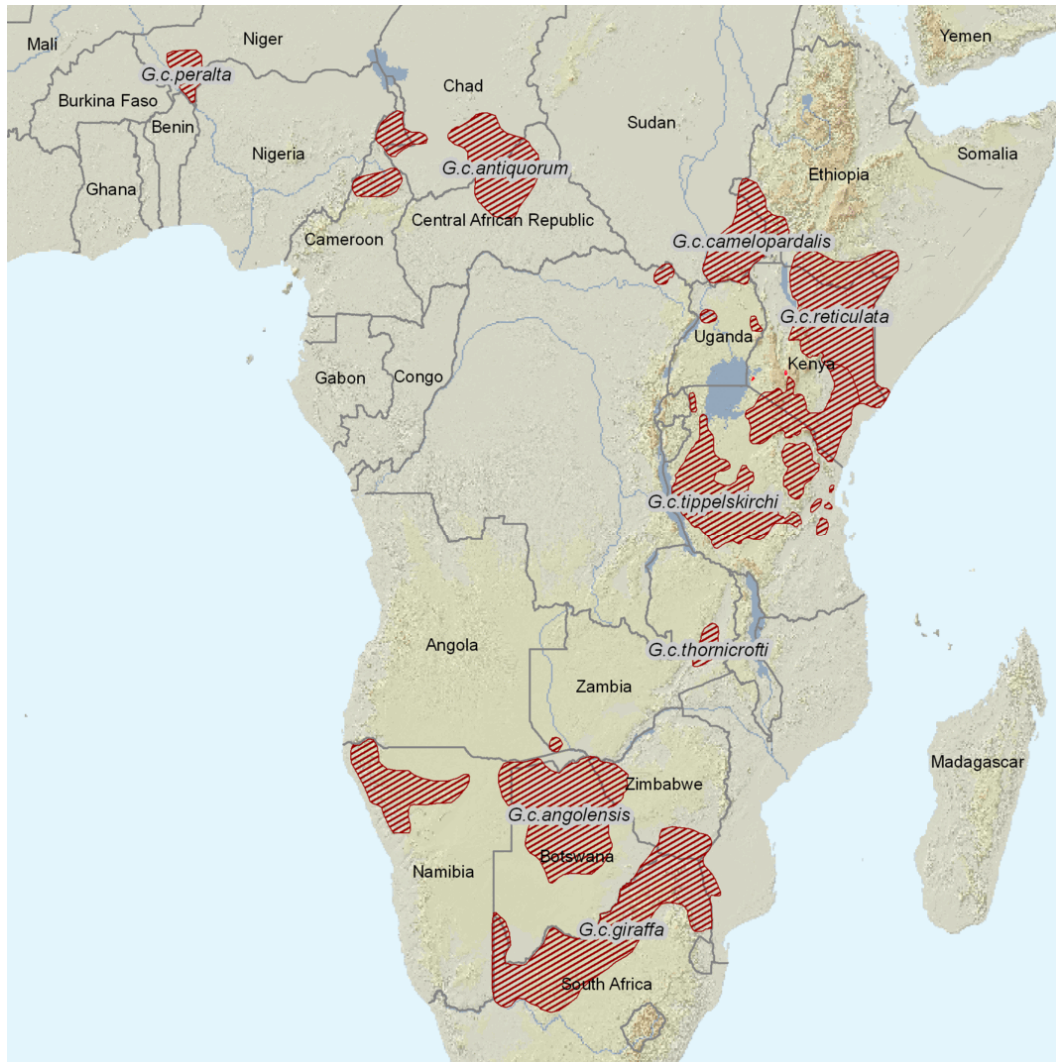


Fig. 2: Distribution of the giraffe (Map Source: IUCN Red List)

2.3.5 Anatomy

The giraffe has a very long neck with a short mane, high shoulders lowering steeply to hind (Apps, 2000). Prominent features of giraffes are large eyes as well as ears and long legs with robust large feet (Burnie, 2002, Grzimek, 2005). As the legs are so long, a walking giraffe moves both legs on a side at almost the same time. It can gallop at up to 56 km/h but can hardly jump (Apps, 2000).

The weight of a male is 1100-1932 kg, weight of the female 700-1182 kg (Estes, 1993). Males are up to 5.5 m and females 4-4.5 m high (Estes, 1992). Male height to top of the head is 3.9-5.2 m, height up to the shoulder 2.5-3.5 m, tail is of 95-150 cm, weight 970-1400 kg. Female height to top of the head is 3.7-4.7 m, height up to the shoulder 2-3 m, tail is of 75-90 cm, mass 700-950 kg (Stuart and Stuart, 2001a).

In giraffes, upper incisor or canine teeth are absent. They have hairy muffle (Estes, 1992), long prehensile tongue up to 45cm long (Burnie, 2002; Grzimek, 2005), narrow muzzle, flexible mouth and upper lip helping the giraffe in feeding (Estes, 1993; Kingdon, 2007). Giraffes are ruminants and have stomach consisted of four parts (Burnie, 2002).

There is a pair of horns on top of their head, covered with hairy skin except at the tips (Skinner and Chimimba, 2005). Both sexes have horns (Estes, 1993; Kingdon, 2007; Burnie, 2002; Grzimek, 2005). Mature bulls and some old cows have at least one bony protrusion in the middle of the forehead (Skinner and Chimimba, 2005), four more humps growing throughout their life, as well as horns (Estes, 1992). There is a mane of stiff, dark brown hair grown down the back of the neck (Skinner and Chimimba, 2005).

The tail is long, thin, with a black tassel at the end (Estes, 1992; Burnie, 2002).

2.3.6 Ecology

Females spend just over half a day browsing, males a little bit less. Nights are mostly spent lying down and ruminating (Estes, 1992). Stuart and Stuart (2001a) say that giraffes are active during the day and night and they rest during the hot midday hours. They are most agile in the early mornings and late afternoons, but also prefer feeding at night by bright moonlight. They are likely to rest lying down, sleeping for only few minutes in the night (Apps, 2000; Alderton, 1996).

Males spend more time walking to find the cows on heat (Estes, 1992). They occupy large home ranges, usually between 20 km² and 85 km² and do not establish defended home ranges (Stuart and Stuart, 2001a). The senses mostly used are smell and eyesight. They may have colour vision (Estes, 1992).

2.3.6.1 Food

Giraffes are browsers and only rarely eat grass (Stuart and Stuart, 2001a; Grzimek, 2005). They mainly feed on broad-leafed deciduous foliage (Estes, 1992), but also fresh shoots, flowers, pods and fruits from trees (Skinner and Chimimba, 2005). There are over 100 species of plants edible for giraffes known (Grzimek, 2005), but *Acacia*, *Combretum* and *Terminalia* trees are the most common (Kingdon, 2007). The long neck allows the giraffes to browse above the levels of reach by other herbivores (Mills and Hes, 1997).

They use lips to pull twigs into the mouth while the tongue curls around them and strips the leaves off (Stuart and Stuart, 2001b). They drink every 3-4 days when the water is available (Estes, 1993). Giraffes can remain independent of water if there is a supply of fresh green food. In extremely arid areas, water and vegetation occur along drainage lines (Skinner and Chimimba, 2005).

2.3.6.2 Communication

The idea that giraffes are mute is a myth (Dagg and Foster, 1982). They are silent most of the time, but calves can bleat and make mewing calls. Males can emit a raucous cough. They can also snort, moan or hiss (Estes, 1992). They have developed a range of grunting and snoring calls (Stuart and Stuart, 2001a).

2.3.6.3 Reproduction

Males begin competing for mating at 7 years of age, but they still grow (Estes, 1993) until they are 10 years old (Diller et al., 1998). Females are sexually mature and can become pregnant for the first time at around four years of age (Grzimek, 2005; Bercovitch et al., 2004). The gestation lasts 14-14.5 months (450 days) (Burnie, 2002; Stuart and Stuart, 2001a) and a minimum interval among calves is 16 months (Estes, 1992). The Giraffe is the only ruminant with gestation longer than one year (Skinner and Chimimba, 2005).

Mothers give birth standing to look out if there are no lions, hyenas or African wild dogs nearby (Burnie, 2002; Grzimek, 2005). One calf with a mass of about 100kg (Stuart and Stuart, 2001b) and shoulder height around 1.5 m is born. Twins have only been recorded once in the wild (Skinner and Chimimba, 2005). The calf learns to control his long legs and his mother takes him to a safe place within the first hours after they are born. The female resides with the young from 10 to 30 days away from the herd. The weaning comes at 13 months of the calves' age (Burnie, 2002; Grzimek, 2005). The offspring begins eating plants at 2 weeks of age. The giraffe's lifespan is up to 20 years (female) (Skinner and Chimimba, 2005). Dagg and Foster (1982) see the issue differently and mention up to 28 years in the wild.

2.3.6.4 Predators

Size, superiority, speed and powerful hooves make giraffes almost unattainable for predators (Estes, 1992). As adults, they are too big to be a prey, but 50-75% of calves are caught by lions or spotted hyenas. There is a very high mortality rate of calves in their first year (Stuart and Stuart, 2001a). Young giraffes are particularly vulnerable despite the brave efforts of their mothers (Mills and Hes, 1997). Mothers defend their young one from predators by moving in a different direction (calf is faster than an adult giraffe) (Estes, 1992). This animal is able to outstrip more predators (Kingdon, 2007). It can also protect itself with the hooves and drives off attackers with powerful kicks of the forelegs (Mills and Hes, 1997; Estes, 1992; Grzimek, 2005; Dagg and Foster, 1982). Their large and heavy hooves can break a lion's back (Apps, 2000). Giraffes are equipped with tough skin to be protected against predators' attacks (Burnie, 2002).

2.3.7 Social behaviour of giraffe

Giraffe herds have been described as random associations of individuals (Dagg and Foster, 1982), but recent research has shown that giraffes have a complex social structure (Bashaw et al., 2007). There is a difference between the wild and the captive animals (Perry, 2011). The social structure of the captive group is influenced by social relationships among individuals, mainly mothers and calves (Bashaw et al., 2007). The captive environment introduces behavioural and spatial limits for an animal (Bashaw et al., 2007; Perry, 2011).

Giraffes in the wild usually live in the open, smaller, less cohesive groups of 4 to 30 individuals (Dagg and Foster, 1972; Leuthold, 1979). These herds are unstable and there are a lot of movements between herds (Stuart and Stuart, 2001b). The herd composition changes daily (Burnie, 2002) and can be composed variously: only females, only males, females with young one. In the group there could be members of all ages. The socialities have no leader and minimum coordination (Estes, 1993; Leuthold, 1979). If there is a leading animal, it is mostly an older female (Diller et al., 1998). Females are more social than males. Males live in the herd until about 3 years of age and then make bachelors' groups (Estes, 1993). When they mature, they become loners (Estes, 1992).

Giraffes are non territorial and sociably reserved (Estes, 1992), with only adult males becoming territorial during the breeding season when they monopolize all females

(Kingdon, 2007). The interaction between mother and daughter and giraffes of the highest age difference are the most common (Bashaw et al., 2007). Closer inter-individual bonds occurred in young animals (Leuthold, 1979).

The only stable association period is a 1 year long period of motherhood. There is one highly localised calving area to which the female returns (Kingdon, 2007). Mothers with young calves often associate (Estes, 1992).

2.3.8 Maternal care of the giraffe

At delivery, the female separates from the group to a hidden and inaccessible place (Estes, 1992; Packer et al., 1992) and give birth to a calf. After the birth, the calf usually rises to its feet in 5 minutes (Kingdon, 2007). The calf spends half of the day lying during the first week and is carefully guarded by the mother at night. They stay reclusive for 1-3 weeks (Skinner and Chimimba, 2005). Mother giraffes tend to form herds with other mothers. They seem to be acting in this way to keep their offspring from predation and they share responsibilities with other mothers (Saito, 2010).

Giraffe calves make a *crèche* counting up to 9 animals. One or more mothers are often nearby but tend to leave the nursery of youngsters by themselves at midday (Kingdon, 2007). Calves spend a higher percentage of the time with calves rather than with their own mothers so that they are closer to one another than to the females (Pratt and Anderson, 1979). They spend most of the day lying (Kingdon, 1979).

