CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

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Social preferences in giraffes (*Giraffa camelopardalis giraffa*)

Master's thesis

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Declaration

I hereby declare that this diploma thesis on the theme: was elaborated independently and is based only on my own knowledge, consultations with my supervisor and literary resources cited in attached bibliography.

In Prague 16th of April 2016

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Abstract

Giraffe herd structure and relationships are changing the former ideas of weak social bonds into understanding of complex social structures of giraffe herds. Our study focused on the 28 neglected Cape giraffe (*Giraffa camelopardalis giraffa).* We investigated the social preferences of 28 introduced giraffes in semi-captivity of Bandia reserve, Senegal. Our aim was to assess the group size of Cape giraffes outside their native range and describe their social relationships. We evaluate whether the focal female associated randomly or patterned their close association in manner indicative of social relationship. The dyads were classified according to strength of relationship (weak, medium, strong), using the association index. We reported weak and medium relationships in all types of dyads except female-juvenile. The strongest bond was found in mother-calf dyads. Three of 21 possible female dyads also demonstrated stronger association patterns. Affiliated interaction, proximity and nearest neighbor were analyzed for each adult female, suggesting that giraffe cooperate and maintain relationships. Females associated and interacted more frequently with calves of familiar female then with the others, even if the mother were not presented. Giraffes are sharing the maternal care. The social preference of the mothers, continuously involve the preference of their calves. We concluded that Cape giraffes in new environment have shown similar group size and nonrandom preference for conspecifics as were described in wild and captive studies. The research was supported by CIGA 20135010, CIGA 2134217, IGA FTZ 20135123, ESF/MŠMT CZ.1.07/2.3.00/30.0040

Keywords

Giraffa camelopardalis giraffa, group, female, calf, social bond, fission-fusion system, relationship, association index, inter-individual distance

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1. Introduction and literature review

During the decades, giraffes have played an important role for people in Africa, especially in their cultural and traditional living. In 20 century has seen a gradual decline of many mammals species (Happold, 2000). However drastic declines have occurred in this century (Bercovitch and Deacon, 2015). Clearance of land and rainforest and savannas destroys the natural environment and dicrease diversity and food source for wild animals. In fact, wild giraffes are not respected by communities because they destroy they fields. They dont have much choices for well being in deserts. Giraffe taxa present charismatic, long-necked ungulates from Africa, which are well known all around the word.. The dedicated efforts to manage well populations in the ex-situ environment is improving daily (Lot, 2004) and need further study.

May be expected, giraffe taxa has hardly been studied in Senegal. Giraffe were over-hunted in this area. The Cape giraffes were translocated to Senegal from South Africa, West coastal weather in Bandia Reserve benefit to Cape giraffes and they are reproducing well in location. It is important to understand population dynamics and structure and to consider how sub-populations within a species may vary with respect to social structure, seasonal responses and habitat (Fennessy, 2004). The Mcs. thesis goal was to investigate Cape giraffes social preferences. This study defined herd structure as individual or group associations. We evaluate whether a herd of giraffe in Bandia Reserve, Senegal have been associated randomly or pattern they behaviour in manner indicative of social relationships. The formation of the social structure in giraffes were studied daily in semi-captive condition of Bandia reserve in Senegal. The herd structure and social preferences among adult female giraffes, the social distance and interactions were recorded. Continuously, the maternal behavior were observed also in the zoological garden in Prague. Here, we investigated the maternal aspect in female giraffes and involvement in sociality of their calves. Giraffes definitely need to be protected to not dissapear from our planet.

By this theses I would like to improve welfare condition of giraffes. Our results have implications with regards to the conservation of giraffe populations. It also sought to obtain a better understanding of the effect that study area size may has on population structure.

1.1 General information about giraffes

The giraffes belong to the family *Giraffidae*, which also contains the okapi, *Okapia johnstoni*. Okapi resides only in the dense rainforests of Central Africa and has recently been classified by the IUCN as ‘endangered’ (Kümpel et al., 2015). Although different in appearance and behavior, giraffe and okapi share a number of common features, including a long neck, and skin-covered horns, called ossicones (Hassanin et al., 2007). Nevertheless, the tallest creatures on the planet (Bercovitch and Deacon, 2015) the giraffes are approximately 4.3m to 5.2m tall. The tallest male recorded had almost 6m. The average mass for adult male giraffe is 1191kg while the average mass for adult females is 828kg (Dagg, 1970; Skinner J, 1990). The evolutionary origin of the long neck of giraffes is enigmatic. The ‘sexual selection’ theory proposed that their shape evolved because males use their necks and heads to achieve sexual dominance. This theory was not supported by (Mitchell et al., 2009). Giraffes are assumed to live for 15 to 22 years in the zoo condition and to 30 years in the nature (Dagg, 1970; Dagg and Foster, 1976; Cameron and Dutoit, 2005; Bercovitch, 2012). On the other hand, the maximum longevity of females in the population is about 28 years (Dagg and Foster, 1976). Calf mortality in the first year of life is 45% (Berry, 2010) and mortality rates of immature giraffes decline after the first year of life (Dagg and Foster, 1976). The average age of disappearance of immature males from the study population is 4 years old. Males who survive the first year of life become independent by 2 years of age and disperse from the natal area when 4 to 8 years old. Males become mature bulls when about 10 years of age and have an average life expectancy of 14 to 16 years (Berry et al., 2012). Males 11- 23 years of age had body masses of 1056–1395kg and females 12–20 years of age had body masses of 779–950kg. (Hall-Martin et al., 1975; Hall-Martin, 1976; Skinner, 1978)

1.2 Giraffes taxonomy

Basic categorization of the giraffe population belongs to the species *Giraffa Camelopardalis* (Linnaeus, 1758). Therefore, the more precise sub-dividing of the species had been questioned (Happold, 1969b; Brown et al., 2007). Giraffe taxonomy has been perplexing and often inconsistent within the literature (Dagg, 1971; East, 1981). *Giraffa sivalensis* (Falconer and Cautley, 1843) was the first extinct Giraffa species to be discovered. (van Sittert and Mitchell, 2015a). (Cautley, 1838) Briefly described the discovery of a remarkable vertebra in the Siwalik Hills in India. However, Lydekker (1885) disputed this and proposed that the holotype was in actual fact a fifth cervical vertebra of a ‘very small individual’ (Van Sittert and Mitchell, 2015b). Continuously, giraffes were characterized as a two species *Giraffa reticulata* and *G. camelopardalis* (Lydekker, 1904) or only one species (Dagg, 1971) The taxonomic incongruence in this case stems from Ansell (1971) and where he classified the Namibian giraffe as *G. c. giraffa*. Historical and current literature shows that the Namibian population is often published under the taxonomic classification *G. c. angolensis* (Rick A. Brenneman, 2009). Beyond the recent taxonomy, the giraffes present the monophyletic and the extant species of its genus (Dagg, 1971; Kingdon, 1997; Rick A. Brenneman, 2009). In the genus, the clearest specification differs in numbers of giraffe subspecies and it is dependent on the census method used (Brown et al., 2007; Hassanin et al., 2007; Fennessy et al., 2013). Taxonomic studies on giraffes (Brown et al., 2007), reveals that the southern African populations have an intricate and tangled taxonomical history (Fennessy, 2009). Despite their mobility, giraffes are characterized by extreme genetic divergence amongst lineages (Brown et al., 2007). Across Africa, at least six distinct groups can be identified, with little evidence of hybridization (Thomassen et al., 2013). However, geographic variation in traits such as pelage pattern is clearly evident across the range in sub-Saharan Africa and abrupt transition zones between different pelage types are typically not associated with extrinsic barriers to gene flow, suggesting reproductive isolation (Brown et al., 2007). Population was separated to northern (West of the Nile) and southern (Great Rift) clades are monophyletic group (makes *G. c. reticulate* paraphyletic) and Rothschild’s group with western populations. The status of the northern giraffes has always been controversial (Hassanin et al., 2007). In Southern clades, the Kenyan/Tanzanian shared the Luangwa/Valley haplotypes. Some Masai giraffes share alleles with Reticulated. Namibian populations differ from other southern at nuclear loci. (Brown et al., 2007). Despite the differences among species concepts, there is a general consensus that species are separately evolving meta-population lineages united by gene flow. Among giraffe sub specific groupings, including those that are adjacent to one another, there is an almost complete lack of gene flow, suggesting that these groups are reproductively isolated and thus constitute separate lineages (Brown et al., 2007). Although those conservation efforts are troubleshooting with hybridization, despite it could results more healthy population.

1.2.2 Population dynamic of the species: *Giraffa camelopardalis*

According to the Giraffe Conservation Foundation (2013), the number of giraffes in Africa has plummeted from 140,000 in 1998. Recent estimates indicate that approximately 110000 giraffes survive in the all Africa continent (Brown et al., 2007) but less than 80,000 today (Bercovitch and Deacon, 2015). The historical knowledge of a population's dynamics can provide a solid background for management; however, long-term data has to be obtained. This is the case for giraffe; this limitation has restricted appropriate conservation and management efforts for giraffe species, subspecies and subpopulations across Africa. (Danowitz and Solounias, 2015). The majority of studies on population dynamics focus on current ranges of species (Berry, 1978) and their relation to conservation and management (Ciofolo, 1995). Precipitation, human disturbances, habitat fragmentation, predation and nutrient and mineral resource availability are extrinsic factors that can affect population density and dynamics. Intrinsic factors, such as the: Alleles effect, intraspecific competition, stress and other density-dependent processes, can have additional influences (Dekker et al., 1996). Low genetic diversity was in the northern Namib Desert population where most giraffe sampled share the same mitochondrial haplotype. The exception is one haplotype shared with an Etosha individual and this in itself is suggestive of the genetic signature left by the translocation of 22 giraffe from western ENP to the ND in 1991 (Fennessy, 2004). Giraffe populations in the study region were assumed not to interact; however, the molecular data estimated migrants per generation supported by ecological observations indicate that giraffe migrate throughout the region and have been found in alternative home ranges on occasion (Brenneman et al., 2009b). There are four distinct groups of giraffes that are reproductively isolated from each other in the wild based on genetic and morphological evidence: Reticulated (*reticulata*), West African group (*rothschildi* + *peralta*), tippelskirchi (*Masai)* and Southern African group (*angolensis* + *capensis*). These groups may be different species of giraffe. The Rothschilds giraffe (*rothschildi)* is distinct in pelage and mtDNA from the West African giraffe *(peralta*). There is deep genetic differentiation between Southern African groups morphologically the same (*capensis* in South Africa and *angolensis* in Namibia). Regional changes in habitat distribution could have promoted the isolation of specific populations, such as the expansion of the Mega Kalahari desert basin during dry periods of the Late Pleistocene that might have isolated Angolan and South African giraffe. Vegetation and habitat, leading to population divergence, then the phyla geographical patterns of giraffes should also be found in other species. Indeed, western, eastern, and southern African phylum geographic groupings in the giraffe mtDNA genealogy are broadly concordant with the genetic patterns observed in other taxa of large African mammals and might correspond to former habitat refuges (Brown et al., 2007). Recent molecular systematics of the Namibian giraffe populations indicates that they are distinct from the subspecies *Giraffa camelopardalis giraffa* and classified as *G. c. angolensis.* Thus we add data on *G. c. angolensis* to our scientific knowledge of this giraffe of southern Africa (Brenneman et al., 2009b).

1.2.3 *Giraffidae*: Intra-species diference

Giraffe populations usually recognized as subspecies have a long history of reproductive isolation possibly by differences in reproductive timing or pelage-based mating (Brown et al., 2007). Several of today's giraffe populations are isolated and live in detached habitat fragments or fenced area. These alterations might even have long-term effects on e.g. intraspecific competition, predator-prey relationships, or parasite transmission amongst other factors and have to be considered in future conservation plans for affected populations (Seeber et al., 2012). The many variations are included in described taxa. One of the first subspecies recognitions was following: "Rothschild's or the Baringo Giraffe (*G. c. rothschildi)* had five horns generally or invariably present in old bulls owing to the development of the posterior or occipital pair (Lydekker, 1904). *G.c. tippelskirchi* were distinguished by the well-marked third horn of the forehead, which were decidedly smaller than in *G. c. rothschildi*. But some of the bulls from the same locality have little or no third horn (Lydekker, 1904). G. c. *thornicrofti* were described by a low and conical frontal horn and the more compact frontal horn (Lydekker, 1911). Variation is certainly there; despite the fact it has not been proved as taxonomically, and biologically relevant.

Observed variation in giraffe was obvious, especially from pelage patterns. Reticulated giraffes have consistently large polygonal spots. Masaai giraffe have distinctive stellate "shattered" spots. Southern group: could not differentiate the southern populations. West Africa east to the Nile River and Great Rift Valley: males have large skulls and a well develop median horns due traditional morphometric. In Western giraffes median horns are cylindrical rather than conical (compared to eastern). Reasonably sampled except Sudan (*G. c. camelopardalis and G. c. antiquorum*). Important to sample nominate subspecies: *G. c. reticulata*: distinct pelage, skull morphology and paraphyletic for haplotype. *G. c. tippelskirchi*: pelage distinctive, morphology variable, genetically unclear. *G. c. rothschildi*: skull distinct from other eastern specimens. Pelage distinct. The two southern subspecies differ primarily in their markings; *G. c. angolensis* has larger patches than *G. c. capensis* (Kingdon, 1979). The patches in both subspecies are numerous and have jagged outlines and the patches of *G. c. capensis* have firmer outlines than those of *G. c. angolensis* (Parker, 2004). *G. c. thornicrofti* differ from other southern individuals by pelage, skull and molecular characters.

1.2.4 Historical distribution of giraffes in Africa

Sub specific variation is a logical corollary of Darwinian evolution by natural selections. Populations of widespread species experience differing environmental conditions and differing selective pressures. Nevertheless, it is also important to obtain a sound understanding of a species' historical, current and potential distribution and population dynamics before appropriate long-term conservation and management approaches can be established (Danowitz and Solounias, 2015). Marked fluctuations in giraffe populations have been reported and are the result of various factors, such as poaching, fragmentation, predation, overuse of forage, and a shift in fecundity (Foster and Dagg, 1972; van der Jeugd and Prins, 2000a). Large herds were crossing most of the Africa continent during historic time. The geographic range of the giraffe has been severely fragmented due to increasing aridity and human population growth so today, giraffes are discontinuously distributed from the Sahel to South Africa (Berry et al., 2012). Three climates related factors could have influenced isolation among giraffe populations. First, pale climatic evidence indicates increasing aridity and cooler conditions beginning in the Late Pliocene that likely reduced connectivity between habitats favored by giraffes (de Menocal et al., 1995). Second, pronounced periodic oscillations of wet and dry conditions driven by changes in the intensity and location of maximal insolation and with a 21000 year periodicity could have facilitated habitat fragmentation and population isolation (Trauth and Maslin, 2005). Third, regional changes in habitat distribution could have promoted the isolation of specific populations, such as the expansion of the Mega Kalahari desert basin during dry periods of the Late Pleistocene that might have isolated Angolan and South African giraffe populations Such concordance in phylo-geographic patterns among multiple unrelated species suggests histories shaped by similar environmental forces, in agreement with models of environmentally driven evolution (Brown et al., 2007).

