Original Research Articles

Social Preferences of Translocated Giraffes (*Giraffa camelopardalis giraffa*) in Senegal: Evidence for Friendship among Females?

Lenka Malyjurkova[1], Marketa Hejzlarova[1], Pavla Junkova Vymyslicka[2], Karolina Brandlova[1]

[1]Department of Animal Sciences and Food Processing, Faculty of Tropical AgriSciences, Czech University of Life Sciences Prague
[2]Department of Ecology, Faculty of Environmental Sciences, Czech University of Life Sciences Prague

Abstract

Giraffe social behaviour and relationships are currently in the period of scientific renaissance, changing the former ideas of non-existing social bonds into understanding of complex social structures of giraffe herds. Different giraffe subspecies have been studied in the wild and only one was subject of detailed study in captivity. Our study focused on the neglected Cape giraffe (*Giraffa camelopardalis giraffa*). We investigated the social preferences of 28 introduced giraffes in semi-captivity in Bandia reserve, Senegal. Our aim was to assess the group size of Cape giraffes outside their native range and describe their social relationships. Mean group size in Bandia was 7.22 ± 4.06 (range 2-17). 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 strong relationships. Those three dyads included six of seven adult females, which we labelled as friends. Females associated more frequently with calves of their friends then with calves of non-friend females. The strength of the relationship between calves depended on the strength of relationship between their mothers. We concluded that Cape giraffes in new environment have shown similar group size and non-random preference for conspecifics as shown 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*; translocation; female; calf; social bond; fission-fusion system; relationship; friendship; association index.

INTRODUCTION

A giraffe herd is described as individuals that are generally engaged in the same activity such as foraging, drinking, resting, and moving in a coordinated manner in the same direction (Bercovitch and Berry, 2010; Le Pendu et al., 2000; Shorrocks and Croft, 2009). Interindividual distances are often long and giraffes in such a herd may be 1 km apart (Estes, 1991). We use the term "group" for all giraffes within the sight of an observer.

Previous studies concluded that giraffes were associated randomly. They were described as forming only loose, unstable and frequently changing ties to their conspecifics (Estes, 1991; Le Pendu et al., 2000). The only strong bond among giraffes was described between a mother and her dependent calf (Langman, 1977) and between young giraffes (Le Pendu et al., 2000). In small herds strong associations developed among adult females (Fennessy, 2009). Recent studies reported that female giraffes showed significant preference for, or avoidance of, other giraffes (Bercovitch and Berry, 2012). In the wild, female giraffes form a stable population of individuals that is divided into geographically distinct subgroups, despite the absence of physical barriers

(Carter et al., 2013b; van der Jeugd and Prins, 2000). Giraffe males are aggregated to bachelor groups or remain solitary. In both cases they often merge with female herds (Estes, 1991).

According to recent studies the giraffe herds represent a fission-fusion social system that is embedded in a larger community with changing size and composition of herds (Bercovitch et al., 2006; Bercovitch and Berry, 2010; Carter et al., 2013b). This system evolved in response to the exploitation of food availability that animals can most effectively use by broadcasting long-distance information to their kin. This is combined with short-distance bonding mechanisms (Bercovitch and Berry, 2012). Social ties in giraffe society could be influenced by kinship and social attraction or may only associate because they have similar habitat preferences (Carter et al., 2013a; Carter et al., 2013b).

Giraffes are known to use a *crèche* or nursery group care system in the wild (Langman, 1977; Leuthold, 1979; Pratt and Anderson, 1985). In captivity the social organization of herds also allows mothers to leave calves in the safe environment of a *crèche* group. They are tended by other giraffes, while they search for food (Greene et al., 2006). It is possible that these *crèche* groups may consist of related

juveniles. Those bonds among juveniles and older females may persist through time (Bashaw et al., 2007).

Recent publication of Bashaw et al. (2007) demonstrated that captive giraffe females formed complex social structure with strong relationships. Further, experimental social separation of captive giraffes proved an importance of social relationships to a specific individual (Tarou et al., 2000). Other findings of Bashaw (2011) supported the fact that captive giraffe maintain strong relationships and suggested that studies of giraffe relationships were applicable across a range of captive conditions.