Their mothers stay up to 1km away from the young (Dagg and Foster, 1972), Skinner and Chimimba (2005) noticed up to 3km of distance between mother and her calf. Mothers return every evening before dusk nurse the offspring and stay close to them all night (Estes, 1993). Mornings together with evenings are the main nursing times (Dagg and Foster, 1972); When the morning feeding is over, the females leave to spend their time foraging. The mother may move away from her calf in captivity and she can be aiding the young giraffe whenever it is distressed. The social organization of herds allows mothers to leave calves in safe environment while they search for food (Greene et al., 2006).

Juveniles begin to ruminate between their 3rd and 4th months; between the 12th and 16th months they are already fully separated (Estes, 1992). They suck up to the age of 13 months but remain associated with the mothers for another 2–5 months (Leuthold, 1979). Estes (1993) found the maternal bond can last up to 22 months. Social bonds between

mothers and calves persist past weaning until another calf is born (Langman, 1977; Skinner and Chimimba, 2005).

Dagg and Foster (1972) characterized the bond between mother and her young giraffe as slightly weaker than what we see in other ungulates. The strongest bond between mother and calf is formed within a year or one and a half years. Nevertheless, Alderton (1996) notes, that giraffes are really caring mother.

2.3.8.1 The milk of the giraffe

Females have two pairs of mammary glands between their hind legs (Skinner and Chimimba, 2005).

The main characteristic of the giraffe's milk is its high fat content, which is by 12.5%, higher in protein and lower in lactose concentration than bovine and goat milk (Casares et al., 2012). The contents of Ca pantothenate, riboflavin, thiamine and vitamin B6 (pyridoxal) were similar to those found in good quality cow's milk. The contents of biotin and α -tocopherol were lower and those of nicotinic acid, vitamin B12 and vitamin A were higher than what is traced in cow's milk. No carotenoids were present (Aschaffenburg et al., 1962).

3 Material and Methods

3.1 Material

The research I performed by observation the Rothschild's giraffes in two zoological gardens in the Czech Republic-Praha and Olomouc.

In the Prague herd, there were 1 male and 6 female giraffes. One adult female was moved and one animal died during the research. The number of young ones was changing during the observation period. New calves were born and a few older calves went to other zoos. One young female newly came to the herd. The number of calves present in the herd ranged from 1 to 8. Up to 4 young ones were of 1 year of age = calves and up to 4 grown-up juveniles = sub-adults. Changes in the herd composition are to be shown in Appendix 1, Table 1. The male remained in the herd for all of the observation period.

The giraffes were kept in a temperated stable during most of the winter months, moved to the joined yard at times of maintenance. The herd spent most of their time outdoors in a large paddock on warmer days. They were fed ad libitum with hay and branches, with supplements of granulated food and vegetables. Females at advanced stages of pregnancy after parturition were fed by milk pap.

The herd of Zoo Olomouc consisted of 1 adult male, 4 adult females, 5 sub-adult females and 1 sub-adult male. A sub-adult female was moved due to premature rut and one adult female came to the herd after delivery as her young one had died. The herd composition see in Appendix 1, Table 2. The male was in the herd all the time.

The stable occupied by animals for most of the winter was also temperated. The giraffes went into a small outdoor enclosure with a solid concrete surface for a limited time according to outdoor temperature. In the summer time, they were in a large grassy enclosure for most of the day. They were fed ad libitum with hay, branches and granulated food, with supplements of the milk pap, vegetables and other accessories.

I also used the data from parallel researches which were realized in two herds in Dvůr Králové nad Labem by Barbora Olejníková, Rothschild's giraffes and Reticulated giraffes. The animals there have had similar conditions of housing and food, but when dwelling in the stable, the male has always been separated and the herd split in females with cubs and other animals. The herd composition of Rothschild's giraffes is shown in Appendix 1, Table 4. The herd composition of Reticulated giraffes is to be seen in Appendix 1, Table 5.

Other additional data were used from my bachelor thesis also carried out in the Praha zoo; other previous observations for bachelor and diploma thesis of Ing. Lucie Valdhansová, realized in the zoos of Praha, Dvůr Králové nad Labem, Olomouc and Liberec (The herd composition from Liberec shown in Appendix 1, Table 3) were used.

I also established cooperation with the Ústí nad Labem Zoo, but the zoo did not own enough of giraffes for any future research.

Together 31 females and 49 calves in 4 zoological gardens observed between the years 2007-2011 were included in the data set.

3.2 Methodology

3.2.1 Identification of the giraffe

The first step in the research methodology was to identify and get to know the individual giraffes. The identification of these animals is not difficult. The differences in giraffe markings I have used as a key. The colourings of patches are variable, ranging from light fawn to almost black (Stuart and Stuart, 2001a). Every giraffe has a different skin sketch (Estes, 1993; Dagg and Foster, 1982).

The animals were distinguished by the colour of the whole body or by the colour of particular marks. There were also differences in the colour of the body basis = ground colour, colour of blotches on the neck and the body (Groves and Groob, 2011), the lattice pattern of their coat consists of shaded patches, separated by networks of light coloured bands (Stuart and Stuart, 2001b).

I was also able to observe the physique, momentary condition, the size of their body, scars, growths, warts, tails or horns.

The same disparities are to be found in the juveniles. The male is the easiest to recognize. An adult male in the herd should be the tallest, with very distinctive humps and horns on the head. It is usually the males darken with age (Estes, 1992) so old bulls are often rather dark (Stuart and Stuart, 2001a).

Some examples of cognitive features giraffes, see in Fig. 3.

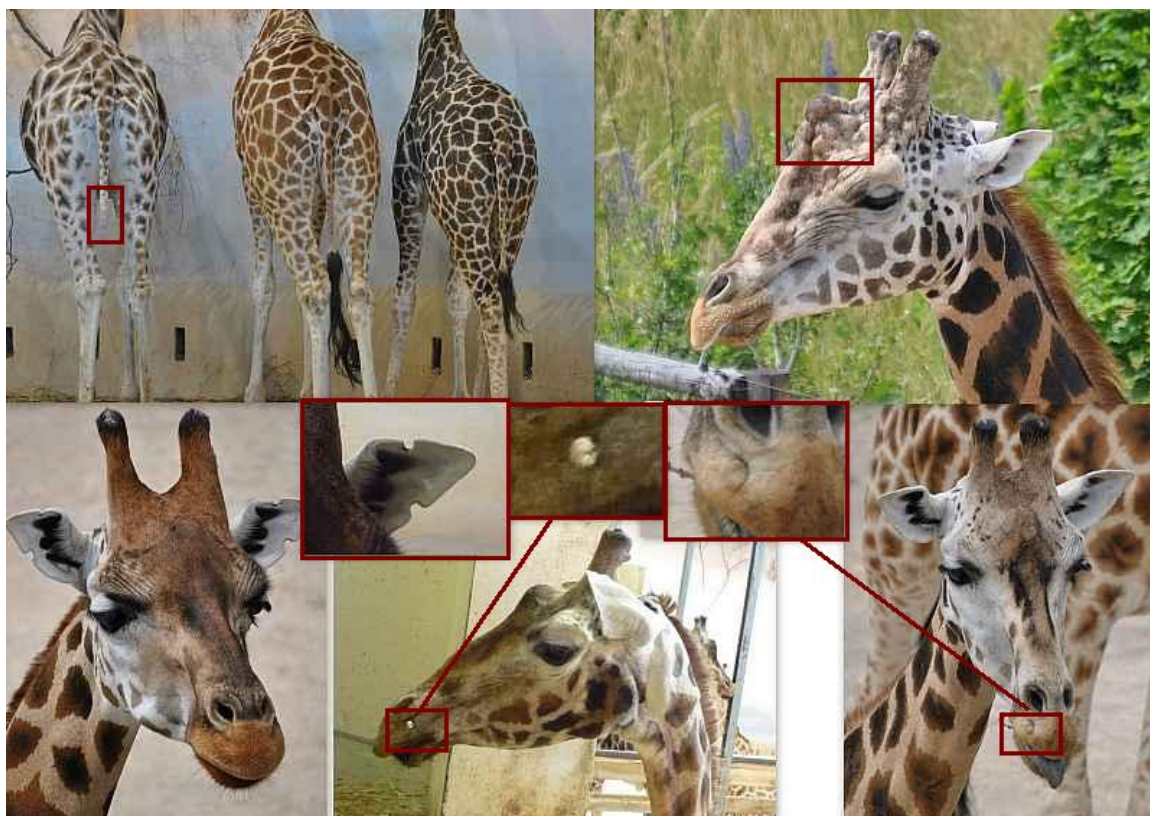


Fig. 3: Identification of the giraffe (© Markéta Hejzlarová, Kamila Švarcová, Daniel Hejzlar)

3.2.2 Observation

As I have stated, the observation was realized in two zoological gardens. The observation in the Zoo of Praha started in September 2010 and lasted till December 2011, with 7-14 days of an observation interval. The length of an observation session was approx. 6 hours, equally distributed between 9 am and 6 pm.

I also observed the animals in the Olomouc Zoo from January 2011 until June 2011 with the observation interval of 14 days, length of observation session was approx. 6 hours equally distributed between 9 am and 4 pm.

My total observation time for the diploma thesis was 224 hours. With data from previous along with parallel observations (513 hours) totalling in 737 hours.

All nursing and attempts to suckle were monitored and recorded in the table. (See in the Table 1)

Table 1: Observation table

The young	Suckling Juvenile
The mother	Nursing Female
Action	Nursing – nursing longer then 5s Attempt- nursing shorter then 5s Unsuccessful- juvenile only tried to suck
Position	L = the juvenile suck from the left side R = the juvenile suck from the right side 1 = the juvenile approaches to the female directly- antiparallel 2 = the juvenile approaches to the female perpendicularly 3 = the juvenile approaches to the female parallel (See in Appendix 3, Fig. 1)
Initiator	Female, juvenile
Terminator	Female, male, juvenile
Number of sucking calves	
Filial calf?	Yes/No
Does the female refuse?	Yes/No
Does the female sniff?	Yes/No (See in Appendix 3, Fig. 2)

3.2.3 Evaluation

Frequency of nursing for each pair of young x female for each day was counted. The frequency of nursing = number of nursing for 6 hours.

Then the coefficient of relatedness for each pair of young x female was calculated. After that, the most of the observed factors were related to the frequency and duration of nursing.

3.2.3.1 Coefficient of relationship

For the evaluation of the kin selection we needed to calculate the coefficient of relationship (Wright, 1992).

Along with Krebs and Davies (1981), it is necessary to draw the diagram with the individuals concerned and their common ancestor and indicate the generation links. The family trees I made in program My Heritage Family Tree Builder (See in Appendix 2). At each generation link there is the probability 0.5 that the genes will be passed on. For L generation links the probability is $(0.5)^L$ and to calculate r we have to sum this value:

$$r = \sum (0.5)^L$$

The probability that any two individuals share copies of the allele depends on their degree (coefficient) of relatedness. Any individual has a probability of 0.5 of sharing the allele with its parent, offspring or sibling, with probability of 0.25 of sharing it with a grandparent or grandchild, of 0.125 of sharing it with a first cousin and so on (Barnard, 2004).

3.2.3.2 Statistical analyses

The data did not have a normal distribution and it was necessary to use nonparametric tests. I used Mann-Whitney U test for comparison of two independent groups, Spearman's coefficient for correlations and contingency tables with Chi square measured for comparison of qualitative data. All the analyses were calculated in program Statistica version 9, Statsoft.

4 Results

3543 interactions were recorded during the research including 2673 attempts and 870 nursing of which 489 (56.2%) were filial and 381 (43.8%) non-filial.

Females nursed non-filial calves in most of the studied herds. Most of the calves sucked from non-maternal females (See in the table 2; Fig. 4).

Table 2: Number of filial and non-filial nursing; Number of allonursing females and allosucking calves (Only the animals who really nursed or sucked)

Zoo	Number of nursing	Filial nursing	Non-filial nursing	Allonursing females	Allosucking calves
Praha	642	344	298	6 out of 6	19 out of 19
Dvůr	170	103	67	10 out of 12	13 out of 15
Olomouc	47	36	11	2 out of 4	3 out of 4
Liberec	11	6	5	2 out of 2	3 out of 4



Fig. 4: Allonursing of non-filial calf (© Kamila Švarcová)/ Multiple nursing (© Daniel Hejzlar)

The average length of the nursing (s) was 17.8 ± 20.24 s, the longest 163 and the shortest 5s. A shorter one was not considered nursing but only an attempt.