1.2.5 Giraffes in northern Africa

In the 19th century the distribution area of the West-African giraffe subspecies *Giraffa camelopardalis peralta* still covered a large part of the Sahel region from Senegal to Lake Chad. Giraffe have been recorded as far south as 8"N (at Lokoja, Nigeria) in the V-shaped area to the north of the confluence of the two rivers. There seems no ecological reason why giraffe could not live in the savanna south of the rivers if they could get there (Happold, 1969a). The present possible distribution is a result of three geographical factors, which are barriers to the dispersal of giraffes. These are I) the southern limit of the Sahara desert which prevents movement of giraffe to the north. 2) The mountains and forests extending from north to south in the Cameroons and in Liberia and 3) The Niger and Benue river system which prevents movement to the south; and (Happold, 1969a). The severe droughts of the 1970s and 1980s in Niger helped to further degrade the landscape and decimate wildlife populations (Caister, 2003). But drought may dry the corridor of Niger and Benue a river and open the way to the south for giraffes.

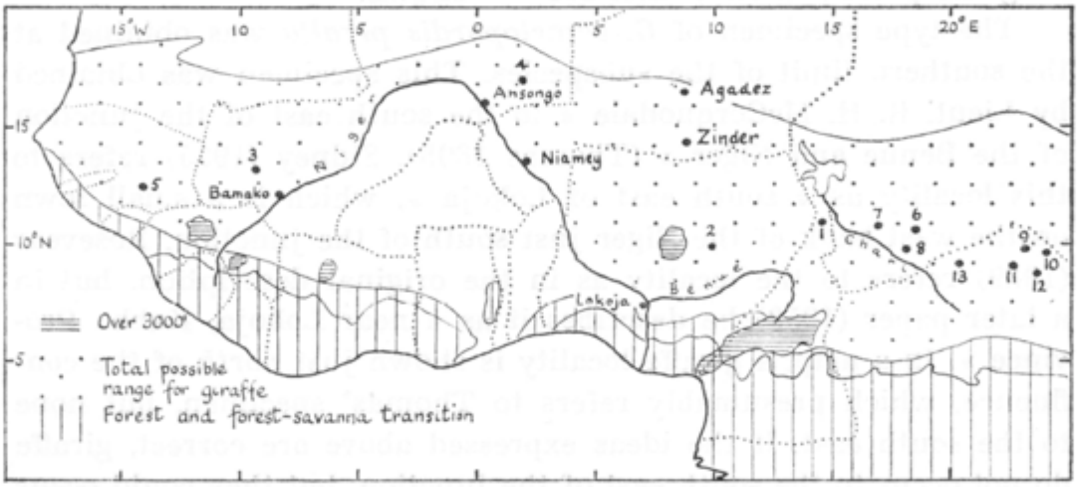

Figure 1: Range of the giraffes in Nort/West Africa (Happold, 1969)

Although giraffes have been occasionally seen in south of the Niger, there is no evidence that permanent population occur in this area. Presumably the giraffes either die or return to the northern side. The southern habitat may be unsuitable because of human harassment habitat modification and may prevent the establishment of viable southern herd. Other possibilities may be an absence or inadequacy of particular food plants or some other environmental requirement. These speculations emphasize the necessity of a thorough ecological study if at some time in the future conservation authorities wish to translocate giraffes into the savannas south of the Niger-Benue river system (Happold, 1978) or other similar localities. In Niger giraffe sub-adults of both sexes strongly prefer *Prosopis africana*. Adult giraffes showed the strongest preference for *Acacia nilotica, Acacia seyal* and *Combretum glutinosum*, and the strongest avoidance of *G. senegalensis, Annona senegalensis and Hyphaene thebaica*. Strong preference index for *C. glutinosum* habitat choice exhibited by female giraffes in Niger were driven more by nutritional demands than by an avoidance of predators or resource partitioning. (Caister, 2003). During the hot-dry season, giraffe aggregate in the eastern and central sections of the study areas in response to the increased availability of *Faidherbia albida* an essential dry-season food and an early flush in *Colophospermum mopane* J. Leonard leaves (*Acacia Robinia, acacia L.*) species. The role of co-habitant and their parasites had to be accomplished before translocations as well the role of plants species. With an increase in the popularity of wildlife ranching in Africa has come the introduction of non-native mammalian herbivores with little or no assessment of the ecological consequences (Parker et al., 2003). The evolutionarily significant units that we have uncovered and their isolated constituent populations merit conservation and separate management. Giraffes of western and central Africa belong to two different subspecies, *peralta* and *antiquorum*. Several of these previously unrecognized genetic units are highly endangered, such as the West African giraffe, numbering about only 100 individuals and restricted to a single area in Niger (Brown et al., 2007). As no giraffe *peralta* exists in European zoos, no re-introduction program could be conducted in the future to deal with the conservation of this endangered population (Hassanin et al., 2007).

1. 2. 6 The Eastern Cape Province, South Africa

The Eastern Cape Province, South Africa forms a complex transition zone between four major phytochoria, the Cape, Tongoland, Karoo-Namib and Afromontane (Lubke, Everard and Jackson, 1986). Probably the most extensive efforts at relocating giraffes have been in South Africa, where giraffe can be privately owned. Almost 10,000 game farms, game ranches and private game reserves, ranging in size from a few to thousands of hectares, are scattered about South Africa (WRSA, 2013). Consequently, the region has a high diversity of plant species. The introduction of giraffe to the Eastern Cape Province has raised a number of ecological, ethical and philosophical questions. The boom in the game farming and tourism industry in the Eastern Cape Province has meant that many of the new game farms and game reserves have stocked extra limited species with little or no scientific evidence to support their actions (Dekker et al., 1996). Historically, most of the land in the Eastern Cape was used for small stock farming, as the region is not particularly suitable for crop cultivation. Consequently, much potentially irreparable damage to the natural vegetation due to overstocking and bush clearing has occurred (Parker et al., 2003). The population decline coincided with the drought attributed to the 1994 El Niño. Relocation can be risky and costly, and pinpointing suitable giraffe habitat is difficult, but such a conservation management plan should be given serious consideration (Bercovitch and Deacon, 2015). Nowadays in South Africa are around 30,000 individuals of giraffes (Deacon et al., 2014). Evaluating target areas for translocation is also difficult given that season influences giraffe food intake, with both foraging height and plant selection differing by sex (Pellew, 1984; Fennessy, 2004; Du Toit and Yetman, 2005; Ginnett, 1999). Giraffe in the Eastern Cape

Province, like giraffe in their native range, prefer deciduous species such as those from the genus *Acacia* during the summer months, and switch to more evergreen species during the winter (Parker et al., 2003). Possible dietary complications from highly concentrated tannin levels because of forced over consumption of the park's declining acacia trees may have compromised young giraffe (Brenneman et al., 2009a). Recent research supports such a contention with Bakke (Martínez-Freiría et al., 2016) demonstrating that cattle grazing in the Netherlands returned less nitrogen to the soil than did common voles (Bakker et al. 2004). Thus, the re-introduction of indigenous herbivores to the Eastern Cape Province may be more desirable than domestic livestock. However, the question as to whether non-native species such as giraffe are more detrimental to the indigenous vegetation than domestic livestock.

1.3 Giraffe identification

Wildlife management typically requires demographic data usually obtained from capturing, marking and tracking individuals (Gilkinson et al., 2007). Identification of individuals is critical to understanding individual behavior and important in investigating aspects of species ecology, such as population structure and dynamics, density, distribution and seasonal movement, home range and habitat preference. Single- species studies have adopted many different methods to aid in the quick and easy identification of individuals (Foster, 1966), including coat patterns, color, tail length, tusk length, scars, gait, horn variations, ear notching, mane clipping, painting, branding, collaring and spoor identification. In giraffes, identification methods relying on chance of individuals have been used (Foster, 1966; Berry, 1978; Le Pendu and Ciofolo, 1999) and VHF radio-tracking method (Foster and Dagg, 1972; Langman, 1973). Modern methods present GPS satellite collar technology has been used to determine movements of giraffe (*G. c. giraffa*) (Bock et al., 2014) in northern Botswana. The identification of individuals generally also enables a closer relationship between study species and researcher, allowing collection of high quality data and increased knowledge of species ecology . Consequently, individuals remain distinguishable, especially when are observed at frequent intervals. Their size, and the ability of researchers to identify them individually, makes giraffe an ideal study species (Fennessy, 2004). Both males and females possess horns covered with skin. The horns of giraffe are soft and cartilaginous at birth, ossifying with age, and eventually fusing with the skull (Skinner J, 1990). Males are distinguished from females by having thicker horns that lack the characteristic “tuft” of hair found at the tip of the horns in females (Parker, 2004). Once juveniles reached approximately one year old they became relatively self-sufficient and their behavior was similar to that of adults and sub adults (Danowitz and Solounias, 2015). Therefore, all giraffe were classified as sub-adults from one year of age, and sub-adults were re-classified as adults after five years when they had reached a height of about 4–4.5 m. This age interval correlates with sexual maturity and social presence (Dagg and Foster, 1976). Photo-identification studies have been conducted successfully on a wide variety of species with individually unique markings (Halloran et al., 2015). Visual photo-identification studies, where the investigator manually identified the images, have been performed successfully on short-beaked common dolphins (*Delphinus delphis*) (Neumann et al., 2002), Florida manatees (*Trichechus manatus latirostris*) (Langtimm et al., 2004), sea otters (*E. lutris*) (Gilkinson et al., 2007) and loggerhead sea turtles (*Caretta caretta*) (Schofield et al., 2008). However, this method is not always practical as large photographic datasets can be difficult to manage, time consuming to analyze (Halloran et al., 2015). Many authors have developed and/or adapted identification methods for individual giraffe in their studies (Innis, 1958; Langman, 1973; Leuthold, 1979; Pratt and Anderson, 1979; Pellew, 1984; Le Pendu, 2000). Nevertheless, the analysis of large datasets requires effective photo-identification software to quickly and accurately process photographs (Halloran et al., 2015). The individually distinctive coat patterns of giraffe provide scientists with a method for estimating population sizes and tracking individual movement patterns using photographic images combined with special software as a type of capture/recapture process (Bolger et al., 2012; Halloran et al., 2015). Mark recapture software present one of open-source application for the storage, pattern extraction and pattern matching of digital images (Bolger et al., 2012). Although the accuracy of the method is dependent upon background complexity (Halloran et al., 2015).

1.3.1 Coat patterns

Giraffes have individually unique coat patterns (Foster, 1966; Pratt and Anderson, 1985; Brand, 2007a; Bercovitch and Berry, 2010). Individuals can be visually identified by a composite of those patterns and distinctive markings in the skin (Halloran et al., 2015). Giraffe are covered in large, irregularly shaped chestnut-brown to black patches separated from one another by a network of off-white, white or yellowish-white bands (Foster and Dagg, 1972; Skinner J, 1990). Among giraffes, the detailed geometric configurations of the darkened pelage differs across subspecies in the area ((Dagg and Foster, 1976; Brand, 2007b), but in all types of giraffes, the blotches darken with age, especially among males (Estes, 1991; Berry et al., 2012). Brand (2007a) has suggested that the initial color change occurs along with the onset of reproductive activity, when around 6 to 7 years of age, and that it takes about 1 to 2 years for complete transition (Berry et al., 2012). These dark patches apparently serve a thermoregulatory function but may have initially evolved as a form of camouflage in the giraffe’s forest or bushes. The possible proximate mechanisms and adaptive significance of male coat-color changes should be studied in more detail (Berry et al., 2012). However, he supported estimation two years to complete in the developmental stage of male coat-color darkening from (Brand, 2007b). Giraffe have a pelage pattern that does not change throughout its lifecycle but color intensity can either fade or darken over time. An Ossicones, another distinctive feature, may increase in size over time, particularly in bulls (Foster and Dagg, 1972). Darker males tended to be older and more dominant than lighter males, associated less with females, but had greater success in courting females. Paler males had a greater chance of interacting with females at waterholes because of higher intruder pressure, but when present, darker males have been always monopolized courtship opportunities. Darkening coat colour reveals life history and life expectancy of male (Berry et al., 2012) (Brandl et al., 2011). It is possible, that the unique individual coat patterns of each giraffe are signaling individual identity to conspecifics (Pratt and Anderson, 1979). Zebra foal imprint upon unique maternal stripe pattern (Olleova, 2012; Beauchamp, 2014), so why not giraffes do?

1.4 The giraffe social behavior

One of the most important attributes of any animal population is its social structure (Whitehead, 2009). The social structure of a population is a crucial element of an individual's environment, fundamentally influencing the transfer of genes, information and diseases (Roggenbuck et al., 2014). Within groups of mammals, social preferences are defined as patterns of interaction or association in witch specific individuals are more likely to direct their behaviour toward each other {Bercovitch et al., 2007). Group living in animals has attracted extensive attention in behavioural, ecological and evolutionary studies and is thought to have evolved from trade-offs between fitness relevant costs and benefits. In the two studied savannah ecosystems, most mammal species tended to form mixed species groups. Notable exceptions were elephants, giraffes, dik-diks, and most carnivores; these species seemed to avoid proximity to other species (Kiffner et al., 2014). Living in a group may also affect the individual foraging success and may either enhance or decrease the transmission rate of disease agents or parasites between individuals (Côté and Poulinb, 1995; Altizer et al., 2003). Personality is important in collective decisions and bolder individuals have a greater influence over the outcome of decisions in groups (Kurvers et al., 2011). Analyses of individual patterns of association provide insight into the social structure of a population (Whitehead, 1999; Whitehead, 2009).

1.4.1 Fission/fusion social system

Giraffes grouping patterns are characterized by frequent changes in subgroup composition (Dagg and Foster, 1976). Giraffe herds consist of all animals within sight of the observer that are generally engaged in the same activity, such as foraging, drinking, moving, resting, etc., and when traveling, they move in a coordinated manner in the same direction (Le Pendu, 2000; Shorrocks and Croft, 2009; Bercovitch and Berry, 2010; Carter et al., 2013a). The herd has been the baseline, for much giraffe herd structure analysis, however specifics between studies differ. Giraffe density, home-range size, mobility, and group stability vary across different habitats. The tendency that more stable groups are found in high-density areas might be taken as evidence for the occurrence of resource defense polygyny in such areas (van der Jeugd and Prins, 2000a).

Fission/fusion systems have been documented in a wide array of taxa (see (Aureli F. et al., 2008), including ungulates (Bercovitch, 2012), primates (Thompson et al., 2007; Lehmann, 2008; Wakefield, 2013), proboscids (Archie et al., 2006; de Silva and Wittemyer, 2012), bats (Vonhof et al., 2004; Willis and Brigham, 2004; Kashima et al., 2013), carnivores (Holekamp, 1997); Smith et al., 2008), cetaceans (Lot, 2004) (Whitehead et al, 2003; Gero et al., 2008; Frere et al., 2010) and macropods (Jarman, 1991). Little is known about the dynamics of opting to lead or follow, or join, subgroups in fission–fusion social systems (Berry and Bercovitch, 2015). Nevertheless, knowledge about social relationships in animal species that exhibit fission–fusion dynamics (Shorrocks and Croft, 2009; Bercovitch and Berry, 2013c) can enhance our understanding of the evolution of close social bonds in humans, who also have fission–fusion social system (Carter et al., 2013a).