Giraffes have been widely distributed across African continent, forming a number of geographically distinctive forms classified at subspecies or species level (Groves and Grubb, 2011; Hassanin et al., 2007). Up to nine giraffe taxa have been recognized, differing in colour pattern and having probably strong environmental and behavioural mechanisms supporting their genetic segregation (Brown et al., 2007). Fission-fusion or similar association patterns have been described in Thornicroft's giraffe (*G. c. thornicrofti*) in Zambia (Bercovitch and Berry, 2010, 2012, 2013), West African giraffe (*G .c. peralta*) from Niger (Ciofolo et al., 2000; Le Pendu and Ciofolo, 1999; Le Pendu et al., 2000), Angolan giraffe (*G. c. angolensis*) in Namibia (Carter et al., 2013b; Fennessy, 2009), Reticulated giraffe (*G. c. reticulata*) in Kenya (Shorrocks and Croft, 2009; VanderWaal et al., 2014). Mother-calf relationships were studied in wild Cape giraffe (*G. c. giraffa*) in South Africa (Langman, 1977).

Contrastingly, studies of giraffe relationships in captivity focused on Rothschild giraffe (*G. c. rothschildi*) (Bashaw, 2011; Bashaw et al., 2007; Bercovitch et al., 2006), two focused on Reticulated giraffe (Greene et al., 2006; Perry, 2011), one focused on Massai giraffe (*G. c. tippelskirchi*) (Tarou et al., 2000).

Regarding giraffe taxa studied in the wild and in captivity, it is obvious that the comparison on the subspecies level can hardly be performed. However, very little is known about importance of social bonds when socially living animals face new environments (Fischer and Lindenmayer, 2000), either being transported to captive or to semi-captive conditions of fenced reserves. Recent efforts to enhance the effectiveness of translocation have focused on questions regarding the composition of founding populations, including social structure of translocated herds (Pérez et al., 2012). Moreover, study of social structure of giraffe in a new environment may help understanding of formation of social structure in giraffe and assess the possibilities of evolution of communal maternal care and formation of *crèche* groups in semi-captivity.

Aims and Hypotheses

Our aim was to assess the herd size and composition of Cape giraffes outside of their native range. (i) We predicted that giraffes were adapted to new environment and that group size and composition would be similar as in wild populations of other subspecies. We classify the dyads of giraffes according to strength of relationship (weak, medium and strong). (ii) We predicted that all dyads of female and filial juvenile would have strong relationships. (iii) Further, there would be some female dyads with strong relationship. We would then label those familiar females as "friends". (iv) 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 (v) the strength of the relationship between calves would depend on the strength of relationship between their mothers.

MATERIALS AND METHODS

Study area and destination

The social preferences of giraffes were observed in the Bandia reserve, Senegal, 15° 27' 0" North, 15° 24' 0" West (see Figure 1). The Bandia reserve is a fenced area (3 500 ha) created for safari-tourism and for the protection of the environment and wildlife. The Reserve is situated on the south-western border of the 'Classified Forest Bandia'. It is managed in public-private partnership since 1990 (Nežerková et al., 2004). The reserve belongs to the Sudan-Sahelian area (Antonínová et al., 2004). 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 et al., 2004). This was the main nutrition source for giraffes in the
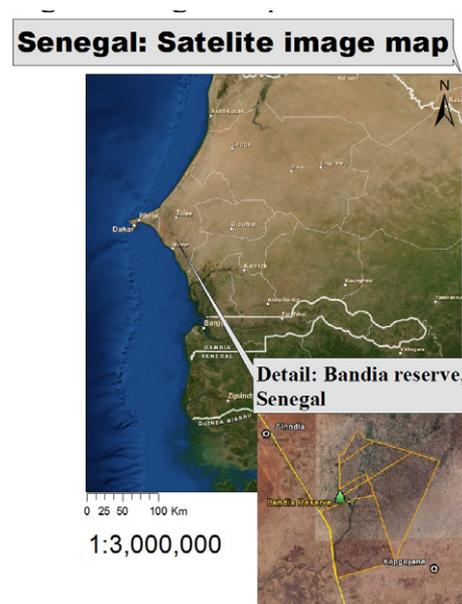

Figure 1. Senegal map with Bandia reserve location created in Gis10.2.

reserve. Two distinguished seasons characterize the climate: dry season (from November to June), and rainy season (from July to October) (White, 1983).