The average frequency of nursing (number of nursing for 6 hours for one pair female x offspring) was 0.94 ± 1.38 , at least 0 and 12 the most.

Nursing duration of non-filial and filial calves did not differ (M-W U test; $P = 0.0785$, $U = 86153$, $Z = 1.7593$) although it was supposed to be different (Fig. 5).

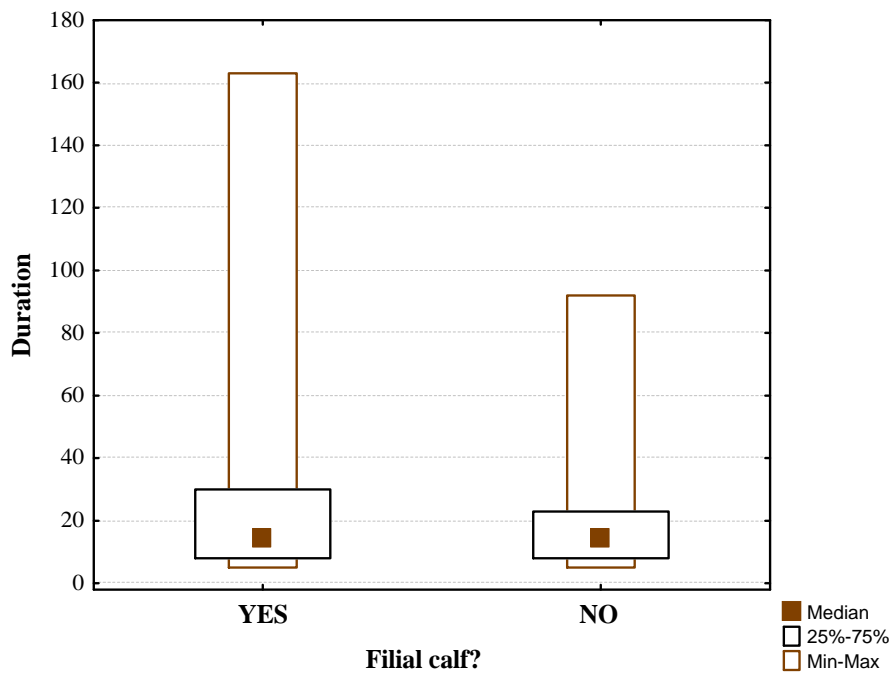


Fig. 5: Difference in nursing duration between filial and non-filial calves

The frequency of nursing non-filial calves was lower than frequency of nursing filial calves (M-W U test; $P < 0.001$, $U = 124807$, $Z = 6.4350$) which shows the females preference in nursing their filial calves (Fig. 6).

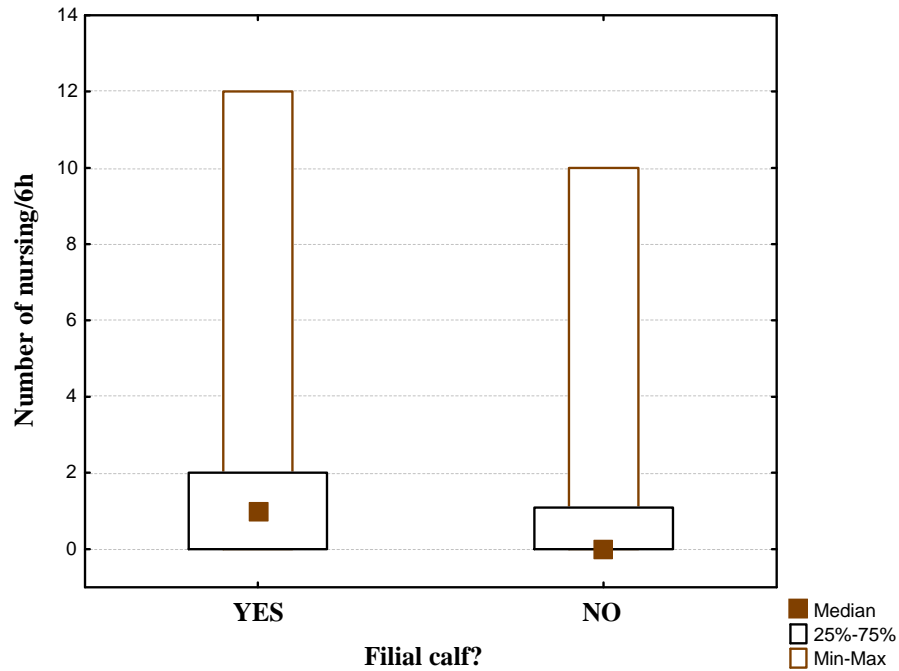


Fig. 6: Difference in nursing frequency between filial and non-filial calves

4.1 Kin Selection

4.1.1 The frequency and duration of allonursing depend on the coefficient relatedness

It was supposed that the frequency of allonursing would be increasing with the coefficient of relatedness = with affinity. Only the non-filial nursing was included in this analysis and the frequency of nursing non-filial calves did not depend on the kinship coefficient (Spearman's coef. = -0.006, $P > 0.05$). See in the Fig. 7.

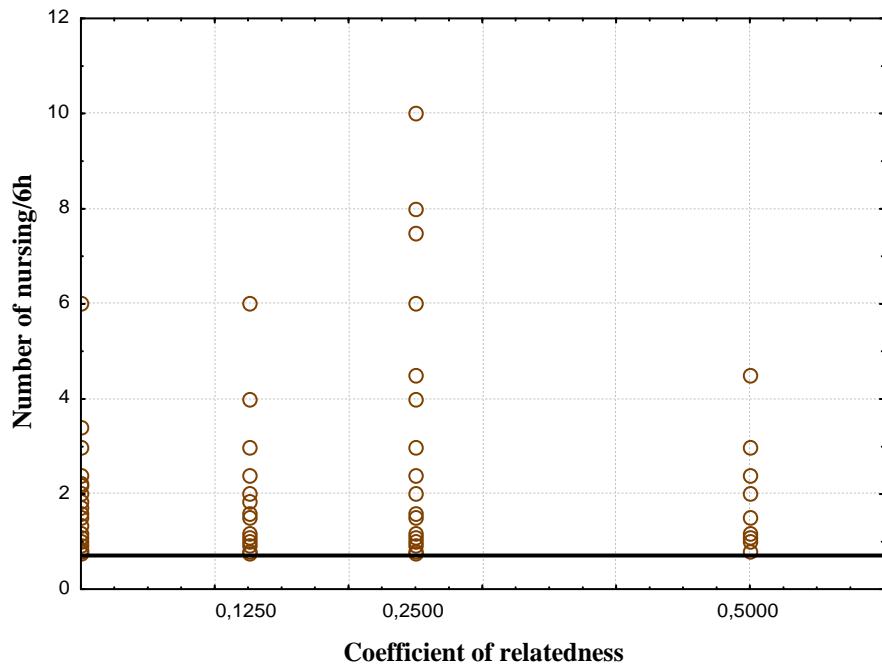


Fig. 7: Dependence of the nursing frequency on the coefficient of relatedness

The same result was reached in the duration. Only the non-filial nursing was included in this analysis and the duration of nursing non-filial calves did not depend on the coefficient of relatedness (Spearman's coef. = -0.079, $P > 0.05$). See in the Fig. 8.

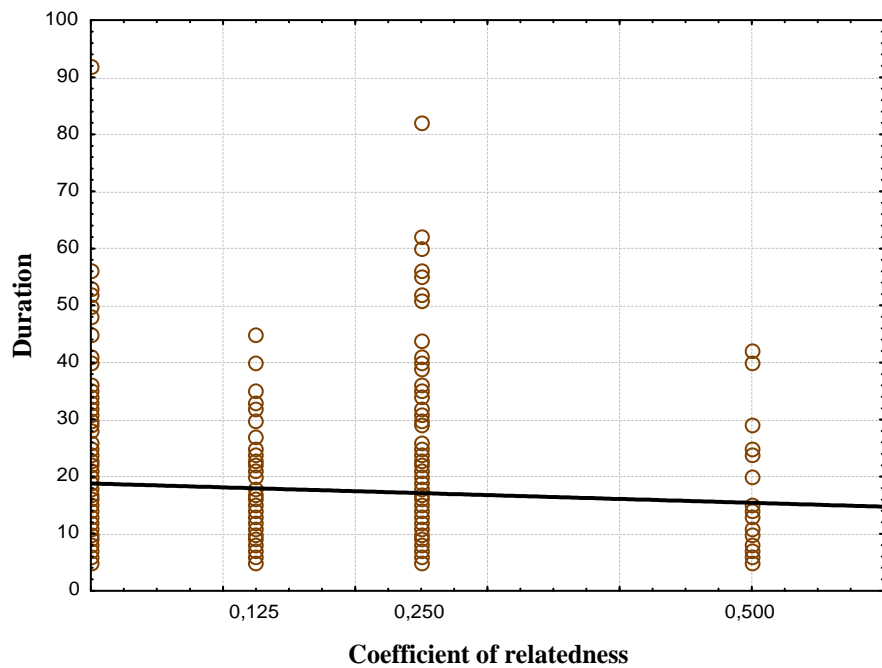


Fig. 8: Dependence of the nursing duration on the coefficient of relatedness

4.1.2 The female initiates allonursing more often with their filial or related offspring

It was expected that the female would prefer and initiate nursing of filial calves more often than with non-filial offspring. When the female initiated the nursing, it was more often to the filial calves, as shown in the contingency table (Pearson's χ^2 : 31.0563, $P < 0.001$). Here, our assumptions were fulfilled (Fig. 9).

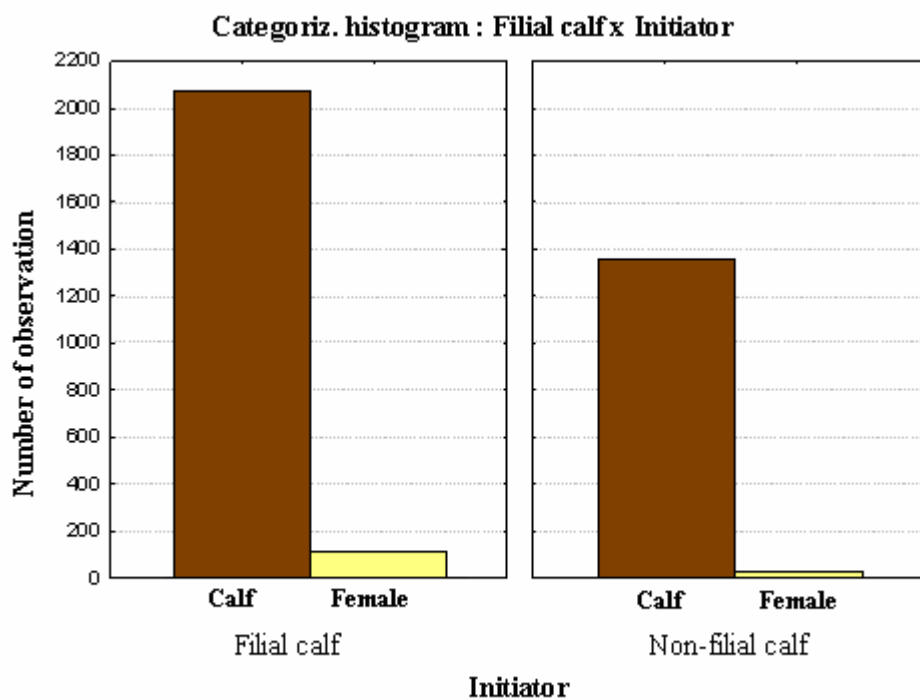


Fig. 9: Difference between initiating filial and non-filial nursing

We also tested whether the females prioritize calves with a higher coefficient of relatedness if they initiate the nursing. This proved not to be so. If the female initiated nursing of non-filial calves, she did not prefer the young ones with a higher coefficient of relatedness (M-W U-test; $U = 2143$, $Z = 0.1877$, $P = 0.8421$).