In the past, the herd structure in giraffes was described as both a loose and constantly shifting amalgamation of non-bonded individuals that periodically coalesce into a herd (Foster, 1966; du Toit, 1990; Estes, 1991; Kingdon, 1997; Le Pendu, 2000). Only strong bond among giraffes were described between a mother and her dependent young (Langman, 1977). Social relationships among giraffes are temporary and occur mainly between young animals (Le Pendu, 2000). In the wild, female giraffe form a stable groups of individuals within an area that is divided into geographically distinct subgroups, despite the absence of physical barriers (van der Jeugd and Prins, 2000a), suggesting that females should repeatedly encounter the same females (Bashaw, 2011). Recent studies of giraffes have shown that they exhibit fission-fusion dynamics with some structure to their pairwise relationships (Shorrocks and Croft, 2009; Bercovitch and Berry, 2013b). The social relationships among female giraffes show characteristics similar to other species with fission-fusion social systems, such as Indo-Pacific bottlenose dolphins, *Tursiops* spp and eastern grey kangaroos, *Macropus giganteus*, (Carter, 2009). Giraffe live in a complex society characterized by marked flexibility in herd size, with the variance in herd composition owing to kinship and sex (Bercovitch, 2012).

1.4.2 Group size and composition

Group size and composition are the basic descriptors of the social organization of ungulates. In general, among ungulate species, individuals tend to coalesce in open environments to avoid predation, but disperse in thicket and dense areas (Jarman, 1991). Herd size is greater in open habitats, which Korte (2008) suggested was due more to food resource distribution than predation risk, given their large body mass. The giraffe herds in wild contain between two and six animals (Bercovitch and Berry, 2010). Giraffes exhibit sexual segregation (Bercovitch and Berry, 2010) in that cows with young calves prefer open habitats, whereas males are commonly observed in woodland areas (Estes, 1991). Males are solitary nearly 70% of the time, whereas females are found in herds 92% of the time. Le Pendu (2000) found that group type distributions for associations of two or more individuals were not significantly different during the three seasons. The group composition is unstable, as evidenced by an individual being observed with only half of its partners of the day before. Females were found in small, yet unstable groups, while males associated randomly with each other (van der Jeugd and Prins, 2000a).

1.4.2.1 The movement of the herd

The giraffes (*Giraffa camelopardalis)*, with large body mass and high bioenergetics requirements, had more expansive home ranges compared to smaller ungulates in the same environment (du Toit, 1990). In species that lack clearly differentiated social relationships characteristic of socially complex mammals, space use patterns must be considered alongside association patterns in order to establish whether non-random association patterns are determined by underlying social structure or are merely an artefact of spatial structure (VanderWaal et al., 2013). Lusseau et al. (2008) et al. (2006) warned, that observed association patterns between individuals may not reflect true relationships because individuals with similar habitat preferences are more likely to be seen associating and therefore their associations may only result from their shared use of space. In addition, individuals can have preferences or avoidances for other individuals that are masked by the amount of spatial overlap between pairs of animals (Carter et al. 2009). Giraffe home ranges have shown a tendency to be larger in areas with reduced forage availability and smaller where forage density is higher (McQualter et al., 2016). Animal movement is a proximate response to local environmental conditions, such as climate, chemo physical parameters, resources, and the presence of mates or predators. Frequently range over several hundred square km and are capable of long distance movements of 50–300 km (Brown et al., 2007). Increased movements occurred post dawn ⁄ early morning and in the period following as well as pre- dusk ⁄ early evening. Incorporating phylogenetic and community abundance information to examine habitat associations is best used as an exploratory tool to examine which patterns in community composition are partially explained by phylogeny. Home range sizes of juvenile giraffe were 12.8 km^2 km2 and mean home range of adult giraffe 24.6 km^2 in South Africa (Langman, 1973). They did correspond with their mothers' home ranges for the same period. Giraffe seldom used all their areas in their home range, as much of it was devoid of forage and encompassed inhospitable terrain. With one exception, no apparent spatial or seasonal segregation in habitat use was observed for either sex in the northern Namib Desert, with giraffe bull and cow home ranges overlapping both within and between study areas. It has been reported that bulls need more food than cows to maintain their larger body mass (du Toit, 1990). It has been hypothesized that, in various ungulate species, cows foraging benefits for environment that are more suitable for raising young (Main and Coblentz, 1990). Giraffe cows in the Hoarusib River study area foraged only in the hot-dry season in the Gomatum River when food availability was reduced elsewhere. The avoidance of certain rivers may be an attempt to reduce conflict with both bulls and communal farmers and thus protect offspring by limiting unwanted interactions. Similar hypotheses have been postulated for the distribution of giraffe cows and juveniles elsewhere (Pellew, 1984; Pratt and Anderson, 1985). Finally, McQualter et al. (2016) highlights the variation in giraffe movement patterns across Africa, which is likely a reflection of the spatiotemporal availability of forage resources within the different environments. Finally, not only food has main influence in giraffe distribution but the water play important role and affects female movements on both a spatial and temporal scale.

1.4.3 The giraffes association

The social behaviour of most species of hooved mammals has been studied by chance observations of animals in the wild where the continuing relationships between individuals are usually not obtainable (Dagg, 1970). Individual social preferences may be obscured by the frequent changes in the group membership overtime. Whereby the individuals were considered to be associating, if they occupied the same group. Multiple methods have been proposed for assessing dyadic social association. It was presumed to respect of foraging associations. Thus the expectation has been to observe positive assortment for genetic relatedness and familiarity, as this might provide inclusive fitness benefits (Mathot and Giraldeau 2010). However, Roggenbuck et al. (2014) noted stronger effect in females than in males, because natal philopatry is female-biased in this species. Attempts to reconcile two different but real values in the use of indices to measure association of two species in space: how often in how many transect sites and how often do two species co-occur. Different association indices reconcile these two values in different ways (Ginsberg and Young, 1992). In wild population, a low degree of association was observed between giraffe, with the majority of dyad interactions being weak. However, these results indicated stronger inter-individual associations in other then mother-calf dyads (Leuthold, 1979). Other studies have reported generally loose associations between giraffe, with the only strong bonds being between cows and their calves (Pratt and Anderson, 1982; (Le Pendu et al., 2000; van der Jeugd and Prins, 2000a). Altough Fennessy (2004) and Van Der Jeugd and Prins (2000b) reported non-random associations in a resident population of female Masai giraffes. Certainly, (Shorrocks and Croft, 2009) found each individual within a giraffe community maintained close ties to a subset of five or six others in the area. A stronger cow-calf association would be expected based on the need for calves to be nurtured and protected. However duration of time co-resident in the population did not influence the strength of social associations (Bercovitch and Berry, 2013a). The captive female giraffe reliably housed together form social relationships that can be measured using nearest neighbors, proximity, or affiliated interactions (Bashaw et al., 2007a).

1.4.4 Female giraffes and their maternal aspect

Knowledge of the reproductive life history of giraffe in the wild is sparse. Giraffe have two fairly unusual reproductive patterns among large mammals: They can become pregnant while lactating, and calf mortality is extremely high. Reproductive state significantly affected the proportion of scans females spent proximate to at least one male (Bercovitch et al., 2006). Examination of the longitudinal data in population of the Thornicroft giraffes conducted that age at first parturition was 6.4 years, or slightly later than in captivity. Giraffe bred throughout the year, with cows producing offspring on average every 677.7 days. About half of the calves died before one year of age, but death of a calf did not reduce inter-birth interval. The lifetime reproductive success of giraffe is more dependent on longevity and calf survivorship than on reproductive rate. An oldest-known female to give birth was approximately 24 years old, and she disappeared 1 year after the birth (Bercovitch and Berry, 2010). Giraffe tend to produce a new calf every 19– 22 months, but large differences occur in reproductive rates within and among females. In protected areas giraffe populations may be quite high (Happold, 1969b). Consequently, hybridization between giraffes North and South of the equator could result in offspring born at the inappropriate season and have reduced fitness (Brown et al., 2007). The average age at first birth among giraffe residing in zoos is accelerated when compared with the Thornicroft's giraffe. The diet provided by zoos might be a factor resulting in rapid reproductive maturation by reducing the age at first parturition by close to 1.5 years. Reports from other long-lived ungulates indicate that age at first birth has a fairly low heritability, implying that environmental factors are largely responsible for regulating age at first birth giraffe are unusual in initiating reproductive cycling while still lactating, as well as breeding on a non-seasonal basis, creating a situation whereby reproductive rate is likely to be one of the most variable facts within a female's reproductive career (Berry, 2009). The terminal investment hypothesis (Charnov, 1982) proposes that females as polygynous species with extensive size dimorphism and a large variance in male reproductive success will produce more sons than daughters when they are older.

1.4.5 The nature of the females mind and decision making

For females, space use played a much larger role in determining social organization, which is consistent with a matrilineal-based society characterized by female philopatry (VanderWaal et al., 2013). In isolated populations of small size, strong associations developed among adult females (Fennessy, 2004). It is apparent that in this condition the association patterns in giraffe are embedded within a structured social network characterized by multiple levels of organization (VanderWaal et al., 2013). These findings were confirmed also in studies of wild giraffes. (Bercovitch and

Berry, 2013b; Carter et al., 2013a). Giraffe herd composition is based upon long-term social associations that often reflect kinship, with close relatives significantly more likely than non-relatives to establish herds. (Bercovitch and Berry, 2013c)). Association patterns in female giraffes may be influenced by other factors, such as aggregation on seasonally changing food resources, seasonal changes in the availability of conspecifics with which to associate or personal preferences. Therefore, preferred relationships may be influential factors in females' decisions on whether to stay with, or leave, a temporary group (Carter et al., 2013d). Female–female dyads were significantly more likely to associate in a herd than were other sex combinations (Bercovitch and Berry, 2013b). Potential advantages gained by females from associating strongly with particular female conspecifics include increased reproductive output, increased survival and psychological wellbeing (Thomassen et al., 2013). Movement of Thornicroft's giraffe in a single file progression was not associated with either season or time of day, but progressions were significantly more likely to occur when giraffe traveled in open areas. The oldest female in a herd was significantly more likely to be at the front position than expected. The matriarchal leadership in giraffe, is associated with resource learning. Giraffe societies integrates relatedness and familiarity with matriarchal leadership in herd movement (Berry and Bercovitch, 2015).

1.4.6 Mother/offspring relationships

The strength of the cow-calf bond have been described in quantitative fashion the behavioral patterns and interactions of mother and young, especially as related to the calf's nurture, protection, and preparation for adult life (Langman, 1977; Pratt and Anderson, 1985). Mother/offspring dyads had the strongest associations, which persisted for years. (Bashaw et al., 2007b). Long associations between cow-calf pairs of up to 22 months have been reported (Langman, 1977); Pratt and Anderson, 1982). Mother/daughter relationships and the difference in age between females influence patterns of social preference (Bercovitch and Berry, 2013c). Perhaps most significant was that the progression pattern observed reflected adult daughters, not dependent young, following their mothers. Mother/offspring bonds contributed to the finding that matriarchs are often leading herd progressions, but such bonds can not account for the ubiquity of the pattern, given that progressions contained non-kin, as well as genetic relatives other than mothers and offspring (Berry and Bercovitch, 2015). Nevertheless, according to Bercovitch and Berry (2013a) social associations that develop among young calves are independent of the social association strength characterizing their mothers. However, some authors describe the maternal bond in giraffe (cow-calf) as weak, noting the abandonment of calves for extended periods while the cows venture off to forage or drink (Innis, 1958; Foster, 1966). Other authors suggest that cows spend periods away from their offspring for different reasons, including the conservation of calf energy, water conservation and increasing calf's crypsis (Fennessy, 2004).

1.4.7 Creche group and calves suckling behavior

It is often difficult to assign giraffe calves to the correct mothers with certainty, because the females often leave their calves alone or with other females for periods of up to four days (Foster, 1966). In sperm whale (*Physeter macrocephalus*) societies, communal care of calves seems to augment female social relationships (Gero, et al., 2013). Giraffes use a 'nursery' care system in the wild (Langman, 1977). Juveniles may be left in the nursery group during the day in the care of one or two adult females. Groups may consist of related juveniles. Seasonal peaks in births can yield creches or nursery groups, and calves associating together when young have been predicted to form bonds that persist into adulthood (Leuthold, 1979; Fennessy, 2004; Bashaw et al., 2007b). For the pattern of age-related associations is paternal kin discrimination (Widdig, 2007). Until now, nobody has assessed whether giraffe are capable of kin discrimination (Brand, 2007a). A high likelihood exists that animals born within the same cohort are paternal half-siblings (Bercovitch and Berry, 2013a).

Guarding of the nursery is a form of alloparental care and therefore provides favorable conditions for the extension of such care to allonursing (Olleova, 2012). A female's calving success is boosted either by social association with other females that had high calving success, or by the female having relatives who are good at calving. The benefits of social associates were more important for female pairs with lower genetic relatedness. This suggests that females might assist each other in some circumstance (Frire et al., 2011). Nursing cows exhibit an avoidance of tannins. Bulls and non-nursing cows prefer high protein and high fat forage, while sub-adults show a strong preference for high protein and carbohydrate contents and moderate tannin levels (Caister, 2003). Captive giraffes are typically fed in the form of a manufactured pellet (Oftedal and Iverson, 1995). Despite our limited knowledge of the exact nutrient composition of the giraffe milk, it appears to have a higher protein and fat content, and lower lactose concentration than bovine and goat milk, as does the milk of most non-domesticated ruminants (Oftedal and Iverson, 1995). Whereas, the milk substitutes used are very similar in nutrients, or are even slightly lower, than cow's milk, except the substitute formulated by (Casares et al., 2012) and Eulenberger (2003). Allosuckling is a situation when a female nurses a non-filial offspring and occur recently in captive conditions in giraffes (Brandlova et al., 2013). Nevertheless, these allosuckling behaviors were observed also in camels and other captive ungulates (Brandlova et al., 2013). Giraffes represent one of the highest occurrences of allonursing, the nursing of non-filial offspring, among non- domesticated mammals (Gloneková et al., 2016). Pratt and Anderson, (1979) concluded that 'when one calf was suckled usually the others were attracted and tried to nurse from the suckling mother's. Therefore, allonursing can be regarded as an extreme case of communal care.