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 native large predators in Bandia reserve, the largest carnivore is Golden jackal (*Canis aureus*).

Several mammalian species were imported into Bandia from Niokolo Koba National Park, e.g. African buffalo (*Syncerus caffer brachyceros),* Buffon's Kob (*Kobus kob),* West African roan *(Hippotragus equinus koba)*. In 2000, a group of Western Derby elands (*Taurotragus derbianus derbianus*) were introduced to the reserve and their conservation programme 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.

The native giraffe subspecies in Senegal was West African giraffe, now surviving only in Niger (Brown et al., 2007; Ciofolo et al., 2009). 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)*. Recent research has proved this to be incorrect, because this subspecies was introduced into Niokolo Koba National Park from Cameroon (Al Ogoumbrabe, 2002) (see Figure 2). The translocation was unsuccessful, Kordofan giraffe did not adapt to new environment and all the giraffes died (Dupuy, 1972).

In January 1997, four Cape giraffes were translocated from South Africa to the Bandia reserve (reserve managers, pers. comm). Giraffes adapted to new environment, reproduction started soon and there were already 10 individuals in Bandia in 2002 (Vincke et al., 2005). Two giraffes (sub-adult male and female) were relocated to Fathala reserve in Senegal in 2003 (Nezerkova-Hejcmanova et al., 2005) and further transfers were realized in 2006, 2008, and 2012 (reserve managers, pers. comm.). Except for the last years when our study has been performed, the relationships among individual giraffes remained unresolved.

Data collection

In total 28 giraffes (13 males, 15 females, see Table 1) were observed for 34 days in the dry season. Owing to Bandia reserve's requirements, all observations were recorded from a vehicle. Data was collected from the 27th January to the 9th March 2013. The identification of each

Figure 2. Native range and differences among giraffe subspecies historically found in Senegal.

Table 1. List of observed giraffes in Bandia reserve, Senegal

Name	Number of observations	Sex	Age Category	Mother
Baobába	27	F	Adult	
Běla Uršula	34	F	Adult	
Bláža	28	F	Adult	
Dáša	29	F	Adult	
Hanča	30	F	Adult	
Liduška Beau Cou	28	F	Adult	
Terka	29	F	Adult	
Bětka	32	F	Subadult	
Dorotka	30	F	Subadult	
Maruška	30	F	Subadult	
Pavla	32	F	Subadult	
Lenka	30	F	Juvenile	Baobába
Majda	30	F	Juvenile	Běla Uršula
Markéta	29	F	Juvenile	Bláža
Růženka	30	F	Juvenile	Dáša
Lenin	26	M	Subadult	
Míša	27	M	Subadult	
Dušan	25	M	Juvenile	Liduška Beau Cou
Vilém	31	M	Juvenile	Terka
Bertík	31	M	Juvenile	Hanča
Unknown	12	M	Adult	
Jóžin	1	M	Adult	
Fall	9	M	Adult	
Bertrand	26	M	Adult	
Souhel	11	M	Adult	
Dan Jan	15	M	Adult	
Martin Absces	30	M	Adult	
Tom Michal	21	M	Adult	

individual was done in the first week. This was according to the unique coat drawing and significant signs which remain constant throughout life. Photographs of all giraffes within the study area were taken from both sides. 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). The genetic data were absent. We distinguished all mother-calf dyads according to the maternal behaviour, particularly suckling.

Data collection occurred generally during two sampling periods each day (8 to 11 am and 3 to 6 pm). The activity of the animals was the highest at this time. 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.