4.1.3 Non-kin offspring and their being driven off more often

We accepted the fact that females initiate nursing of filial juveniles more often and it was inferred that the non-filial ones will be driven away more often. The females did not refuse more of the non-filial calves compared to their filial ones (Contingency table; Pearson's χ^2 : 1.59404, P = 0.2067). See in the Fig. 10.

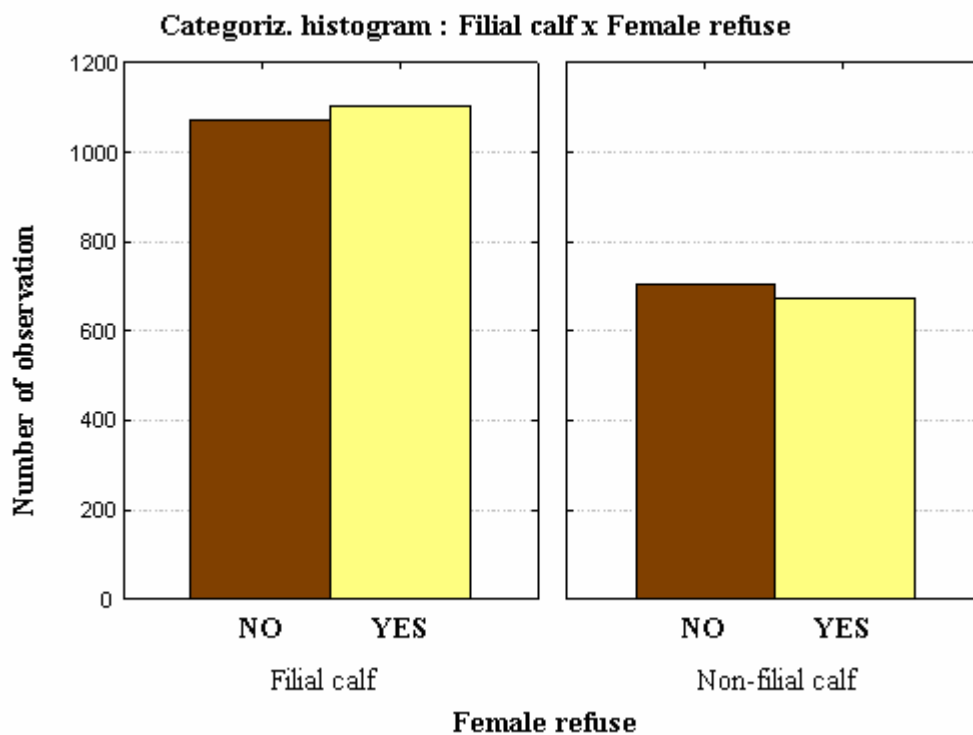


Fig. 10: Difference between refusing filial and non-filial calves

When the female refused, it was mostly in the parallel position = position 3 (Contingency table; Pearson's χ^2 : 17.7156, P < 0.001), which could be related to the hypothesis of milk theft (Fig. 11).

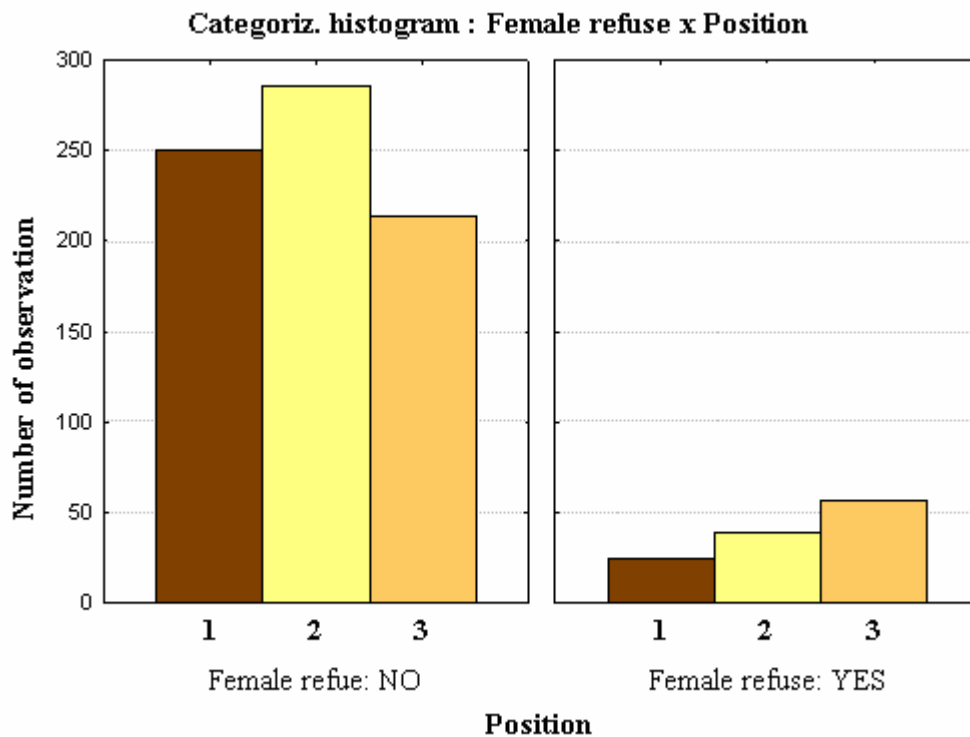


Fig. 11: In which nursing positions does the female refuse

4.2 Milk theft

4.2.1 The Frequency and duration of allonursing depend on the mother's parity

The multiparous females have already had calves several times. Here lower rates of allonursing were presupposed to take place, as they would have more experience with the identification of their calf so the frequency and also the duration of allonursing would be lower. However, the frequency of allonursing was noted more frequently with multiparous females (M-W U test, $U = 17658$, $Z = 2.3942$, $P = 0.0166$). See in the Fig. 12.

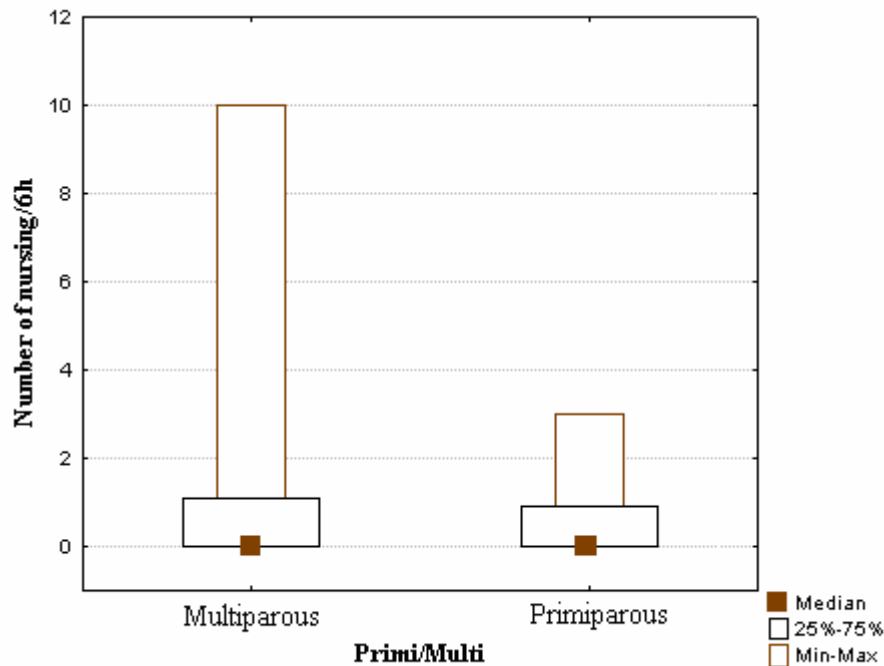


Fig. 12: Difference in nursing frequency between primiparous and multiparous females

The duration of allonursing for primiparous and multiparous proved no significant difference (M-W U test, $U = 2580$, $Z = -0.7874$, $P = 0.4310$).

4.2.2 Frequency and duration of allonursing depends on the mother's age

As well as with the issue of maternal parity, it was assumed that the older (more experienced) the females were, they will be less keen on nursing non-filial calves. The frequency of all nursing increased with the age of mothers (Spearman's coef.: -0.1383 , $P < 0.05$). See in the Fig. 13.

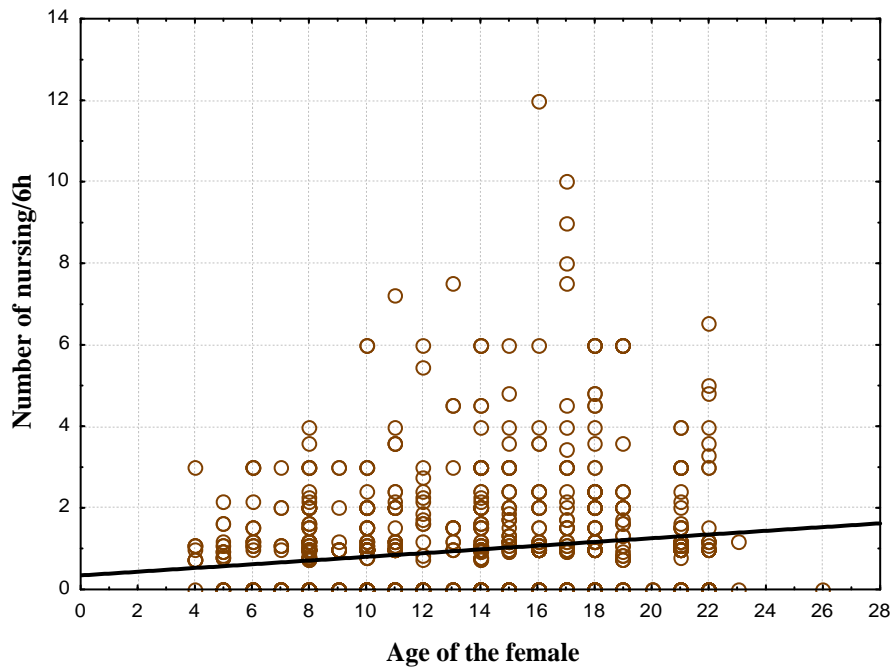


Fig. 13: Dependence of the nursing frequency on the age of the female

In terms of duration, our assumption was confirmed. The duration of all nursing decreased with the age of mothers (Spearman's coef.: -0.1213, $P < 0.05$; Fig. 14).

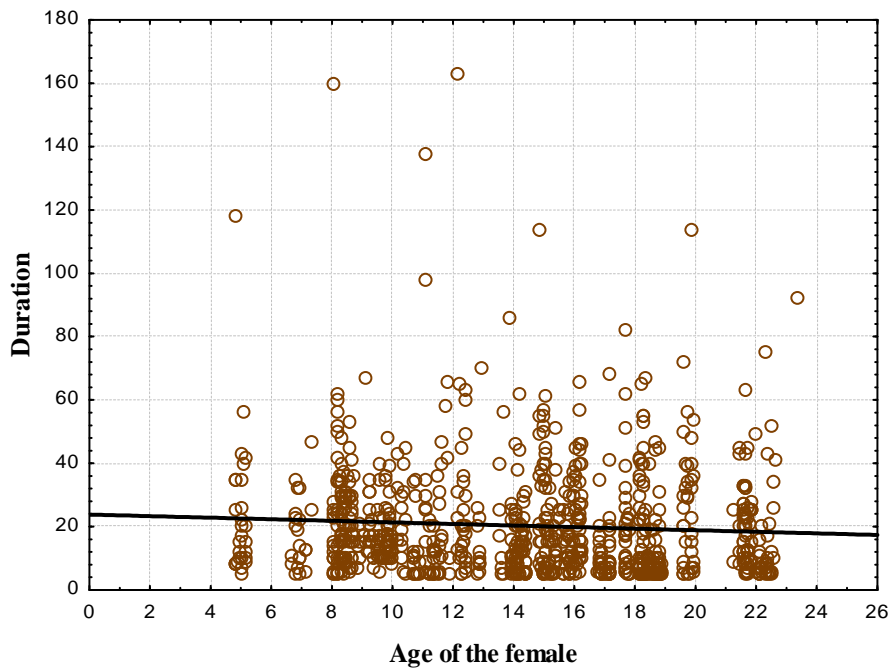


Fig. 14: Dependence of the nursing duration on the age of the female

4.2.3 Female giraffes sniff (identify) filial calves more frequently

According to the hypothesis of milk theft, it was assumed that the female would sniff the filial calf more often than non-filial ones. It could happen because of non-filial calves trying not to be identified. The female usually sniffs the young one if she initiates the nursing, and she would have done so with her own calf more often. If the female sniffed (identified) her young giraffe, it was almost ever in the case of her filial calf (Contingency table; Pearson's χ^2 : 78.0958, $P < 0.001$). See in the Fig. 15.