1.4.8 Reciprocal altruism

Reciprocal altruism has been documented in animal societies with elaborate social structures for behaviors where the costs paid by the donor are low in comparison with the benefits gained by the recipient (Davies, Krebs, and West, 2012). Reciprocity is the secret of our success, even though two unrelated individuals sometimes find it difficult to cooperate. They may mutually reciprocate help if they know they will meet again (Milinski 2010). If the giraffe are reciprocal, thus may tolerate this allonursing behavior (Gloneková et al., 2016). However, although reciprocal altruism is not necessarily based on kinship, the evolutionary conditions leading to altruism are the same as those for kin selection (Aureli F. et al., 2008; Welsh and Herzing, 2008). Even in the absence of an inclusive fitness explanation, female social cliques may set the stage for evolution of crèches by reciprocal altruism (VanderWaal et al., 2014). Because symmetry requires both individuals to be responsible for the relationships, reciprocity is used as a measure of the strength of relationships between individuals (Bashaw et al., 2007b)

1.4.9 Females association with males

Male giraffe adopt a roaming reproductive tactic designed to maximize time spent with cows during the fertile window while minimizing time spent with non-fertile cows and searching for mating partners. The lack of female perceptive behavior, combined with the urogenital inspection by males of females in all reproductive states, indicates that males need to physically come in contact with a female in order to accurately assess her reproductive condition (Bercovitch et al., 2006). Males adopt a roaming strategy in seeking sexually receptive females (Bercovitch et al., 2006). But no studies have yet documented actual male reproductive success in wild giraffes (Berry et al., 2012). Male and female giraffe differ in their choice of food plants and habitat, and also in their feeding strategy. As predicted, females appeared to maximize their food intake year-round, while males minimize their time spent foraging during the wet season, when food was more plentiful (Pellew, 1984). At waterholes, encounter rates were increased and consequently mating and agonistic interactions have been observed more frequent (Brand, 2007b). Mature males demonstrated a diversity of ranging strategies that affected association with females. These individual differences are assumed to relate to status and probably affect individual reproductive success. Evidence suggests male reproductive success is skewed towards mature dark males, but may also vary among dark males, with some potentially being excluded from mating (Brand, 2007b).

1.4.10 Giraffe cooperation

Long-term studies of sociality in wild animals are rare, despite being critical for determining the benefits of social relationships and testing how long such relationships last and whether they change as individual's age (Bercovitch and Berry, 2013b). The female partner preferences coincide mainly with proximity, co-feeding and affiliative interactions (Bashaw et al., 2007b). Giraffe synchronizing with communal farmer activities in Niger (Pendu and Ciofolo, 1999) and searching for forage in Zambia (Berry, 1978). The behavior was not correlated with proximity of forage to water, but rather forage quality and availability (Fennessy, 2004). In this instance, the quality of forage strongly involved the formation of the giraffe sociality. Long-term relationships were evident among female giraffes, but not males, which may be explained by sex differences in ranging patterns and reproductive priorities. As younger females reached adulthood, they associated with greater numbers of females and increased their network strength and social connectivity, perhaps because of dispersal (Carter et al., 2013a) and regional differences in timings of precipitation (Thomassen et al., 2013). Young females may be less able to deter mattings from related males due to their inexperience or vulnerability. Females were observed to risk injury by joining a female who is being herded by males (Frere et al 2011). Social and genetic interactions supported, that females might assist each other when they can. Frere et al. (2006) used of social association between pairs of females in the same analysis as the pairwise molecular relatedness. Two factors have been shown to have an impact on the prospects for individuals to form and maintain social bonds within larger sets of individuals: age proximity and relatedness. The study focusing on relationships among captive female giraffes has shown that giraffes show stronger preferences to be with older relatives (Bashaw et al., 2007b). Adult female giraffe form strong social associations with both relatives and age mates, as is common among other ungulates (Bercovitch and Berry, 2013a). In red deer *Cervus elaphus,* mother–daughter and sister–sister pairs associate also more than other female pairs (Albon et al, 1992). The features of this social system are unique among bats and mammals in general, and point to groupings based on kinship or cooperation (Vonhof et al., 2004). Close associations with relatives may confer benefits such as reduced competition for resources and increased breeding success (reviewed in Silk 2007). Nevertheless, for the pattern of age-related associations is paternal kin discrimination (Widdig, 2007). Obviously, the giraffe have evolved mechanisms for fostering the formation of social associations with similar aged non-kin (Bercovitch and Berry, 2013a). Therefore, preferred relationships may be influential factors in females' decisions on whether to stay with, or leave, a temporary group (Carter et al., 2013a). This suggest that the social relationships among adult female giraffe may form the basis for social structure of giraffe herds (Bashaw et al., 2007b). Clear and linear hierarchy were formed in females in the zoos (Horova et al., 2015b). Neverthelles, that matriarchal leadership among giraffe is an adaptive phenomenon (Berry and Bercovitch, 2015).

1.4.11 Impact of captivity on giraffes behavior and sociality

Giraffe are popular animals in the Zoos around the world. In 2008 were 754 giraffes in the giraffe European Endangered Species Programme (EEP). The Rotchild' giraffe comprises the largest group in the EEP with 308 individuals kept at 73 institutions have a healthy and growing population (Damen, 2009). However, as a result of the decline of the wild population, every additional animal born is important (Casares et al., 2012). In addition, the approach mentioned above are beneficial for adequated institutions. Neverthelles the other subspecies with even less numbers in the wild as *Giraffa camelopardalis peralta* has been forgotten to acomplish to EEP.

Captive giraffe were occasionally observed feeding on grass. To be able to graze, a giraffe has to adopt the typical 'drinking position', where the forelegs are splayed out laterally, and sometimes the carpal joints are also flexed. In this position, the animals are particularly vulnerable to predators (Seeber et al., 2012). Probably they are adapting to the conditions of the zoological exterior whose not provide trees. For this reason they change from the browsers to the grassers. Despite the diet related disorders have received much attention in the zoo literature, evidence-based results on relationships between diet and disease are still rare, often due to a lack of quantitative dietary information that can be linked to clinical or necropsy reports (Gattiker et al., 2014). The giraffes at the Taronga Zoo were much more tolerant of each other, compared to other ungulates. During the copulating season most of the other male ungulates exhibited such intense intraspecific aggression (Dagg, 1970). Future studies should examine social density, enclosure size, sharing of feeders, and presence of males to determine how much each of these factors contributes to differences in social interactions across institutions (Bashaw, 2011). Per acute mortality, chronic wasting, energy malnutrition, mortality neonatal health concerns, intestinal parasitism, hoof disease, and laminitis may be initiated or intensified by traditional captive diets (Seeber et al., 2012). Domestic animal requirements and diets are often applied to captive animals. The invasive studies needed to determine these specific nutrient requirements are not appropriate for captive or endangered animals. In United States diets in Zoos based on acid detergent fiber 16 (ADF-16) pellets and alfalfa hay. Free-ranging giraffes had higher concentrations of potassium and magnesium and lipase activity, whereas captive animals had higher ALT activities and higher concentrations of bilirubin and chloride. Sub-optimal nutrition may in fact not only provide an inappropriate energy source but also may induce a chronic inflammatory condition of the gastrointestinal tract and become a chronic stressor in itself. The higher concentrations of omega-3fatty acids in serum of free-ranging giraffes appeared to be the most significant finding, especially in a ruminant animal in which dietary fatty acids are typically bio-hydrogenated in the rumen. Among the charismatic herbivores kept in zoos, the giraffe remains a species whose nutritional management is still considered to be a challenge. The results confirm that giraffes are unlikely to meet energy requirements on Lucerne-hay diets. Fowler (1978) recommends that diets in captivity should consist of 10–25% browse material. However, the logistics of zoo management and the facilities often do not allow the provision of browse material in such amounts. Additionally, as hay is usually fed ad libitum with no control of the actual intake, feeding recommendations that give proportional values are difficult to adhere to. The relatively small amount of time spent sleeping by giraffes can be attributed most directly to the need for constant rumination (Balch 1955). This is consonant with the more general ecological notion that sleep patterns in prey species are usually characterized by brief, intermittent periods of sleep (Noonan, 1978). Giraffe activity budgets are similar across zoo environments and add that patterns of social behavior are also similar. The uniformity of activity budgets and social preferences suggests that these aspects of behavior are not strongly dependent on the environment and encourages the generalizability of behavioral results across captive giraffe herds. Crowding increases affiliative and dominance-related behaviors in primates (Judge and de Waal, 1993) and may have the same effect on giraffe (Bashaw, 2011). In captivity, dominance hierarchy in adult females have been proved by (Horova et al., 2015a) and may be resulted by crowding in small space.

1.5 Interactions and signals among giraffes

Within groups of mammals, social preferences are defined as patterns of interaction or association in which specific individuals are more likely to direct their social behavior toward one another than toward other potential partners (Bashaw et al., 2007b). In a study of social behavior it is difficult to know what actions between two animals are significant (VanderWaal et al., 2013). An animal's original intention is in many cases difficult to evaluate and rather oblique, which applies particularly to large animals like the giraffe with its rarely assessable visual facilities (Pratt and Anderson, 1979). Cooperation between vision and hearing is a general mammalian feature (Nummela et al., 2013). Bercovitch and Deacon (2015) suggested that the key sensory modality that giraffe use for social communication among conspecifics is visual monitoring. Similar process could mediate giraffe herd formation if individuals can identify others based upon their blotch pattern.

1.5.1 Communication between giraffes

What does a giraffe sound like? (Baotic et al., 2015) Although visual, olfactory and auditory signals have been noted for giraffes (Giraffa camelopardalis) by the author (Innis, 1958), these are virtually impossible to record (Dagg, 1970). However, recent research suggests that giraffe communicate using low frequency vocalizations (e.g. von Muggenthaler et al., 2001; Bashaw, 2003) similar to that reported for elephants and marine mammals (Baotic et al., 2015). They might use infrasound for social communication (von Muggenthaler et al., 1999; Bashaw, 2003; Dagg, 2014). Infrasound consists of long wavelength vocalizations that demonstrate little attenuation in the environment and are emitted at sound levels of less than 20 Hz, or too low for people to hear (Pye and Langbauer, 1998). With knowledge that giraffe communicate using low frequency vocalizations, our understanding of the giraffe's social dynamics can increase. Recording was made of a cow approaching her calf while displaying neck-stretch behavior, which is indicative of possible infrasound emission (Bashaw (Bashaw, 2003), 2003)

1.5.2 Social interaction

In giraffe, the social interactions are highly fluid in nature (VanderWaal et al., 2013). Mother–offspring interactions soon after parturition play a key role in the survival of mammals (Hejcmanová et al., 2010). Female partner preferences coincide with proximity, co-feeding (Bashaw et al., 2007) and affiliative interactions (Dagg, 1970). An affiliative interactions are interactions between a mother and its own calf suckling attempt; suckling, licking, touching; scenting (Le Pendu, 2000). Contact interactions characterized interactions between unrelated giraffes as scenting, licking, touching. Touch or close encounters that occur between two giraffes are easier to detect. These encounters can be divided into the following six basic types: nosing, licking, rubbing, hitting and necking matches. Sexual interactions consist of mounting attempt and urine testing (Dagg, 1970). When male giraffe encounter females, they often provoke a flow of urine that results in a ‘flehmen’ response as a means of gauging female reproductive status (Pratt and Anderson, 1985; Bercovitch, Brand, 2007, Dagg, 2014; Deacon, 2015). An Agonistic interactions content necking or sparring behavior and avoidance. Under captive conditions, when a giraffe companion is removed from their exhibit, the remaining giraffe display signs of negative interaction as agitation and stereotypical behavior (Tarou Loraine, 2000). Pratt and Anderson (1985) reported that a dominant bull will walk towards an opponent with its head held high, intending to look as big as possible. Dominant bull, threatening an opponent will carry his head deep with the neck parallel to the ground, as if assuming a fighting position. Nevertheless, both observations are adequate. The typical intention of a threatening giraffe bull is often expressed by arched and tensed neck (Seeber et al., 2012). All occurrences of agonistic (male-male) interactions between males include all offensive and defensive, dominant and submissive behaviors, as well as more ambiguous interactions between males. Dominance was observed among the bulls in wild (Fennessy, 2009). Nevertheless, dominant hierarchy occurs also in female giraffes in captivity (Horova et al., 2015a). Little is known about the intensity and frequency of social interactions among the herd members (Estes, 1991). The frequency of social interactions between giraffes, even in a large naturalistic outdoor enclosure (Bashaw, 2003); del Castillo et al., 2005), raises questions about social bonds and relationships between individual giraffe (Bercovitch and Deacon, 2015).

1.5.3 Inter-individual distance

This study defined herd structure as individual or group associations. However, herds were not determined necessarily just by proximity of individual giraffe (social distance) as determined in other studies e.g. Foster (Foster, 1966). It was considered irrelevant whether giraffe were 100 m or 1 000 m apart—this also varied between published giraffe studies Foster (1966) van der Jeugd and Prins (2000). Social preferences have been measured with proximity (Horwich, et al., 1982), nearest neighbors (Bashaw et al., 2007b) and interactions (Green et al., 1989), preferred association and interaction partners in ungulates are frequently the same individuals. Spatial proximity is usually a prerequisite for social interaction and the development and maintenance of social relationships (Smolker et al. 1992). Individual giraffe actively chose to feed on the same tree, or nearby trees, rather than be more spaced out. This information regarding distance was examined for a relationship between spacing and group size, and the results (Bryan Shorrocks1, 2009). Communication of dominance might vary with the distance between opponents. In this regard, the “head-high” posture could be assumed for a distance of greater than two body lengths, while the “fight” posture would be assumed with the opponent in close proximity (Brand, 2007b). Measuring distance traveled through visual tracking of focal animal as widely applied to primates (Wrangham et al., 1993) and occasionally to other species has the potential to provide sufficiently fine-scale information on movement paths. Nevertheless, stronger inter-individual associations were observed in the smallest giraffe population, in the Khumib River study area, with fewer strong dyad associations occurring in the larger study areas.

2. Aims of the thesis

Mcs. thesis provide an opportunity to examine the social preferences of Cape giraffes living in Bandia Reserve, Senegal. We evaluate whether a herd of giraffes has been associated randomly or pattern they association and interaction in manner indicative of social relationships. We suppose that stronger bonds occur among mother/calf dyads and among specific adult females. Furthermore, the social preferences among adult female giraffes also influenced the associative patterns of their calves. This suggests that the care of calves can be exchanged among familiar females. In this context they would share a common maternal aspect.

(i) We hypothesized, that giraffes were adapted well to new environment and that group size and composition would be similar as in wild populations.

(ii) We classify the dyads of giraffes according to strength of relationship (weak, medium and strong). We predicted that all dyads of female and filial juvenile would have strong relationships. Further, there would be some adult females with stronger relationship. We would then label those familiar females as "friends".

(iii) From the findings connected with non-maternal care in giraffes we predicted that a female would develop a strong relationship with a calf of familiar female and that

(iv) The strength of the relationship between calves would depend on the strength of relationship between their mothers

3. Materials and Methods

3.1 Study area

The Bandia Reserve (GPS coordinates: 15° 27' 0" North, 15° 24' 0" West) presents a fenced area in Senegal for the purpose of the safari-tourism and to contribute to the protection of environment and wildlife conservation at the same time. The reserve was created on the south-western boundary of the 'Classified Forest Bandia' by the Society for Protection of Environment and Wildlife in Senegal (SPEFS) in 1990 (Nežerková et al., 2004). Phytogeographically the reserve belongs to the Sudan-Sahelian area (Antonínová M., 2004). Two distinguished seasons characterize the climate: dry season (from November to April) and rainy season (from July to October) (Lawesson, 1995; White, 1983).

3.1.3. General description of the study site, Senegal and his history

The social preferences of giraffes were observed in the Bandia reserve, Senegal. The Bandia reserve is a fenced area (3 500 ha) created for safari-tourism and for the protection of the environment and wildlife. The ecosystem is flat with baobabs and dense shrubs. The original vegetation is composed by the variation of acacia species (Hejcmanová et al., 2010), with dominant *Acacia seyal* (Antonínová M., 2004), which are main nutrition source for giraffes. The representatives of native fauna in Bandia reserve include African warthogs (*Phacochoerus africanus*), patas monkeys (*Erythrocebus patas*) and green monkeys (*Chlorocebus sabaeus*). There are no predators in Bandia Reserve. Several mammalian species were imported into Bandia from Niokolo Koba National Park, for example African buffalo (*Syncerus caffer brachyceros*), Buffon's Kob (*Kobus kob*), West African roan antelope (*Hippotragus equinus koba*). In 2000 a group of Western Derby elands (*Taurotragus derbianus derbianus*) were introduced to the reserve and their conservation program was started (Nežerková et al., 2004). Further mammals were imported to Bandia reserve from South Africa to increase its attractiveness for tourism, e.g. Cape eland (*Taurotragus oryx oryx*), Great kudu (*Tragelaphus strepsiceros*), Impala (*Aepyceros melampus*), Gemsbok (*Oryx gazella gazella*), White rhino (*Ceratotherium simum simum*) and Cape giraffe (*Giraffa camelopardalis giraffa*). The native giraffe in Senegal have been giraffes from Niger, West African giraffe (*Giraffa camelopardalis peralta*). Only small group of white giraffes from Niger survive recently (Le Pendu et al., 2000). This subspecies became extinct in Bandia before the announcement of the 'Classified Forest' in 1933 (Al Ogoumbrabe, 2002) and in 1954 disappeared form Niokolo Koba National Park (NKNP) and from the whole Senegal. In 1971 seven Kordofan giraffes (*G. c. antiqorum*) were translocated to NKNP in Senegal as they were assumed to be native subspecies *(G. c. peralta*). Fig. 1 Senegal map with Bandia reserve location. Recent research has proved this to be incorrect, because these subspecies was introduced into Niokolo Koba National Park from Cameroon (Al Ogoumbrabe, 2002). The translocation was unsuccessful. Kordofan giraffes did not adapt to new environment and all the giraffes died (Dupuy, 1972). In January 1997 four Cape giraffes were translocate from South Africa to Bandia Reserve, Senegal (Vincke et al., 2005). Giraffes reproduce well in the reserve. The herd in Bandia Reserve contained 10 individuals in 2002 (Vincke et al., 2005). Two giraffes (sub-adult male and female) were relocated to Fathala Reserve in Senegal in 2003 (Nežerková et al., 2004) and further transfers were realized in 2006, 2008 and 2012 (reserve managers, pers. comm.). Except the last years where our study has been performed, the identifications of individuals remained unresolved.

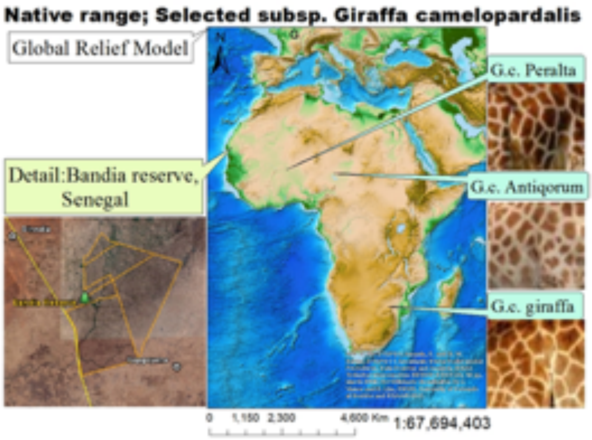

Figure 2: Native range of subspecies of giraffe presented in senegal and detail of Bandia reserve

3.1.4 Site description and climate factors

Two distinguished seasons characterize the climate: dry season (from November to April) and rainy season (from July to October) (Lawesson, 1995). The climate in the study area is with mean annual rainfall ranging from 300 mm in the north to 700 mm in the south, concentrated in the summer months (July to October) and highly variable from year to year. Hence, the region is considered marginal for agriculture, and production has been hit by several severe droughts in the past. Semi-arid climate, during the rainy season, the pond water levels show daily fluctuations, increasing with rainfall and decreasing with infiltration (favored by sandy-loam soils) (White, 1983).

3.1.4.1 Topography and geology

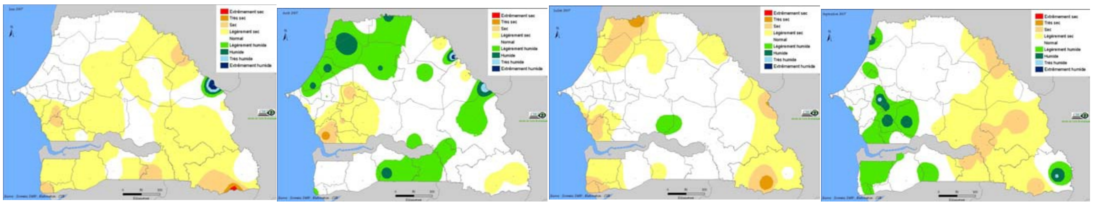

Figure 3: Examples of increasing, stable and decreasing tree cover, contrasting current very high resolution satellite imagery (top row) and Corona images from 1968 (bottom row) for selected 1 km2 samples: (a) 14.76°N, 17.05°W, south of Pout in the region of Thies: Arboriculture in formerly sparsely covered land (Herrmann, et al., 2013).

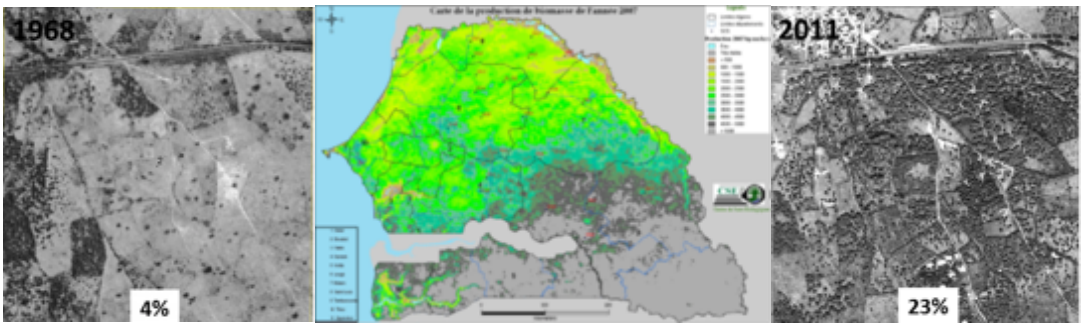

Figure 4: Brandt et al. (2013) state that strict laws, farmer managed protection, reforestation programs and the dispersion of robust species (especially *Balanites aegyptiaca* and *Acacia raddiana*) contribute to a large scale greening and increase in leaf biomass in both study areas in Mali and Senegal.

2.2 Data collection

In total 28 giraffes (13 males, 15 females) were observed for 34 days in the dry season. Owing to Bandia Reserve's requirements, all observations were recorded from a vehicle. The study was conducted between the 27. January to the 9th March 2013. The identification of each individual was done in the first week, according to the unique skin drawing and significant signs which remains constant throughout life.

Continuously due to skin coloration, body size and long of the tail. Age determination of calves was based on general features, which included items such as the angle and appearance of the ossicones, the state of the umbilical cord, hair on the top of the horns and their size.

Giraffe were considered juveniles up to the age of about 18 months, by which time they have generally stopped suckling and have left their mother. Giraffe older than 18 months, and up to about four years were classed as sub-adults and contain males that still had a fringe of hair around the horn tips. All individuals over four years, of approximately adult height, were classed as adults (Leuthold and Leuthold, 1978). Genetic data has been absent, but the detailed observation enabled us to distinguish close relatives. Mother/calf dyads were identified by maternal investment behaviour particularly suckling behaviour.

The first week photos of giraffe were taken of both sides, where possible, of any new giraffe encountered within the study area. The photos were used for the identification carts. When we were able to individually recognize each giraffe, we started with observations of each focal adult female. Data collection occurred generally during two sampling periods each day. The morning period started at 8 a.m. The afternoon sampling period continued until dusk. The activity of animals is highest in this time. At each sighting of a giraffe group, information was recorded about herd size, GPS position and identity of all individuals. For each hour was chosen one focal female and the inter-individual distances between her and all visible giraffes were measured every 10 minutes. Each adult female was observed for 10 hours. The focal adult female activity, nearest neighbour, and proximity (animals of 2 neck lengths away) were recorded during observation, along with all interactions.

2.3 Measure of grouping patterns

We recorded (i) size and composition of all sighted groups and we recorded all observed individuals too. Age classes were categorized as juvenile-male, juvenile-female, sub-adult male, sub-adult female, adult-male and adult-female. This was based on their size criteria and approximate age (Cameron and Dutoit, 2005). We were recording the group composition while driving on transects through the study area. At each sighting of a giraffe group, information was recorded about herd size, GPS position and identity of all individuals.

2.3.1 Association index (AI)

Many options have been proposed for calculating associations in animal societies (Cairns and Schwager, 1987; Ginsberg and Young, 1992; Wojcik, 2004; White and Smith, 2007; Wey et al., 2008). The most standard measure of association is affected by sample size. This is so that the dyad of individuals seen often will have a higher association index than those seen rarely (Wojcik, 2004; Whitehead, 2009). To describe giraffe social structure we examined the dyadic associations between identified individuals. We refer to this measure as the 'Association index' (AI) where A and B refer to the identified individual. Based on Bercovitch (2012) we calculated the association index using following formula:

(A + B TOGETHER)/ [(A WITHOUT B) + (B WITHOUT A) + (A + B TOGETHER)]

(Cairns and Schwager, 1987)

In the formula, (A + B TOGETHER) is the number of occasions A and B are seen together; (A WITHOUT B) is the number of occasions where A is seen without B. (B WITHOUT A) is the number of occasions B is seen without A. This index has the merit that all scores fall between 0, which means no association, and 1, which means complete association. We refer to this measure as 'Social Association' and therefore refer to the frequency when a dyad of individuals was observed in the same herd. Dyads consisted of any two individuals from the same group. If social preferences are consistently maintained over time, then they are considered relationships (Wojcik, 2004).

(ii) We compared the levels of associations between giraffes in Bandia Reserve, Senegal with those reported for captive and wild giraffes residing in fission-fusion social systems (Bercovitch, 2012). According to the recorded AIs, we classified dyads into three categories: weak relationship (AI range 0 – 0.2), medium relationship (AI range 0.2 – 0.4), and strong relationship (AI range 0.4 – 1). Further, we classified dyads into five types: male-male (includes any combination of AD, SUB, and JUV males except dyads of JUV males only), male-female (includes AD, SUB, and JUV males and females, except dyads of two JUV animals regardless the sex), female-female (include any combination of AD, SUB, and JUV males except dyads of JUV females only and dyads of AD and filial JUV females, female-juvenile (includes AD female and a her filial JUV), juvenile-juvenile (includes any dyad of JUV). We labelled as “friends” the female-female dyads with strong relationships.

We expect that ‘Social Association’ will occur between mother and her calf and (i) two particular individuals "friends" will occur together in the same group more often and they supposed to have an association index higher than 0.4.

We assessed the AIs of all dyads of females and their filial juveniles (ii), Consequently, we compare the AIs of female-female dyads to find out whether strong relationships would occur in some of them. We would then label those familiar females as “friends” We compared the AIs among females and juveniles (filial calf, calf of a friend, calf of non-friend) using Kruskall-Walis test.

Finally (iii) For comparisons calves of friend and non-friend females we use Spearman r-test.

Using Spearman correlation we tested (iv) the relation of strength of the relationship between calves and the strength of relationship between their mothers.

2.4 Interactions and inter/individual distance

Ultimately, from the focal watches, *ad-libitum* recordings positive and agonistic (negative) interactions were used in analyses. To support the social preferences we recorded the interactions between the observed animal (always the adult female) and all the other members of the herd and compared if the AI influences the intensity and frequency of social interactions. 5 degrees of intensity of social interactions were considered and we counted the frequency of all interactions for each dyad with the observed females. Each female was observed for 10 hours (totally 70 hours).

2.4.1 Inter/individual distance

Perhaps, more helpful, however is the ability to use nearest neighbor or proximity measures to describe social preferences (Bashaw et al., 2007b). The adult females were considered as nearest neighbor if they stay to 3 meters apart from each other. Proximity was characterized as distance between individuals of maximum length 100 meters. The distance between focal individuals and all other members of the group were measured with range finger and compass every 10 minute. Each focal adult female were observed 10 hours. In the analysis have been used datasets just for adult females. The frequency of positive interaction, the number of scans observed as nearest neighbors and numbers of scans observed in proximity were compared with Chi square test. Continuously, data were compared in K regression matrix (Kendau tau) in program Statistica- betabinomial regression is a robust statistical method, adapted in the case of over-dispersed proportion data, which are often encountered in epidemiological or ecological studies. Interactions among focal females and variables were tested using the Pearson correlation coefficient (criteria: Pearson correlation coefficient <0.8) (Soti et al. 2013). These hypothesis matrices were compared with distributions of affiliative interactions, proximity, and nearest neighbor with K_r matrix correlations. K_r partial correlations were computed to assess which of a pair of related hypotheses contributed more to explaining variation of social preference and to further examine the relationships between measures (Bashaw et al., 2007b).

4. Results

4.1 Herd structure

Social preferences and grouping patterns of 28 introduced giraffes (13 males, 15 females) were observed in semi-natural enclosure of Bandia Reserve, Senegal. In total 144 contacts with giraffes were recorded (88 group sightings and 56 individual sightings) in 34 days. The average number of individuals in the group (i) was 4.8 ± 0.37. Group size was dependent on the presence of the females and/or calves and/or sub-adult individuals (M/W U test, $p<0,001$) but not in presence of males. The solitary individuals presented mostly adult males. From 56 encounters there was only one solitary female. The adult female mentioned above was in high stadium of pregnancy.

3.2. Association index

Our aim was to prove the social preferences among herd members (especially adult females) according to association index (AI). Association index indicates how much time two individuals spend together (range 0-1). We expected that stronger relationships occur among: mother-calf, mother-mother and calf-calf. We reported weak relationships ($AI < 0.2$, $n = 251$) and medium relationships ($0.2 < AI < 0.4$, $n = 91$) in all types of dyads except female-juvenile. Two animals were seen together 7 ± 0.35 times (0-26) with the mean association index 0,16 (0 – 0,76). The highest AI was recorded for mother-calf pairs as expected. Three pairs of female giraffes met our defined criteria of $AI > 0.4$. Therefore we consider those pairs as non-random. We reported strong relationships ($AI > 0.4$, $n = 32$) in two types of dyads (female-female and female-juvenile). From 378 possible dyads giraffes were observed 313 dyads. The hypothetic dyads, which were never observed, always included an adult male either with another male or female. Observed dyads (excluding dyads never observed together) revealed mean AI of 0.19 ± 0.16 (range 0.02 – 0.76, $n = 313$). We reported weak relationships ($n = 251$) and medium relationships ($n = 91$) in all types of dyads except female-juvenile. We reported strong relationships ($n = 32$) in two types of dyads (female-female and female-juvenile). The AIs significantly differed among types of dyads ($H_{(4,\, n=313)} = 86.012$, $p < 0.0001$, (see Figure 5)

Mean AI between females and their filial calves was 0.66 ± 0.09 (range 0.50 – 0.76, n = 7), the highest of all dyad types. All female-juvenile pairs demonstrated strong relationship. The mean AI among adult females was 0.22 ± 0.15 (range 0.03 – 0.54, n = 21).