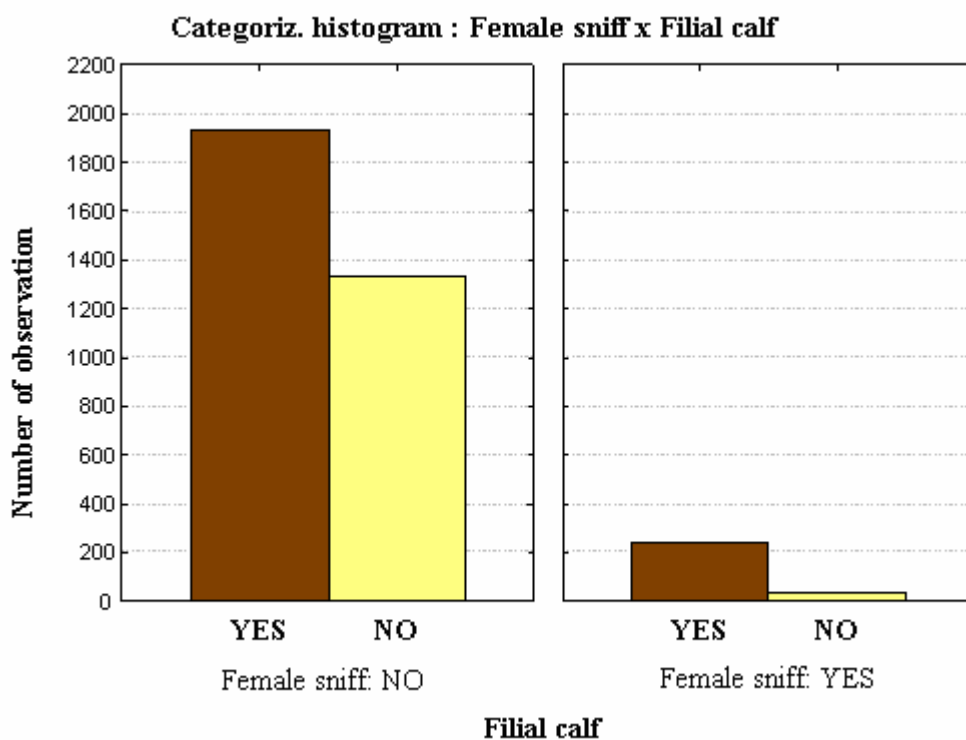


Fig. 15: Difference between female sniffing the filial and non-filial calves

4.2.4 Does the female reach the calf in position 3?

We wanted to know if the female is able to reach a calf with her head in the parallel position = position 3, where mostly the non-filial calves sucked. The female did reach with the head in this position and she did sniff the filial calf mostly in the anti-parallel position = position 1 and the non-filial in position 3 (Contingency table; Pearson's χ^2 : 10.7884, $P=0.0045$). See in the Fig. 16.

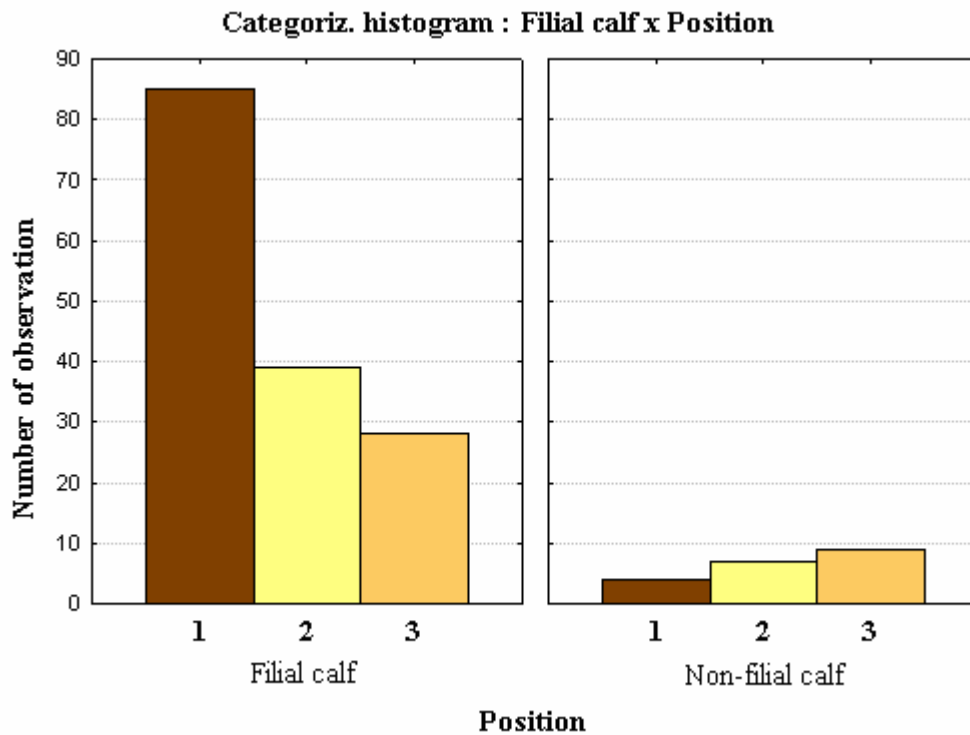


Fig. 16: Difference between positions in which the female sniff filial and non-filial calves

4.2.5 The non-filial calves suck more often together with filial calves than alone.

The last presumption was that the non-filial calves sucked more often with the filial calves. The female could not stop the nursing if she wanted to feed the filial young one and so nurse the others, too. See in the Appendix 3, Fig. 1. This behaviour was confirmed. The non-filial calves sucked more often together with the others than alone (Contingency table; Pearson's χ^2 : 88.8360, $P < 0.001$). See in the Fig. 17.

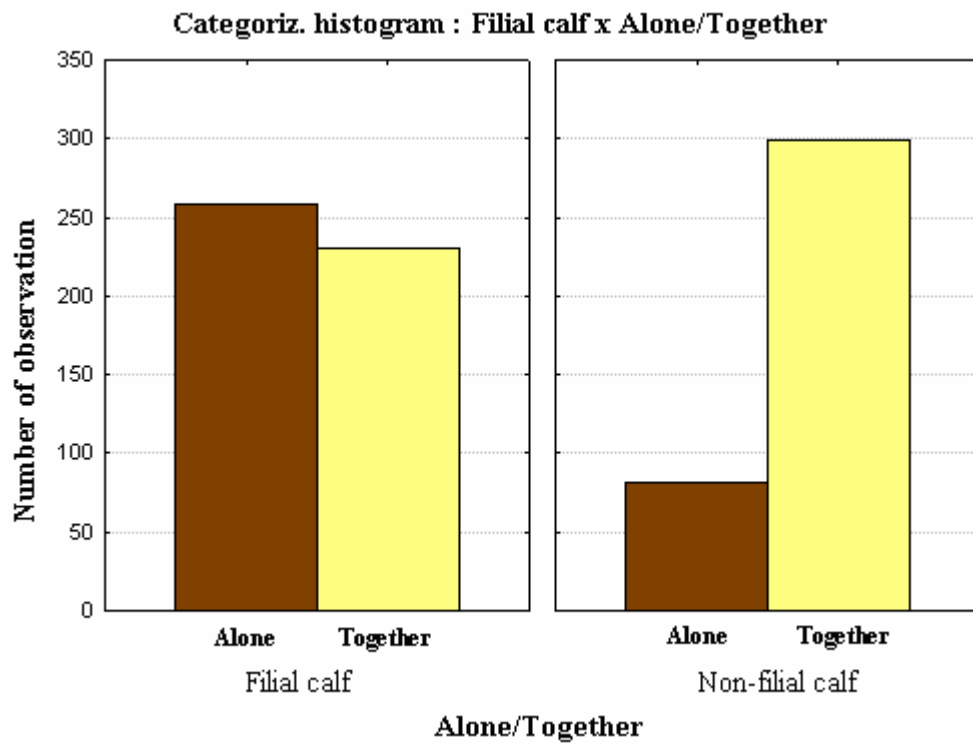


Fig. 17: Difference between filial and non-filial calves in multiple nursing

5 Discussion

Providing milk to the young is perhaps the most important and obvious maternal behaviour (Keyserlingk and Weary, 2007). This thesis should find out why female giraffes nurse also non-filial calves. Allonursing in giraffes has not been studied immensely yet. Only 10% allonursing of all nursing (Pratt and Anderson, pers.com.in Packer, 1992) was found in the wild animals, but in captivity it was many more. This research has been carried out for four years in the captive giraffes and we observed 43.8% of allonursing.

Despite this quite high incidence of allonursing in captivity, it was assumed that the nursing duration of non-filial and filial calves will differ. Such a presumption has not been confirmed. The same result was reached with zebras by Pluháček et al. (2011), for example, and also Drábková et al. (2008) found that allosucking duration in deer was only marginally different from the filial nursing. However, filial calves tended to have longer sucking bouts than occasionally allosucking non-filial calves.

The frequency of nursing non-filial calves was lower than frequency of nursing filial calves. This means that giraffes still prefer the filial offspring. This behaviour was expected. The same result was supposed by Illman et al. (2005) in pigs and also the number of suckling in cattle was unequally distributed among filial and non-filial calves (Kilgour, 1972).

During the research was observed that the nursing and also allonursing is quite often terminated by the male. Few analyses were made but the results were not significant.

5.1 Kin Selection

Pratt and Anderson, pers.com.in Packer (1992) found that allonursing of the wild giraffes is limited to young ones closely related to the females. In this research, it was also assumed that the frequency and duration of allonursing depended, on the coefficient of relatedness, but nor was it at both. The hypothesis of kin selection has not been confirmed as it was in Bison (*Bison bison*), where kin selection may explain allonursing and cooperative birthing behaviour (Jones, 2008). Giraffe mothers did not choose the non-filial calves according to the coefficient of relatedness.

If the female initiated the nursing, it frequently invited filial calves; in comparison to allosuckling in hippopotamus where it was never initiated by the female (Pluháček and

Bartošová, 2011). When the giraffe female initiated nursing of non-filial calves, she did not prefer a young one with a higher coefficient of relatedness. Allonursing was unrelated to kinship also among the buffalo (Murphey et al., 1995).

The female giraffes did not refuse the non-filial calves more than filial ones as we had suspected. The rejections of non-filial nursing attempts were threefold higher than the rejections of filial nursing attempts in captive guanacos (Zapata et al., 2009a).

5.2 Milk theft

We assumed that more experienced or older females would nurse the non-filial calves less often than the inexperienced and young females. That means the more juveniles they had, the more experienced she is. But the results were opposite. The frequency of nursing increased with the age and experience of the mother and the frequency of allonursing was higher in multiparous females.

The duration of allonursing for primiparous and multiparous was not significantly different as for example by red deer where there was not found any significant effect of parity on allosucking duration (Drábková et al., 2008). The opposite was observed in fallow and in white-tailed deer. Fawns to primiparous mothers sucked relatively longer, compared to multiparous mothers (Ekvall, 1994; Gauthier and Barrette, 1985).

The frequency of all nursing increased and the duration of all nursing decreased with the age of giraffe mothers, meaning the older (more experienced) the female is, the more and longer she nurses a young calf. The same tendency was found in fallow deer where allonursing was positively correlated to the age of the females (Ekvall, 1998), compared to buffalos where allonursing is associated with the lack of experience of cows (Murphey et al., 1995). It need to be said that parental care of ewes of mouflon decreased with the increasing age of the female, meaning a decline in suckling frequency and duration (Re´ale et al., 1999). Calves of primiparous dams spent more time suckling than did calves of older cattle cows (Edwards and Broom, 1995).

It is probable that non-filial calves suck from the non-maternal females in positions further from the female's head or together with other calves. They impede to the female their identification. During this research there was similar behaviour observed in giraffes.

The non-filial calves sucked more often in the positions where they can be difficult to identify. The non-filial calves sucked more often together than alone.

The multiple nursing was observed in camels (Miková and Sovják, 2005), water buffalos (Murphey et al., 1991) and captive guanacos where the non-filial calves adopted parallel position during allonursing (Zapata et al., 2009a). The hypothesis of milk theft was found in the wild and also captive guanacos, but it was said that females failed to discriminate their own calves (Zapata et al., 2009a). Calves of the cattle tried to suck from any cow and cows could not consistently discriminate between the calves (Kilgour, 1972).

If the female of giraffes sniffed (identified) the young, it was more often filial calf which sucked more in the position 1 (anti-parallel position). The female reached the head also into the position 3 (parallel position), where she mostly sniffed the non-filial young. That means that she is more or less able to identify the young ones in all of the positions. This shows the female knows that non-filial calf is suckling and even so she goes on nursing. This research did not find out that there would be a giraffe's choice of a non-filial calf in the procedure of a decisive nursing. They prefer the filial offspring. Non-filial ones behave as in the case of milk theft but it cannot be called theft, if the female knows about stealing.

This behaviour can be caused by captivity. The animals have enough food and probably also enough milk (Packer et al., 1992). They will have no shortage of milk due to lack of food and succumb to insistence of the calves for which is the milk addition is purely beneficial. It could explain the frequency of nursing increasing with the age of mother giraffes.

6 Conclusion

The first objective of the thesis was to confirm or not to confirm the kin selection theory. Giraffe mothers did not choose the non-filial calves according to the coefficient of relatedness. They prioritize the filial calves, but the duration of nursing, for example, did not differ with the non-filial and filial juveniles. If we accept it as the mother's choice, we still did not recognize the criteria.

The second hypothesis was hypothesis of milk theft. It was found that the non-filial calves sucked more frequently in the positions where it could be difficult for the mother to identify the young animal and often the calves practised feeding on a non-maternal's milk together with filial calves. We believe such behaviour suggests the calves did not want to be detected.

I have also traced that the female has devices to identify her own calf. We suggest it can be a result of good conditions and sufficient food supply. The mothers probably succumb to insistence of the calves after a time. This may serve as an explanation for the fact that the frequency of nursing increased with the age and experience of the mother. In this situation we can not call this behaviour real "milk theft" but by the young it is undoubtedly a kind of "parasitism".

In the future research we would like to test the hypothesis of compensation. It is possible that the calves improve their weight gain (Roulin and Heeb, 1999). We can maybe mention also the theory of reciprocity among giraffes. Almost all of the nursing females were also allonursing and it could be the result of a form of reciprocal behaviour.

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8 List of Figures and Tables

Fig. 1: Taxonomy of the giraffe

Fig. 2: Distribution of the giraffe (Map Source: IUCN Red List)

Fig. 3: Identification of the giraffe

Fig. 4: Allonursing of one non-filial calf/ Multiple nursing

Fig. 5: Difference in nursing duration between filial and non-filial calves

Fig. 6: Difference in nursing frequency between filial and non-filial calves

Fig. 7: Dependence of the nursing frequency on the coefficient of relatedness

Fig. 8: Dependence of the nursing duration on the coefficient of relatedness

Fig. 9: Difference between initiating filial and non-filial nursing

Fig. 10: Difference between refusing filial and non-filial calves

Fig. 11: In which nursing positions does the female refuse

Fig. 12: Difference in nursing frequency between primiparous and multiparous females

Fig. 13: Dependence of the nursing frequency on the age of the female

Fig. 14: Dependence of the nursing duration on the age of the female

Fig. 15: Difference between sniffing the filial and non-filial calves

Fig. 16: Difference between positions in which the female sniff filial and non-filial calves

Fig. 17: Difference between filial and non-filial calves in multiple nursing

Table 1: Observation table

Table 2: Number of filial and non-filial nursing; Number of allonursing females and allosucking calves (Only the animals who really nursed or sucked)

9 List of the Appendices:

Appendix 1: The herd composition and changes in the individual zoos

Table 1: The herd composition of zoo Praha

Table 2: The herd composition of zoo Olomouc

Table 3: The herd composition of zoo Liberec

Table 4: The herd composition of the Rothschild's giraffes in zoo Dvůr Králové

Table 5: The herd composition of the Reticulated giraffes in zoo Dvůr Králové

Appendix 2: Genealogies of herds in the individual zoos (by males)

Fig. 1: Genealogy of Johan from zoo Praha

Fig. 2: Genealogy of Šimon from zoo Praha

Fig. 3: Genealogy of Marc from zoo Olomouc

Fig. 4: Genealogy of Ben from zoo Olomouc

Fig. 5: Genealogy of Tommy from the Rothschild's giraffes from zoo Dvůr Králové

Fig. 6: Genealogy of Janosh from the Rothschild's giraffes from zoo Dvůr Králové

Fig. 7: Genealogy of Jitu from the Reticulated giraffes from zoo Dvůr Králové

Fig. 8: Genealogy of Dhaifu from the Reticulated giraffes from zoo Dvůr Králové

Fig. 9: Genealogy of Bebe from the Reticulated giraffes from zoo Dvůr Králové

Fig. 10: Genealogy of Theo from zoo Liberec

Appendix 3: Photographic documentation of nursing

Fig. 1: Nursing in position 1/2/3

Fig. 2: Identification of one filial calf/ Identification of calves in multiple nursing

Appendix 1: The herd composition and changes in the individual zoos

Table 1: The herd composition of zoo Praha

Name	Sex	Age Category	Birth Date	Place of birth	Date of loss
			Date of increment	Whence	How / Where
Šimon	M	Adult	21.12.1986	Praha	6.5.2009
					Death
Berta	F	Adult	25.3.1988	Köln	
			3.11.1988	Transport to Praha	
Kleopatra	F	Adult	13.1.1993	Dvůr Králové	
			13.4.1994	Transport to Praha	
Eliška	F	Adult	6.10.1995	Praha	
Nikola	F	Adult	28.11.1997	Praha	30.3.2010
					Sosto
Nora	F	Adult	27.6.1999	Praha	
Diana	F	Adult	6.1.2003	Praha	
Johan	M	Adult	20.12.1999	Rhenen	
			12.11.2004	Transport to Praha	
Kasunga	F	Adult	2.7.2000	Olomouc	30.7.2009
			17.5.2005	Transport to Praha	Death
Marek	M	Young	25.4.2006	Praha	5.5.2008
					Cabarceno
Hana	F	Young	16.8.2006	Praha	1.7.2009
					Lodz
Dagmar	F	Young	20.12.2006	Praha	7.3.2008
					Bandholm
Inka	F	Young	26.1.2007	Praha	21.4.2008
					Budapest
Sandra	F	Young	23.8.2007	Praha	14.10.2008
					Budapest
Luděk	M	Young	26.8.2007	Praha	15.4.2009
					Gdansk
Václav	M	Young	28.9.2007	Praha	15.4.2009
					Gdansk
Mahulena	F	Young	17.11.2007	Praha	23.6.2009
					transport
Bořek	M	Young	11.7.2008	Praha	13.5.2010
					Plzeň
Slávek	M	Young	19.1.2009	Praha	15.12.2010
					Plzeň
Bedřiška	F	Young	1.3.2009	Praha	21.3.2011
					Sosto
Gabriela	F	Young	8.3.2009	Praha	
Jiří	M	Young	28.4.2009	Praha	10.11.2010
					Plzeň
Laura	F	Young	30.5.2009	Praha	21.3.2011
					Sosto
Farra	F	Young	30.10.2007	Rapperswill	
			24.6.2009	Transport to Praha	
Jakub	M	Young	24.7.2010	Praha	
František	M	Young	14.10.2011	Praha	
Vilma	F	Young	6.1.2011	Praha	
Doubravka	F	Young	23.1.2011	Praha	

Table 2: The herd composition of zoo Olomouc

Name	Sex	Age Category	Birth Date	Place of birth	Date of loss
			Date of increment	Whence	How / Where
Veronika	F	Adult	15.12.1988	Olomouc	
Amina	F	Adult	23.10.1994	Olomouc	
Kimberley	F	Adult	20.3.1998	Dvůr Králové	
			15.4.1999	Transport to Olomouc	
Zaira	F	Adult	14.5.2000	Olomouc	
Lerbie	F	Adult	7.11.2002	Olomouc	
Samantha	F	Adult	31.5.2004	Olomouc	
Marc	M	Adult	24.5.2003	Arnhem	
			24.5.2006	Transport to Olomouc	
Susanne	F	Young	2.5.2008	Olomouc	
Natasa	F	Young	19.5.2008	Olomouc	
Pavlina	F	Young	6.4.2009	Olomouc	
Kayla	F	Young	17.1.2010	Olomouc	
Zainabu	F	Young	26.2.2010	Olomouc	
Wambua	M	Young	12.5.2010	Olomouc	

Table 3: The herd composition of zoo Liberec

Name	Sex	Age Category	Birth Date	Place of birth	Date of loss
			Date of increment	Whence	How / Where
Nancy	F	Adult	30.3.1993	Liberec	
Sandra	F	Adult	27.1.2000	Liberec	21.4.2008
					Budapest
Sulika	F	Adult	29.3.1985	Dvůr Králové	5.4.2009
			16.4.1986	Transport to Liberec	Death
Kimi	M	Young	24.7.2007	Liberec	20.4.2009
					Riga
Mike	M	Young	24.8.2006	Arnhem	
			6.3.2008	Transport to Liberec	
Nela	F	Young	21.4.2008	Liberec	
Nisa	F	Young	24.5.2008	Liberec	
Sangha	F	Young	7.3.2006	Liberec	16.11.2008
					Paignton
Twiga	F	Young	9.12.2006	Liberec	

Table 4: The herd composition of the Rothschild's giraffes in zoo Dvůr Králové

Name	Sex	Age Category	Birth Date	Place of birth	Date of loss
			Date of increment	Whence	How / Where
Viola	F	Adult	3.4.1982	Dvůr Králové	19.11.2010
					Death
Ali	M	Young	22.6.2009	Dvůr Králové	10.8.2010
					Bordi
Jan	M	Young	25.7.2009	Dvůr Králové	10.8.2010
					Bordi
Noel	M	Young	26.7.2008	Dvůr Králové	16.9.2010
					Schmiding
Vilem	M	Young	15.12.2007	Dvůr Králové	11.8.2009
					Aywaille
Kimi	F	Adult	6.2.1990	Dvůr Králové	
Mick	M	Young	2.8.2011	Dvůr Králové	
Jenifer	F	Young	11.2.2007	Dvůr Králové	
Raha	F	Young	10.11.2011	Dvůr Králové	
Jaruna	F	Adult	2.7.1997	Olomouc	
			23.9.1998	transport to DK	
Johan	M	Young	23.8.2011	Dvůr Králové	
Kenia	F	Adult	2.5.2000	Barcelona	
			22.5.2003	transport to DK	
Akin	M	Young	7.10.2001	Dvůr Králové	
Viktoria	F	Adult	1.11.2001	Dvůr Králové	
Tery	M	Young	18.8.2010	Dvůr Králové	
Etola	F	Adult	20.11.2001	Dvůr Králové	
Edgar	M	Young	12.8.2011	Dvůr Králové	
Ozák	M	Young	5.1.2010	Dvůr Králové	
Ella	F	Adult	26.9.2005	Dvůr Králové	
Legas	F	Young	7.7.2010	Dvůr Králové	
Johari	F	Adult	5.10.2006	Hannover	
			28.5.2008	transport to DK	
Nina	F	Adult	12.7.1997	Liberec	
			10.7.1998	transport to DK	
Tommy	M	Adult	2.3.2002	Rhemen	
			13.5.2004	transport to DK	