We found strong relationship (ii) in three dyads of female giraffes (Baobába – Hanča AI = 0.46, Běla – Dáša AI = 0.54, Liduška – Terka AI = 0.46). We labelled those female dyads as “friends”. Each of adult females had just one friend; only female Bláža remained strongly associated only to her filial calf.

Female giraffes associated more often with the filial offspring and the offspring of their association partners than with the other offspring (K-W test, $p < 0,001$) (see table 2). Adult female giraffes were associated more often with the calves of familiar females than with the calves of other adult females (iii) ($H_{(2, n=49)} = 26.25$, $p < 0.001$ (see Figure 6) Relationships between females and calves of their friends were medium to strong (mean AI = 0.41 ± 0.07, range 0.31 – 0.46, n = 6). Relationships between females and calves of non-friends were weak to medium (mean AI = 0.18 ± 0.12, range 0.05 – 0.38, n = 36). Familiarity between the mothers had influence on the relationship of their calves

The higher was the AI between females, the higher was the AI of their calves (iv) (Spearman coef. = 0.86, $p < 0.001$ (see Figure 7). Preference for particular giraffe and consequently the involvement in their offspring were proved. Therefore, we support the formation of social structure in semi-natural conditions and social bonds among the certain female giraffes.

3.3. Giraffes social interactions

We have found 3 pairs of females from a total number of 7 females with AI greater than 0.4, which was considered as "friends ". We have registered together 482 interactions. The higher was the AI the higher were the intensity of all social interactions (see Figure 8). The females considered as “friends” had the higher frequency of interactions. The association indexes were correlated with intensity and frequency of interaction.

Kendau tau Correlation matrix N: 4: r = .99936. The 3 variables: Frequency of positive interaction was signicantly correlated with proximity and nearest neighbor (see Figure 12). Numbers of scans proximity and nearest neighbor were consistent across measures and time, suggesting that adult female giraffe maintain relationships. Negative interactions were not statistically significant. We have proved the social preferences among giraffe females are supported by intensity and frequency of positive interaction (see Figure 9,10,11) and by the shorter inter-individual distance (See Figure 12,13) based on nearest neigbor measures and proximity (see Table 3). The adult females elaborate in their movement and share the maternal care with specific females.

5. Discussion

5.1Giraffes social organisation in Bandia Reserve

We have no clue as to how giraffe decide to join a herd, remain in a herd, leave a herd, follow a herd or stay behind when a herd wanders away (Bercovitch and Deacon, 2015). Regular fluctuations in herd size among giraffe indicate a fission-fusion social system embedded within a larger social community (Berry et al., 2012). Group size of giraffe in Bandia Reserve may be dependent on season and food availability. The groups were moving continuesly due to the flowering of their prefered trees, especially Acacia species. Fortunately in Bandia Reserve the *acacia seyal* and other multipurpose trees were planted to restore land degradation and provide enough food for large ungulates. Predation pressure also affect grouping in species with fission-fusion system, promoting stronger bonds and reduced fission under high predation risk (de Silva et al., 2011). Studies of giraffe populations under high predation risk may reveal the existence of stronger bonds with a greater number of associates (Kelley, 2011). The Bandia Reserve contain no predators for ungulates. Giraffes were habituated well to vehicles with the tourist's, and they were disturbed only if the cars approach them from to close distance. During our study we recorded 88 groups of two or more individually recognised giraffes.

(i) The average number of individuals in the group was 4.8 ± 0.37. Giraffe group size shown similar patterns, as in the wild observations, where usually five to six giraffes formed a group (Leuthold and Leuthold, 1978; Le Pendu et al., 2000; van der Jeugd and Prins, 2000a; Shorrocks and Croft, 2009; VanderWaal et al., 2014). Majority of study described giraffe group composition is fluid, changing from one day to the next. But at any one time, herd size is usually small, averaging approximately 4-6 individuals (Innis, 1958; Foster, 1966; Leuthold, 1979; Pratt and Anderson, 1985). The number of individuals seen together as group varied from 2 to 17. Larger group size was observed early in the morning and in the evening, when the temperature was lower. Nevertheless, giraffe density, home-range size, and group stability was found to differ across different habitats (van der Jeugd and Prins, 2000a). One would expect that the fission–fusion dynamics of giraffe social systems would also depend upon the population density, but studies have not yet systematically examined how the strength or weakness of giraffe associations across populations is a function of population density and demography (Bercovitch and Deacon, 2015). The group size of observed giraffes in Bandia reserve was comparable to those in the native range of other subspecies. Our first hypothesis was supported. The giraffes adapted well in new location. The weather conditions, humidity and altitude have to be considered before translocation. More successful is to transport giraffes to new location in dry season. The adaptation to new environment is easier for giraffes, if insect does not disturb them during the raining season. Diseases and parasites play important role in grouping patterns of the giraffes. It's possible that during the raining season, when giraffes have been affected more by blood suckling insect, group size, composition and distribution change to avoid inflammation from other individuals. Small reserves, which often support higher population densities of large mammals than large reserves, play an important role in the conservation of individual species and may also retain diverse large mammal communities where modern wildlife management technique are practised (East, 1981).

5.1.1 Male resource defense and dominance between relative males

In study population the most solitary individuals were adult males. This corresponds with general grouping patterns of giraffes in other studies (Fennessy et al., 2003; Carter et al., 2013c). Only adult female observed alone has been in high stadium of pregnancy. In subspecies *peralta*: solitary bulls were most commonly observed especially in dry season, followed by groups of two or three females or sub- adults. Stronger inter-individual associations were observed in the smallest giraffe population, in the Khumib River study area, with fewer strong dyad associations occurring in the larger study areas. Strong bull-bull associations occurred in. However, in river bends have been higher risk of inflammation by parasites. So higher male association with rivals for mating could increase chance for transition of disease. Males have been found in groups or solitary (see Table 2), but females are mainly aggregated, even in different habitat (Le Pendu, 2000; Bercovitch and Berry, 2012; Bercovitch and Berry, 2013a; Carter et al., 2013a). Sexual segregation of males is not connected only with sociality but may be connected with food selectivity (Estes, 1991). Younger males actively prefer to associate with animals of similar age, whereas older males, which tend to dominate mating opportunities, avoid associating with rivals. It would also be interesting to explore whether these individual differences involve a spatial reference for dominance, whereby one male may be dominant to another in one location, but subordinate to the same male elsewhere. If such a spatial reference for dominance does exists, and if it holds even in the absence of females then this could be considered as evidence for a form of resource defense overlap among individuals (Brand, 2007b). In other study more stable group was found, and resident males who were probably defending a temporary harem, engaged in necking contests with immigrant males (van der Jeugd and Prins, 2000a). Nevertheless, male giraffe rarely associate with the same individuals, so development of stable dominance hierarchies between bulls is unlikely (Bercovitch and Berry, 2015). During our study in Bandia reserve, we observed one older bull monopolizing the association with groups of females. Those familiar bull has not been found to interact with females, he just spend time in their proximity but feed on different trees. That social bull prefers to rest with the females in shadow of the trees during the hot afternoons. Dominance among adult male were also observed, but the most dominant male were not observed often with group of females. To date, we have no clue about the extent to which mating success differs among males, nor do we know the degree to which actual male reproductive output varies by body mass or differs across males (Bercovitch and Deacon, 2015). In Bandia Reserve we observed dominant behavior among bulls. We observed male running away from the herd of giraffes when the other approaches the group from distance of approximately 60 m. Dominant bull in Bandia Reserve behave mostly solitary, but once he approached group of giraffes, where other bull were presented every other bull showed submissive behavior and leave directly from the group containing adult females. The group composition seems to be based on adult females, the size of the group has not been found dependent on presence of bull. The fear of the bull escaping from the herd may be reasoned by negative experience from the past. The fight and necking behavior between bulls occur often in the reserve. The bulls have plenty of scars around their neck. Is possible that the scares on the neck of bulls can determinate their decisions, if they escape to avoid conflict or not. The dominant male interacts with adult females. He provoked a flow of urine that results in a 'flehmen' response to receive the chemoreceptor message about female reproductive status and after inspection of females he continued his solitary life. We observed even three adult males one by one approaching the group of females and showing submissive behavior to each other, depend on the circumstance. The bull reaction to rivals varies due to situations. The composition of the group may also influence the hierarchy between closely related males. Is possible, that males act different if their mother is part of group, which they encounter. Our observation were dissimilar to conclusions mentioned by (Bercovitch and Berry, 2015). The development of stable dominance hierarchies between bulls has been observed in Bandia Reserve. But may be caused due to isolation of the population. Formation of dominance hierarchies in bulls may be caused by relatedness of isolated population and by limited opportunities for dispersal in area of fenced reserve. Face to face encounter between bulls occur daily in the reserve.

5.2. Social preference in giraffes

Dyadic preferences is in agreement with recent findings on giraffe kinship, where the social preferences are not distributed evenly among herd members (Bercovitch and Berry, 2013c; Malyjurkova et al., 2014). The average AI in our study (excluding dyads which were never observed together) was 0.19 (range 0.02-0.76). This value is slightly higher than 0.12 as published by Bercovitch and Berry (2012) for wild giraffes. The higher AI corresponds with greater group size reported in fenced Bandia reserve. Most of the dyads (male-male, male-female and part of the female-female dyads) did not regularly associate together, as reported by other studies (Bercovitch and Berry, 2013a; Carter et al., 2013a). Mean association index (0.16) include also pairs of males, whose were not observed together, because they are mostly solitary. The same results were published by Bercovitch and Berry (2013) in wild giraffes and shown association with is similar with other animals with fission-fusion society as chimpanze (*pan troglodytes*). long-term studies have found that giraffe social associations and herd structure are not random in Rothschild's giraffe (VanderWaal et al., 2014), Angolan giraffe (Fennessy, 2004; Carter et al., 2013c) and Thornicroft's giraffe (Bercovitch and Berry, 2013a,b). DAI values of the same females after the birth of their calves increased threefold. This suggests that the presence of calves changes the relationships between the mothers.(Saito and Idani, 2016)

(ii) The highest values of AI in mother-calf dyads correspond with findings from both captive and wild populations (Bashaw et al., 2007b; Bercovitch and Berry, 2012). Giraffe cow reactions to their dead calves provide evidence that a mother-calf bond develop from birth (Bercovitch and Berry, 2012; Strauss and Muller, 2013) and may persist for years (Carter et al., 2013a). Such a long-term relationship would have an important influence on further association patterns of adult giraffes, resulting in formation of female-bonded kin groups. These groups change according to certain social preferences among the adult females. These preferences may depend on kinship (Bercovitch and Berry, 2013a; Malyjurkova et al., 2014).

Relationship among female giraffes in zoos appears to reflect continuation of mother-calf attachment so after weaning, as well as possible effects of allomothering (Bashaw et al., 2007; Bercovitch and Berry, 2012; Carter et al., 2013). Stronger bonds among females may have adaptive function due to reciprocity and maternal care. As we do not know genetic relationships among adult and sub adult individuals, we cannot assess whether the strong association persist there for years as in wild populations. Bercovitch and Berry (2013a) suggested that giraffe have evolved mechanisms for fostering the formation of social associations with similar aged non-kin. In our study giraffe females associated more often with the filial offspring and the offspring of theirs preferred association partners than with other offspring. Within a fission-fusion society of wild chimpanzees (*Pan troglodytes*), mothers with dependent offspring will group together and form nursery groups (Mitani et al., 2002). This can be comparable with nursery groups that have been observed in wild giraffe (Leuthold and Leuthold, 1975).

5.2.1 Influence of group

In our study (iii) adult female associated more often with a calf of familiar female (friend) than with a calf of other females. Relationships between females and calves of their friends were medium to strong and relationships between females and calves of non-friends were weak to medium. Calves of these familiar females associated together and formed *crèche* group more often than the calves of non-familiar females. This corresponds with result of Pratt and Anderson (1985) on wild giraffes. The *crèche* cohesion seems to be tighter when strong social bonds exist among mothers and giraffe's calves reared in a *crèche* have a higher probability of survival than those reared alone (Bercovitch and Berry, 2012). It is possible that personal preferences for particular conspecifics are formed in giraffe *crèche* groups (Leuthold, 1979). Female giraffe social structure in captivity appears to reflect continuation of mother-calf attachment (Bejder and Fletcher, 1998) and promoted allomaternal care, including allonursing. Calves' preferences for females could emerge from allomothering activities according to Perry (2011). In the wild allomothering was reported rarely, but at least one successful allonursing event was documented (Pratt and Anderson, 1985). In captive condition the nursing of non-filial calves could occur. In Prague zoo allonursing of non-filial calves occur very often, even the adult female have been observed to nurse milk of other adult females together with the 2 or 3 calves. (Personal observation), Nevertheless relatedness and stable composition of the herd in captivity and stable nutrition could increase these allo-mothering activities. But consequence of those act resulted nutritional problems of those adult female.

The strength of the relationship between calves depended on the strength of relationship between their mothers (iv). The idea that offspring affect the behaviour of their caregivers is not new. The early concepts of instinct portrayed the activities of animals as mechanical reactions to external stimulation- including stimuli emanating from the young. The Darwinian revolution simply provided a secular explanation of their origins (Suraud, 2011). This conclusion corresponds with results of Bercovitch and Berry (2013a), giraffe calves born into the same cohort have stronger social associations than calves born into different age cohorts. Association patterns of females may influence further associations in their calves, as the relationships among cohort members may persist long time. Patterns of giraffes associations are variable. It is possible that long-lived females exercise social preferences and avoidances based on previous experiences over many years with known conspecifics (Bejder and Fletcher, 1998). Social preference have influented by mother–daughter relationships (Carter et al., 2013) Female giraffes shown a tendence to associate with relatives (Perry, 2011; Wells et al., 1987), but still unknown is whether relatedness has any role in the formation of preferential associations among juveniles and adults (Welsh and Herzing, 2008). Close associations with relatives may confer benefits such as increased breeding success. It could also explain why different subspecies of giraffe living in the same area avoid hybridization. Mother preferences for mate could be transmitted to their offspring and avoid crossbreeding to increase fitness. The personal preferences for particular conspecifics are formed in giraffe *crèche* groups (Leuthold, 1979). The situation regarding paternal genetic influence on cohort social bonds is unknown. Whether social relationships among immature animals reflect individual preferences or maternal bonds is also unclear (Berman, 1982).

According to Bercovitch and Berry (2013) suggest that giraffe calves born into the same cohort have stronger social associations than calves born into different age cohorts, and that the strength of their association is independent of the strength of maternal associations. We concluded that mother friendship was correlated with the social ties of their calves (iv). This correlation indicates same result as research from Pratt and Anderson (1985). *Crèche* cohesion seems to be tighter when strong social bonds exist among mothers giraffe's calves reared in a *crèche* will have a higher probability of survival than those reared alone. This behavior may show friendship among female giraffes that was caring about her calf. Therefore, preferred relationships may be influential factors in female decisions on whether to stay with, or leave, a temporary group. (Carter et al., 2013b). The maternal bond in giraffe (Dagg and Foster, 1982) were characterized weak, because they abandonment their calves for extended periods while the cows venture off to forage or drink (Innis, 1958; Foster, 1966), or while they go to drink (personal observation) Giraffe herds are not frequently fluctuating groups of unfamiliar individuals, but consist primarily of family and friends among females. Nevertheless, in Rothschild giraffe in zoological garden in Prague, the calves have been showing the same behavioural patterns as their mothers. If the mother was not careful enough and attention has not been give to her calf, her calf has been discovering the enclosure alone. This calf female has been attack by bees, when calf disturbed them. No one female give attention to social learning and awareness to offspring, transmit of information to protect them. In the other hand the other adult giraffe have been scared of everything. Her reared calf displayed the same behaviour as mother.

5.2.2 Progression in matriarchal-based social system

Not only is herd composition non-random, but also when giraffe herds form a progression to move from one place to another, the oldest female matriarch is most likely to occupy the leading position (Berry and Bercovitch, 2015). The cooperation among adult females is based on good experience and trust. This preference to conspecific is transmitted to their calves and the calves' relationships are involved by mother decisions to who to stay with and who they can trust. The inexperienced calves don't have clue how to recognise the rare honest ones from the selfish individuals. If the mother is not involving the preference of her calf, the calf will be eaten.

5.2.3 Crèche group organization and suckling behavior

Allonursing may increase several risks, such as a lack of milk for the filial offspring and the high probability of pathogen transmission between females and the nonfilial offspring (Roulin, 2002). However in the zoological garden the giraffes have being periodically dewormed and vaccinated. They were fed ad libitum with hay and branches, with limited supplements of granulated food, fruit and vegetables. Females at advanced stages of pregnancy, during and shortly after parturition were separated and fed with milk supplements (Gloneková et al., 2016). Females can nurse non-filial offspring to evacuate the surplus milk that their own offspring do not consume (Roulin 2002). In zoo were recorded 95 cases of nursing only nonfilial offspring, and the milk evacuation hypothesis is a possible explanation for this (Gloneková et al., 2016). Those speculations seem to me more realistic, especially due to high number of allonursing calves. In 385 cases multiple nursing occurred 189 times, including the nursing of two calves in 106 cases, the nursing of three calves in 65 cases, the nursing of four calves in 13 cases, the nursing of five calves in four cases and one case of nursing six calves simultaneously (Gloneková et al., 2016). We has been observed even one adult female to be allonursing from other adult female (Personnal observation). Mentioned adult female from Prague zoo have nutritional problems this time (curator of ungulates in Prague zoo, personal communication.). The calves that were the first to start a suckling bout (order of suckling calves 1⁄4 1) tended to be younger than calves that joined the bout (Gloneková et al., 2016). Contain the feed whose are given to giraffe to much nutrient? Why it resulted as abnormal lactation? The stressing factors and character of the mother could be transmitted to their daughters. Thus even the partner choices. According to hypothesis of social benefits females preferentially allonurse the offspring of dominate females (Roulin, 2002). Thus due to close relatedness of Rotchild giraffe in the Prague zoo the allosuckling behaviour logically increase among half-sibling. It may become stereotypic behaviour. Recently the pellets given to giraffe in zoos are rich in protein from plants whose were genetically modified as soya, corn or bone meals. In cows, the production of milk is higher after feeding with bone meals. Nowadays in Europe the vegetarians are not supported well.

5.3. Interactions frequency

Our aim was to prove the social preferences among adult females, according to their association patterns and interactions. We recorded the interactions between the observed animal (always the adult female) and all the other members of the herd and compared if the distance and association involve the social interactions. The highest was the AI the highest was the intensity of all social interactions. The highest was the AI the highest was also the frequency of all interactions. The females considered as "friends" had also the higher frequency of interaction. Those female dyads spent together more time and agonistic interactions don't occur among them. This relation can be formulated as a friendship. Therefore leads to the formation of social structure in natural conditions. Female giraffe preferences for friend calf confirm the existence of social preferences among females. Using the chi-squared test a significant correlation was found between positive interaction, proximity and nearest neighbour. The interactions were compared in Kendau Tau correlation matrix and they were consistent over time so we confirmed formation of social preferences in adult female giraffes. Giraffes are able to leave a group, find and connect to other group or individual in a short period of time (Bashaw et al., 2007). Patterns of social association and interactions among individuals reflect formation and maintenance of social relationships (Bashaw, 2007).

5.3.1 Giraffe communication and signals

Visual, olfactory and auditory signals have been noted for giraffes (*Giraffa camelopardalis*) by the author (Innis, 1958), these are virtually impossible to record. To mediate social interactions, giraffe must be communicating with each other, but giraffe have few audible vocalizations (Bercovitch and Deacon, 2015). Nevertheless, in one test of the potential for giraffe to communicate with infrasound, a recording was made of a cow approaching her calf while displaying neck-stretch behavior, which is indicative of possible infrasound emission (Bashaw, 2003). Giraffes might adopt infrasound as a long-distance social communication signal mediating their relationships, for example as a mechanism for cows and calves to identify each other prior to re-unification after a maternal foraging bout (Bercovitch and Deacon, 2015). However, these signals are hard to record because of their low frequencies and recording need specialized equipment. The playback is possible only with low frequency rotated speaker and many other supplies, but still the quality is not accurate to original.

In captivity, after the initial post-partum period, a mother may move away from her calf but she will usually come to its aid if it is distressed (Greene, 2006). Therefore the division of interactions and activities not related to a social context remain unknown (Seeber et al., 2012). In particular, we need analyses that allow incorporation of multiple pairwise matrices within a mixed model framework. Such advances would enable evolutionary ecologists and quantitative geneticists to start partitioning the effects of genetic, social, environmental factors and their multi ways interactions to better understand main evolutionary attributes of their fitness. Genetic and social effects could be broken down into maternal and bi-parental relatedness, while social effects could include pairwise association, sharing of behaviors such as foraging and sexual advertisements (Frire et al., 2011).

In Bandia, more reactive and scared have been of classic cars. The mostly they run away if they see person out of vehicles. They remember rangers and us. The prove of it is that they fall a sleep just 8 meters far away from us. We observed them from close distance during their resting and swallowing in the shadow of acacia trees next to do watterhouse in hot aftenoon. The giraffes accept our mantenance after couple of days. But certain days we could look for them many hours driving threw all transects within the area of the Reserve de Bandia without finding of the giraffe herd. Just individual adult males we seen disspersed from each other. Is quite amazing how the tall animal like a giraffe could disapper in the bushes. They have good camouflage due to their coat patterns. It could be a coat drawing and color preffered patterns for females in decision making to who mate with? Giraffe skin appear different with frequency of the light. Some individuals looks almost the same but they differ in apperance in shadow and on the light and during the dusk. Intensity of the light is quite imporant aspect and make dificult identification of individuals. Because of that we prefer to spend first two weeks just with identification to be able to recognised each individuals from each side and angle. My opinion on the capture, mark, or others automatic programs used for recognition of each individual of the group is pragmatic, The diferences in coat patterns between some group member were problematic to detect, especially with caming of dusk. I dont believe that the computer has better result of identification than three of us. The complex dynamics of a fission–fusion society have led to the suggestion that a relatively large brain capable of distinguishing among individuals (Bercovitch and Deacon, 2015), My opinion is that the communication is the key factor for long term ties whose stay in in memory of the giraffe. They vision is adapted to see the predators from side. They dont see clear in front of them. The close encounters have to use other kind of signals, infra basic sequence or vibrations with different kick base longevity. The long of the neck could have important role in their communication. African elephants recognize each other based upon vocal characteristics (McComb et al., 2002). The delphins, the mammals with the biggest brain are calling the group member by their name. Is possible that giraffes are able to recognise their friends and family at by their infrasound communication. The noise of silence may be the best adaptation of the prey to avoid the vue of predators and also hearing because there is no record of predators responding on infrasonic frequencies. To prove this one method is to cover the eyes of the calf and observed if they are able to find the mother or other female calling them for nursing. Giraffes might adopt infrasound as a long-distance social communication signal mediating their relationships. For example as a mechanism for cows and calves to identify each other prior to reunification after a maternal foraging bout. How they regulate their relationships, and how they reunite for suckling by their own calf, remains to be determined, but could involve infrasound. (Bercovitch and Deacon, 2015).

Lactating females with dependent infants maintain affiliative friendships with specific males, most likely as a measure against harassment and infanticide risk (Lemasson et al. 2008;). In limited space of zoological garden adult females prefer their benefits unstead of the siblings. One of the young mother try to still the milk of the young calves. Suprisingly, we observed her to pushed the fillial calf away from the mother and drink herself the milk. In accordance with Schoener's theory of feeding strategies ((Brand, 2007b). Few studies mention that the giraffe also 'very occasionally’ feeds on grass (du Toit and Olff, 2014). I have been observed giraffes feed on grass very often in Prague zoological garden. In the Prague zoo adult giraffe female show first her new born calve to the only adult male in the herd. He sniffed the calves gently and continously all giraffes from the group come to welcome new part of their group.

7. Conclusion

Changes in herd size among giraffes reflect a dynamic process regulated by individuals adjusting the number of associates based upon an interaction of foraging, reproductive, social and antipredator strategies (Bercovitch and Berry, 2010). Recent studies of giraffe sociality show us the existence of an elaborate social system (Brandlová, personal communication). The smaller population and higher mean herd size in our study have similar patterns as in the Khumib River study area. In Niger, the female social preferences correlated with stronger inter-individual associations. (Danowitz and Solounias, 2015)(Danowitz and Solounias, 2015). Dna analysis of giraffes translocated to Senegal is nessesary to be shure of their well done subdivisions. The coat patterns are variable among individuals especially in adult females. The studied herd of semi-captive giraffes in Bandia Reserve, Senegal exhibited social preferencies. This herd of giraffes appear to have formed social relationships. The strongest relationships were proved: in mother-calf, adult familiar female dyads and among adult female and non-filial calf, those calves were left in crèche group in care of well-known female and with sibling, from the same cohort. Giraffe social preferences were maintained over time. The intensity of interaction and proximity support the idea of elaboration among females. Sociality and cooperation may prevent sub adult females from unwanted interactions and harassment of adult males. Our research supported the formation of complex social structure in giraffes, especially in females. We confirmed the calves are involved by the social preferences of theirs mothers. Adult female could determine sexual preferences of their calves in giraffes. Finally, the cooperation and friendship occur in females and their calves.

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9. Tables and figures

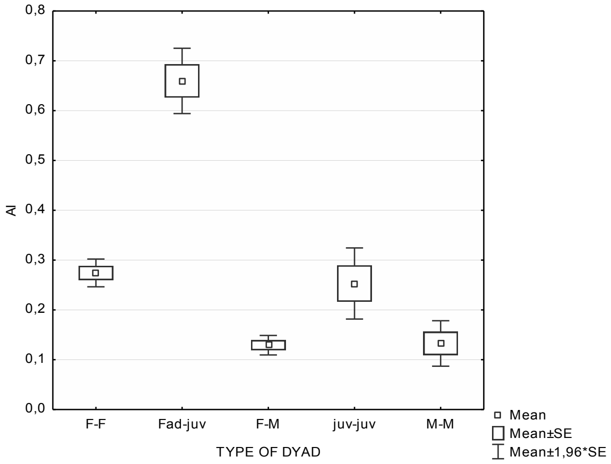


Figure. 5: Mean AI for five dyad types showing the highest value for mother-offspring dyads. N values for specified types of dyads are following: female-female F-F N = 95, female and filial offspring Fad-juv N = 7, female-male F-M N = 184, juvenile-juvenile juv-juv N = 15, M-M N =77

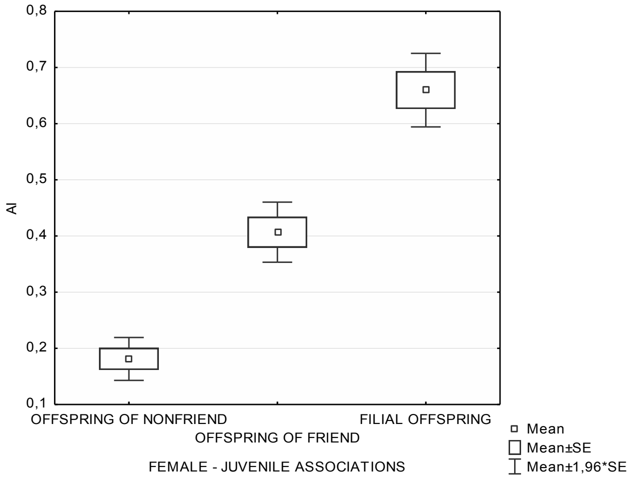


Figure 6: Differences in AI in female-juvenile associations showing the difference between AI with filial calf, calf of a friend and calf of a non-friend. N values for specific association types are: offspring of non-friend N = 36, offspring of friend N = 6, filial offspring N = 7

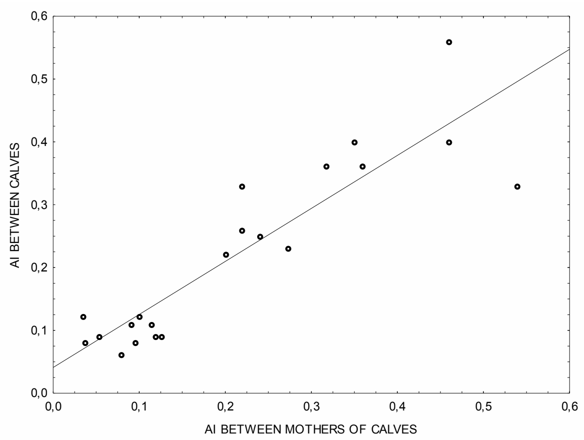


Figure 7: The higher the AI between mothers, the higher the AI between their calves

Table 1: Number of observation adult males in group and alone

	Group	Alone
Martin Absces	29	1
Bertrand	17	9
Tom	8	13
Dan	7	8
Fall	5	4
Unknown	4	8
Souhel	4	7
Jóžin	0	1