Table 5: The herd composition of the Reticulated giraffes in zoo Dvůr Králové

Name	Sex	Age	Birth Date	Place of birth	Date of loss
		category	Date of increment	Whence	How / Where
Julie D	F	Adult	23.5.2003	Dvůr Králové	
Justina	F	Young	27.8.2011	Dvůr Králové	
Julie B	F	Adult	8.12.2006	Brno	
			11.4.2008	Transport to DK	
Joachim	M	Young	12.10.2011	Dvůr Králové	
Brindisi	F	Adult	28.12.1989	Dvůr Králové	
Bazyl	M	Young	1.11.2011	Dvůr Králové	
Lydie	F	Adult	23.12.2001	Amsterdam	
			17.4.2003	Transport to DK	
Lukrecie	F	Young	7.11.2010	Dvůr Králové	
Tootsie	F	Adult	5.10.1995	Dvůr Králové	
Tim	M	Young	3.10.2010	Dvůr Králové	
Tanaka	F	Adult	11.8.2002	Dvůr Králové	
Tanja	F	Young	22.10.2010	Dvůr Králové	
Izabela	F	Young	23.9.2010	Dvůr Králové	
Leila	F	Young	16.7.2006	Dvůr Králové	
Ituri	F	Young	1.8.2006	Dvůr Králové	
Bisina	F	Young	29.8.2009	Dvůr Králové	
Jeník	M	Young	22.8.2009	Dvůr Králové	
Jitu	M	Adult	2.2.2003	Frankfurt	
			2.6.2004	Transport to DK	

Appendix 2: Genealogies of herds in the individual zoos (by males)

Fig. 1: Genealogy of **Johan** from zoo Praha

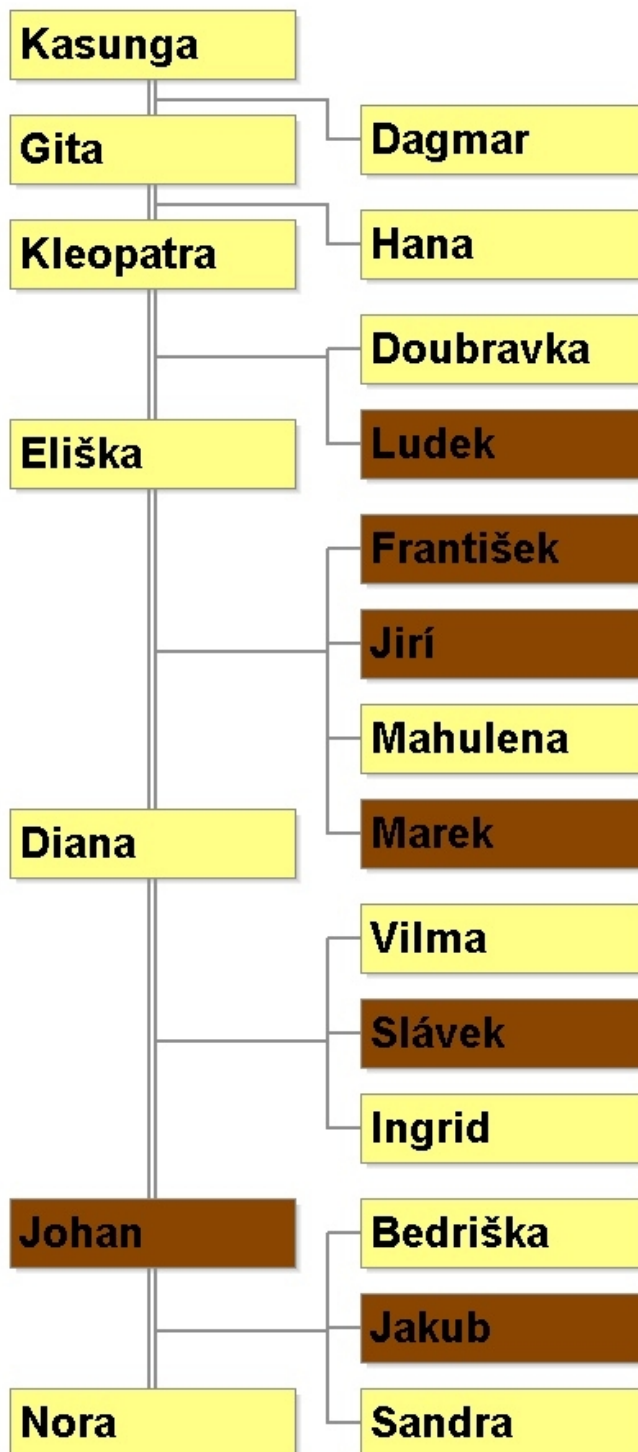


Fig. 2: Genealogy of Šimon from zoo Praha

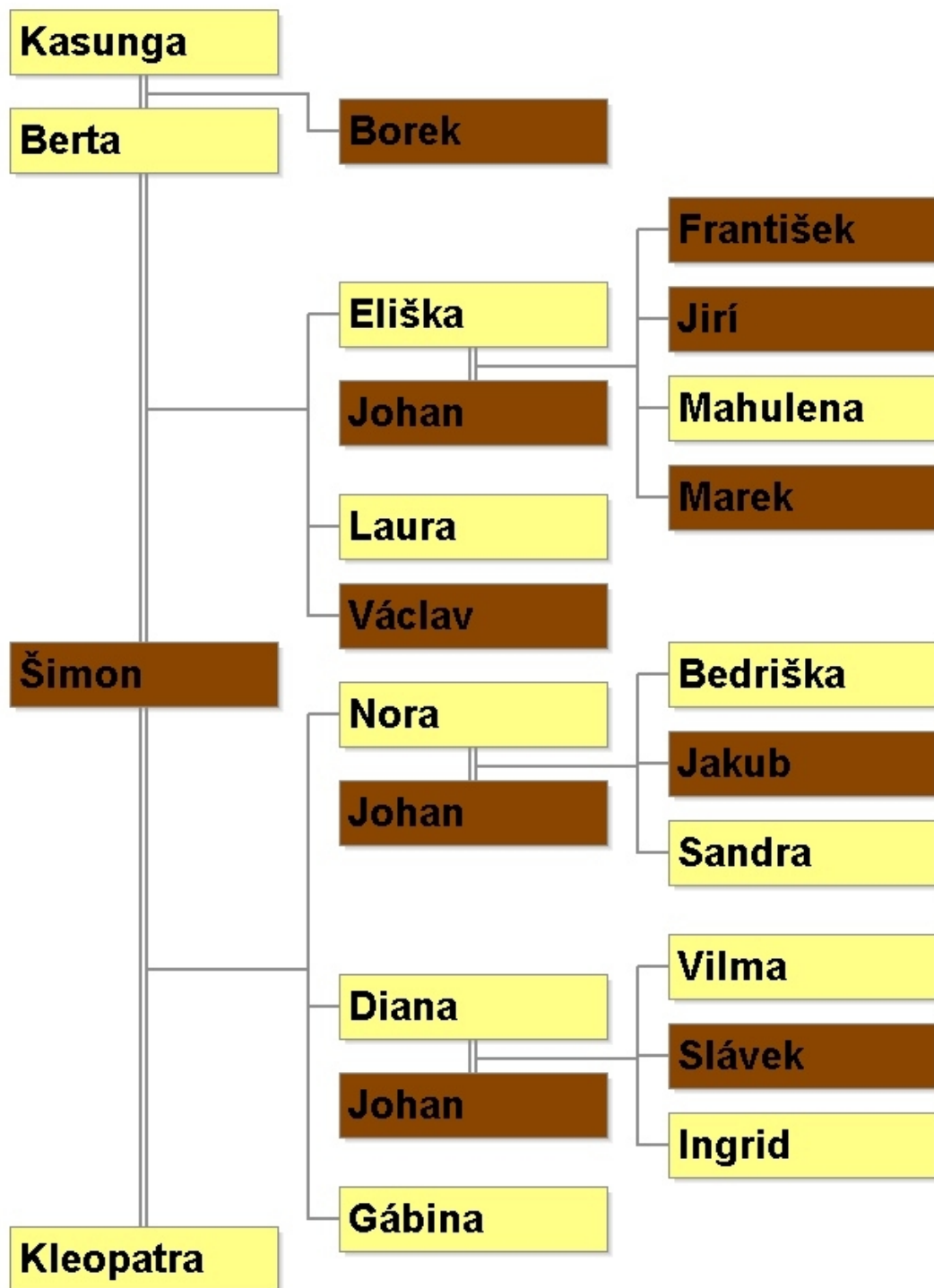


Fig. 3: Genealogy of **Marc** from zoo Olomouc

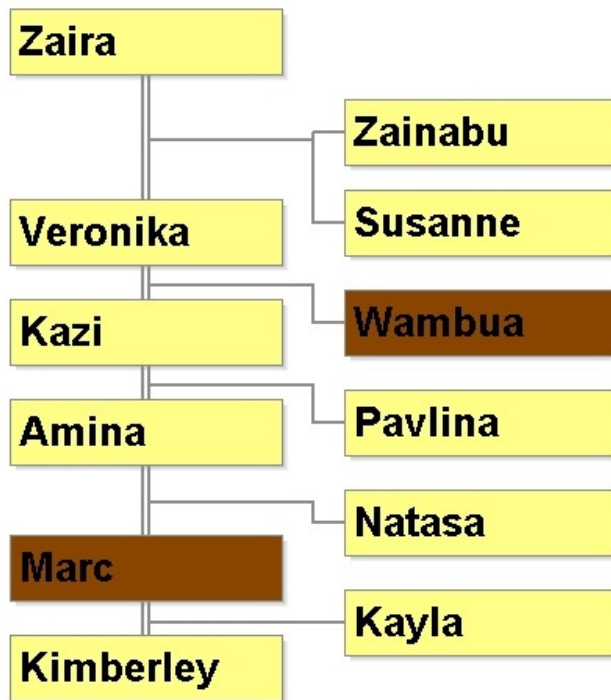


Fig. 4: Genealogy of **Ben** from zoo Olomouc

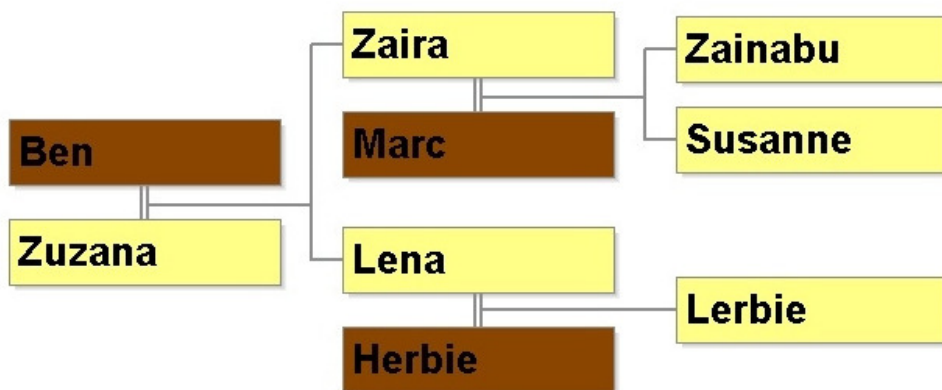


Fig. 5: Genealogy of **Tommy** from the Rothschild's giraffes from zoo Dvůr Králové