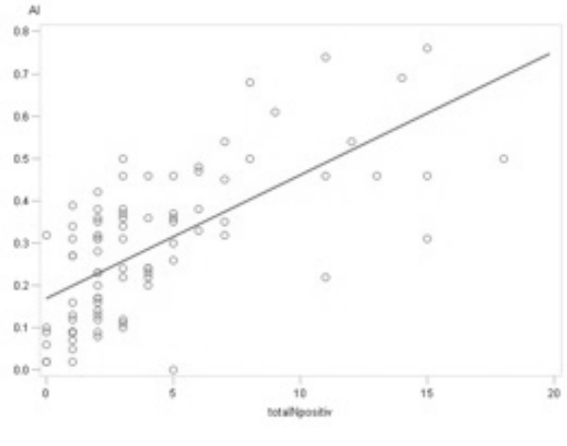
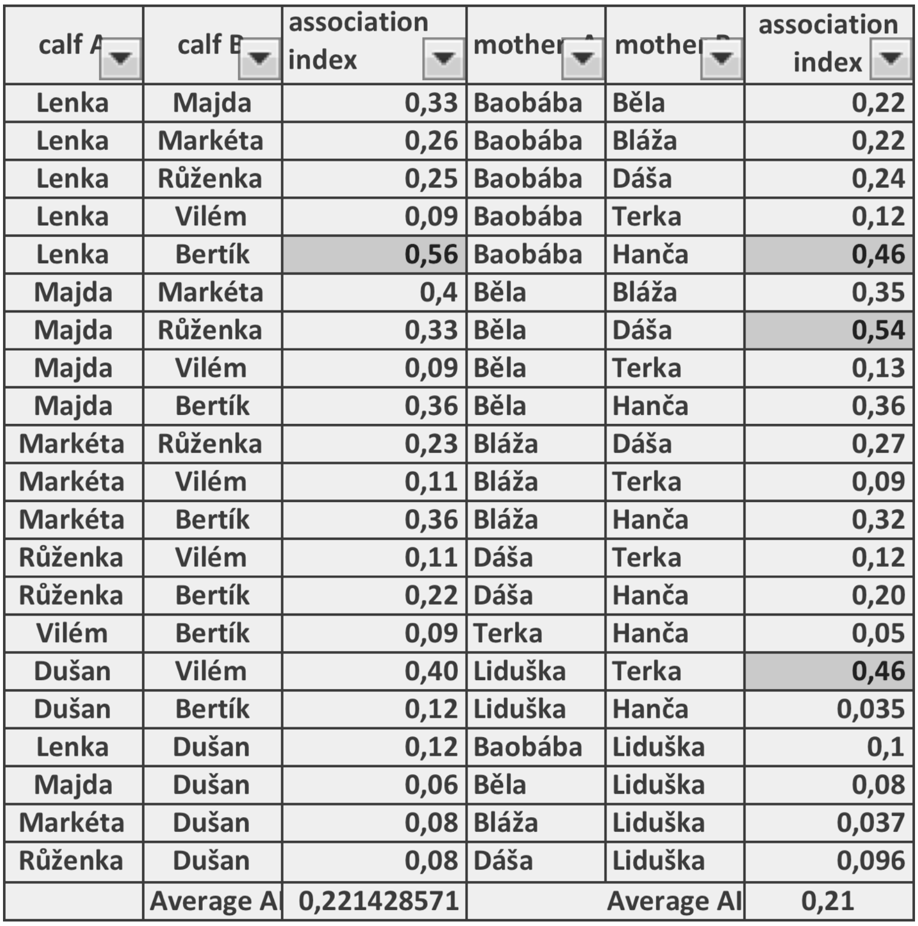


Fig.8: show that association index and positive interaction were correlated
p < ,05000, U=3, Z=-2,26 Spearman Correlation Coefficients, N = 87 Prob > |r| under H0: Rho=0 0.67952< .0001

Table 2: Association index among calves and among adult females



calf A	calf B	association index	mother A	mother B	association index
Lenka	Majda	0,33	Baobába	Běla	0,22
Lenka	Markéta	0,26	Baobába	Bláža	0,22
Lenka	Růženka	0,25	Baobába	Dáša	0,24
Lenka	Vilém	0,09	Baobába	Terka	0,12
Lenka	Bertík	0,56	Baobába	Hanča	0,46
Majda	Markéta	0,4	Běla	Bláža	0,35
Majda	Růženka	0,33	Běla	Dáša	0,54
Majda	Vilém	0,09	Běla	Terka	0,13
Majda	Bertík	0,36	Běla	Hanča	0,36
Markéta	Růženka	0,23	Bláža	Dáša	0,27
Markéta	Vilém	0,11	Bláža	Terka	0,09
Markéta	Bertík	0,36	Bláža	Hanča	0,32
Růženka	Vilém	0,11	Dáša	Terka	0,12
Růženka	Bertík	0,22	Dáša	Hanča	0,20
Vilém	Bertík	0,09	Terka	Hanča	0,05
Dušan	Vilém	0,40	Liduška	Terka	0,46
Dušan	Bertík	0,12	Liduška	Hanča	0,035
Lenka	Dušan	0,12	Baobába	Liduška	0,1
Majda	Dušan	0,06	Běla	Liduška	0,08
Markéta	Dušan	0,08	Bláža	Liduška	0,037
Růženka	Dušan	0,08	Dáša	Liduška	0,096
	Average AI	0,221428571		Average AI	0,21

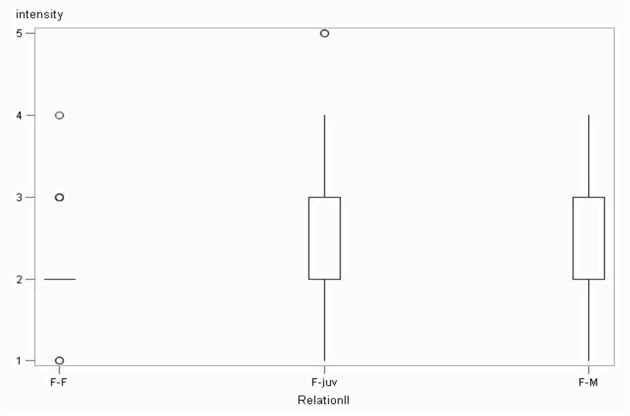


Figure 9: The highest intensity of interactions occur among adult females and calves, then between females and males and less among adult female dyads

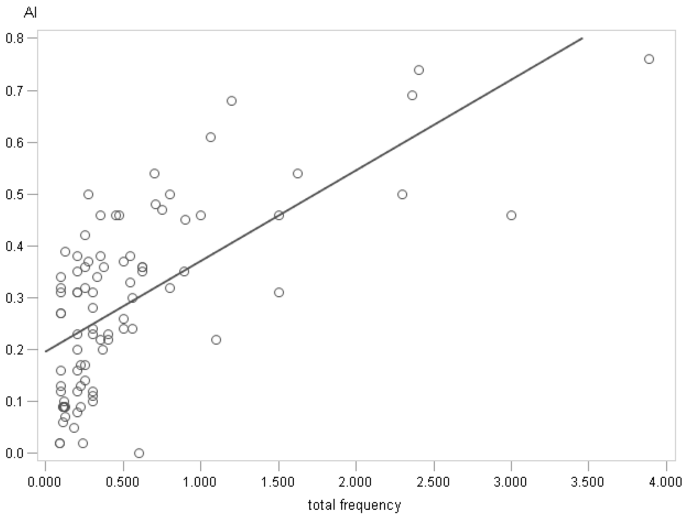


Figure 10: Total frequency of interactions was correlated with association index. Spearman Correlation Coefficients, N = 87 Prob > |r| under H0: Rho=0
AI 0.67952 <.0001

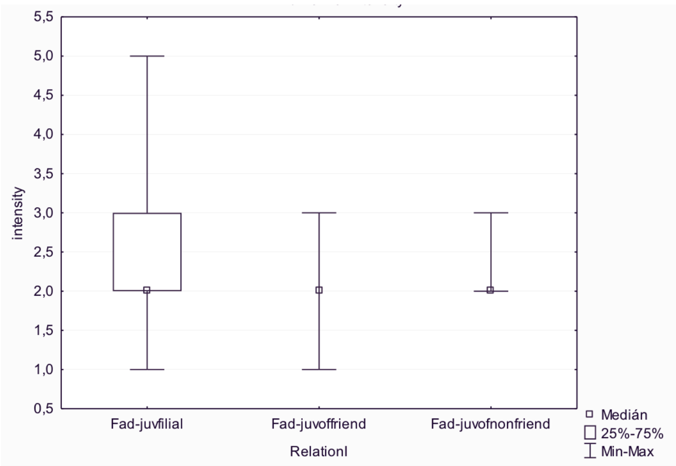
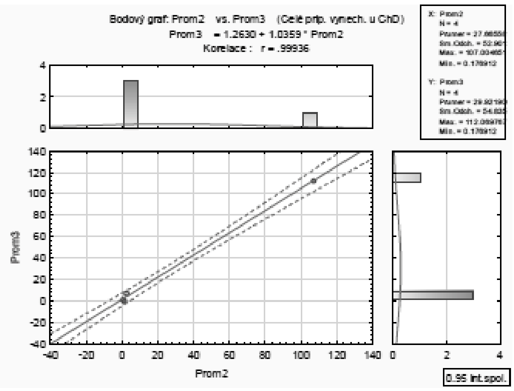
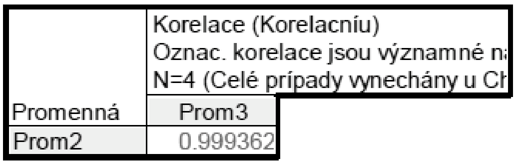


Fig.11: Intensity of interaction was highest in adult females and their calves, after among adult females and calves of friends and less intensive was intensity between adult female and calves from adult female, whose were not friend. Pearson Correlation Coefficients, N = 87 Prob > |r| under H0: Rho=0 Total positive frequency AI 0.68000< .0001





	Korelace (Korelacníu) Oznac. korelace jsou významné n N=4 (Celé prípady vynechány u C
Promenná	Prom3
Prom2	0.999362

Figure 12: Kendau tau Correlation matrix N: 4: r = .99936. The 3 variables: Positive interaction, proximity (100m) and nearest neighbor (3 m) were consistent during the time. Negative interactions were not statistically significant.

Prom2 vs. Prom3 = 1.2630 + 1.0359 * Prom2 Positiv frequency p <,05000, U=3, Z=-2,25092573548455 1,25715 sv = 2 p = ,0000

Chi-Kvadr. = 46,96078 sv = 2 p = ,0000

Chi-Kvadr. = 105,6444 sv = 9 p = ,0000

Chi-Kvadr. = 31,25715 sv = 2 p = ,0000

Figure 13: Frequency of positive and negative interactions of female giraffes compared with numbers of scans spent as nearest neigbor

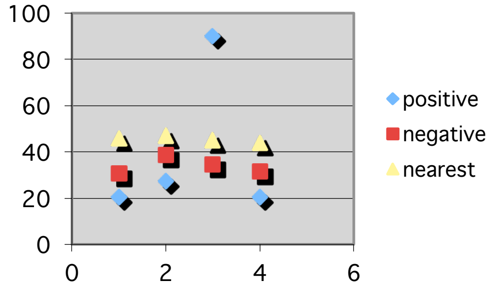
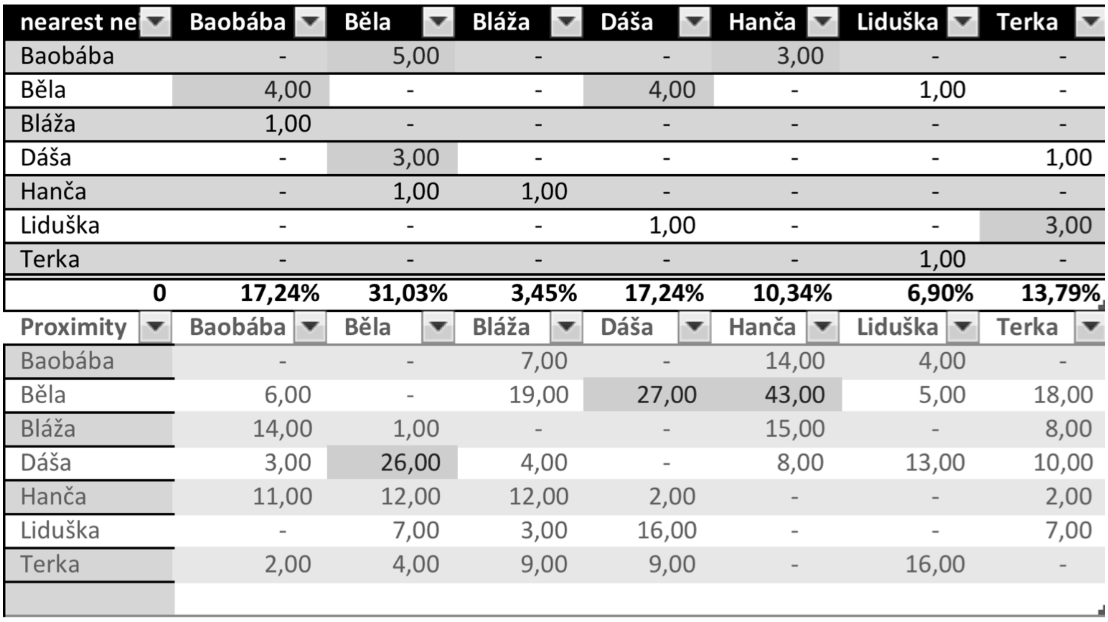


Table 3: Positive and negative interaction and proportion of scans, when were female observed as nearest neighbour.

Focal	recipient	positive interaction	negative interaction	nearest neighbour
Baobaba	Bela	4	0	5
Baobaba	Blaza	11	0	0
Baobaba	Dasa	3	0	0
Baobaba	Hanca	15	0	3
Baobaba	Liduska	0	0	0
Baobaba	Terka	1	0	0
Bela	Baobaba	0	0	4
Bela	Dasa	12	1	4
Bela	Hanca	5	0	0
Blaza	Baobaba	0	0	1
Blaza	Bela	1	0	0
Blaza	Dasa	1	0	0
Blaza	Hanca	7	1	0
Dasa	Hanca	2	0	0
Dasa	Liduska	3	0	0
Dasa	Terka	3	0	1
Liduska	Baobaba	0	1	0
Liduska	Dasa	0	0	1
Liduska	Bela	1	0	0
Liduska	Terka	4	0	3
Terka	Liduska	0	0	1
Terka	Bela	2	0	0
Terka	Blaza	1	0	0

Table 4 : Comparison between scans spent as nearest neighbor and numbers of scans observed in proximity of adult female giraffes.



nearest ne	Baobába	Běla	Bláža	Dáša	Hanča	Liduška	Terka
Baobába	-	5,00	-	-	3,00	-	-
Běla	4,00	-	-	4,00	-	1,00	-
Bláža	1,00	-	-	-	-	-	-
Dáša	-	3,00	-	-	-	-	1,00
Hanča	-	1,00	1,00	-	-	-	-
Liduška	-	-	-	1,00	-	-	3,00
Terka	-	-	-	-	-	1,00	-
0	**17,24%**	**31,03%**	**3,45%**	**17,24%**	**10,34%**	**6,90%**	**13,79%**

Proximity	Baobába	Běla	Bláža	Dáša	Hanča	Liduška	Terka
Baobába	-	-	7,00	-	14,00	4,00	-
Běla	6,00	-	19,00	27,00	43,00	5,00	18,00
Bláža	14,00	1,00	-	-	15,00	-	8,00
Dáša	3,00	26,00	4,00	-	8,00	13,00	10,00
Hanča	11,00	12,00	12,00	2,00	-	-	2,00
Liduška	-	7,00	3,00	16,00	-	-	7,00
Terka	2,00	4,00	9,00	9,00	-	16,00	-