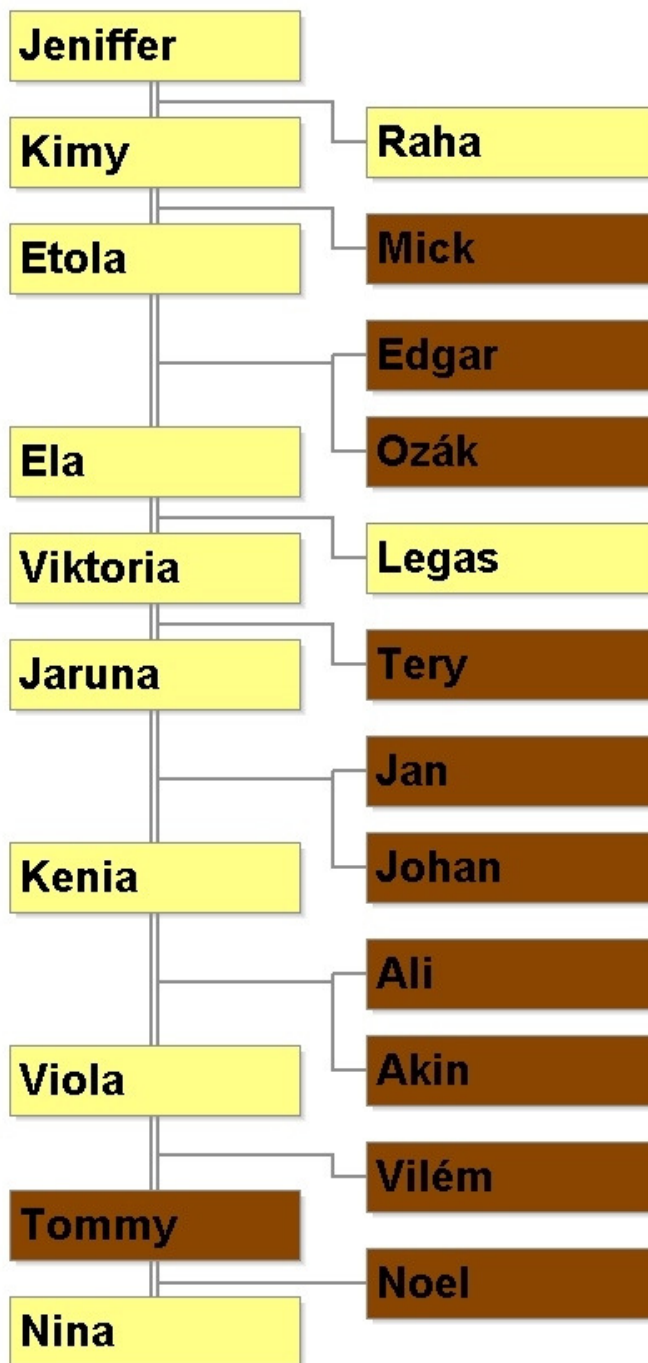


Fig. 6: Genealogy of **Janosh** from the Rothschild's giraffes from zoo Dvůr Králové

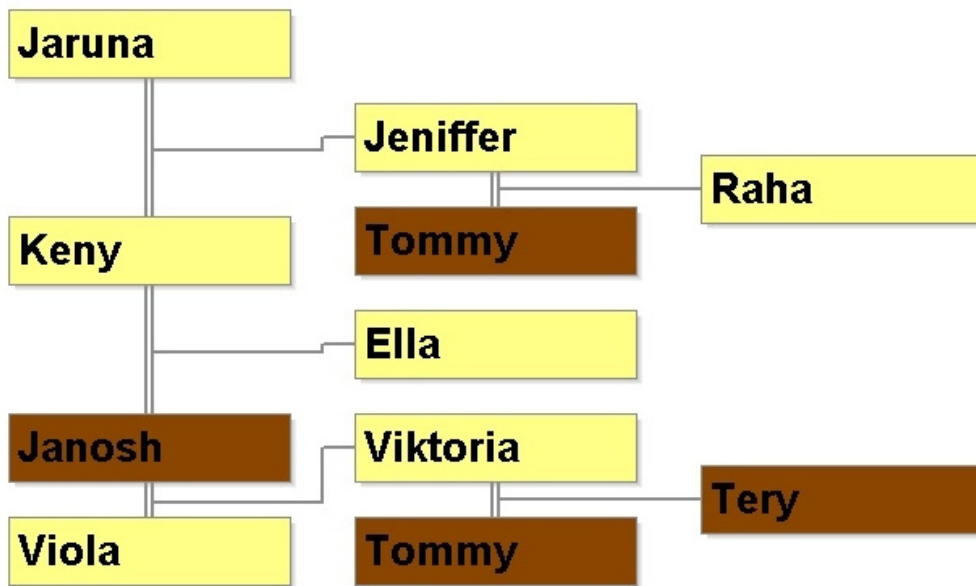


Fig. 7: Genealogy of **Jitu** from the Reticulated giraffes from zoo Dvůr Králové

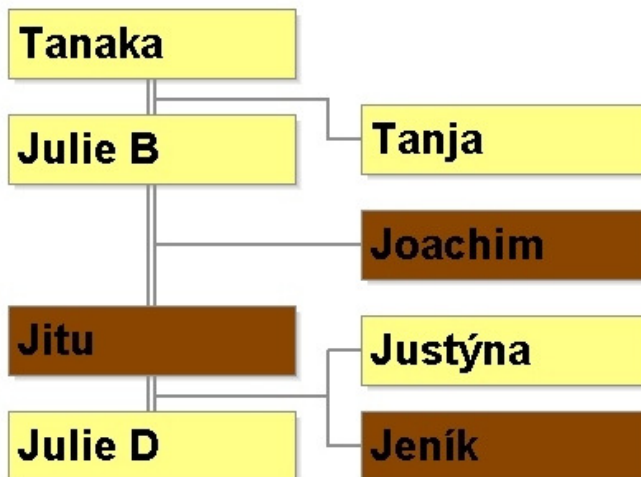


Fig. 8: Genealogy of **Dhaifu** from the Reticulated giraffes from zoo Dvůr Králové

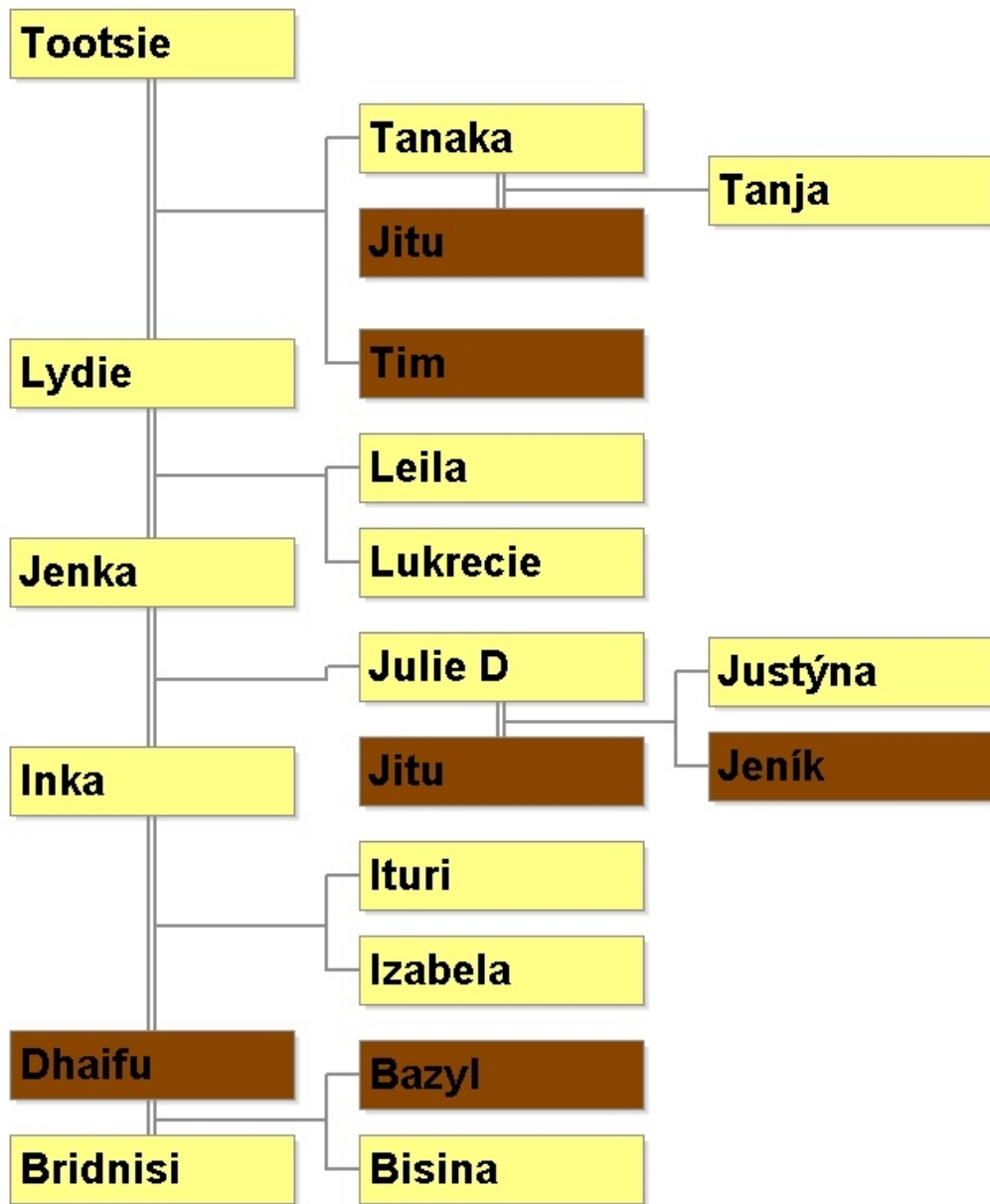


Fig. 9: Genealogy of **Bebe** from the Reticulated giraffes from zoo Dvůr Králové

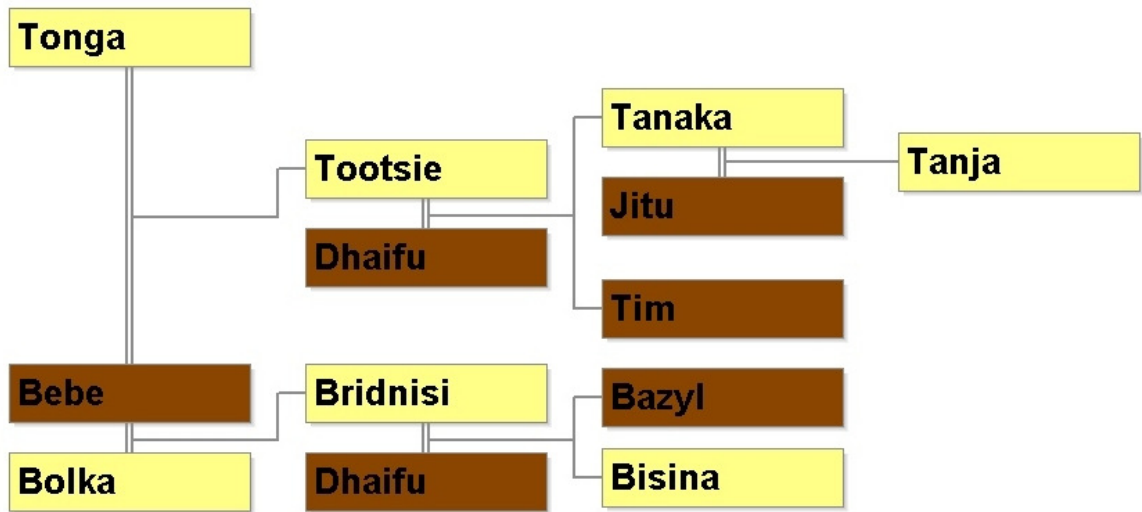
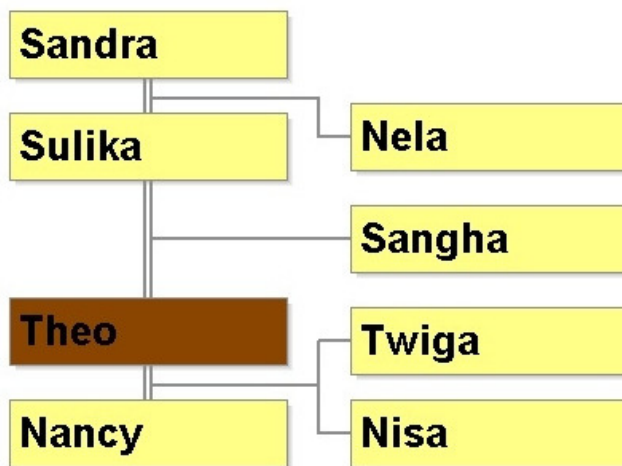


Fig. 10: Genealogy of **Theo** from zoo Liberec



Appendix 3: Photographic documentation of nursing

Fig. 1: Nursing in position: **1** (© Daniel Hejzlar) /**2** (© Kamila Švarcová) /**3** (©Markéta Hejzlarová)



Fig. 2: Identification of **one filial calf** (©Dalibor Sýkorovský) / Identification of **calves in multiple nursing** (©Markéta Hejzlarová)