Association index (AI)

Many options have been proposed for calculating associations in animal societies (Cairns and Schwager, 1987; Ginsberg and Young, 1992; Wey et al., 2008; White and Smith, 2007; Whitehead et al., 2005). The most standard association indexes are affected by sample size. This is so that the dyad of individuals seen often will have a higher association index than those seen rarely (Whitehead, 2009; Whitehead et al., 2005). 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 and Berry (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. Association, therefore, refers 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 (Whitehead et al., 2005). We compared the levels of associations between giraffes in the Bandia reserve, with those reported for captive and wild giraffes residing in fission-fusion social systems (Bercovitch and Berry, 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).

We further 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 (includes 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 recorded (i) size and composition of all sighted groups and we recorded all individuals, too. We classified the dyads of giraffes according to strength of relationship (weak, medium and strong) and we compared the mean AIs for all types of dyads using Kruskal-Wallis test (the data distribution was not normal). (ii) We assessed the AIs of all dyads of females and their filial juveniles. (iii) We further assessed 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". (iv) We compared the AIs among females and juveniles (filial calf, calf of a friend, calf of non-friend) using Kruskal-Wallis test. Last, using Spearman correlation, we tested (v) the relation of strength of the relationship between calves and the strength of relationship between their mothers.

RESULTS

In total, 144 giraffe contacts (88 groups of two or more individuals and 56 individual sightings) were recorded in 34 days. (i) The average number of individuals in the group was 7.22 ± 4.06 (range 2-17).

Any two animals were seen together 7 ± 0.35 times (range 0-26). 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. 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 in 313 dyads. The hypothetic dyads, which were never observed, always included an adult male either with another male or female. From 56 encounters with solitary individuals there was only one 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, Figure 3).
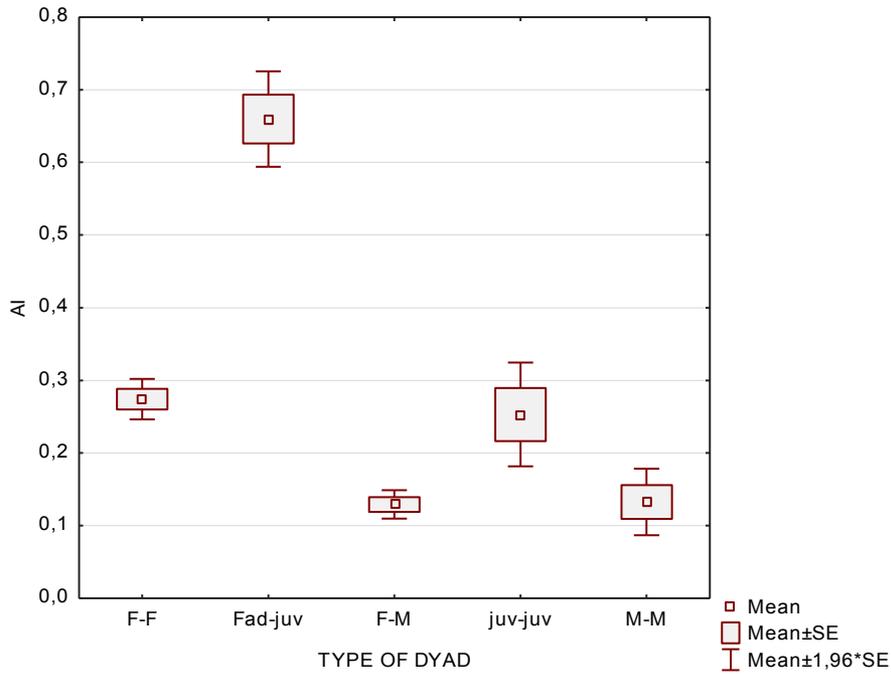
Figure 3. Mean AI for five dyad types showing the highest value for mother-offspring dyads. N values for specified types of dyads are following: female-female F-F N = 95, female and filial offspring Fad-juv N = 7, female-male F-M N = 184, juvenile-juvenile juv-juv N = 15, M-M N =77
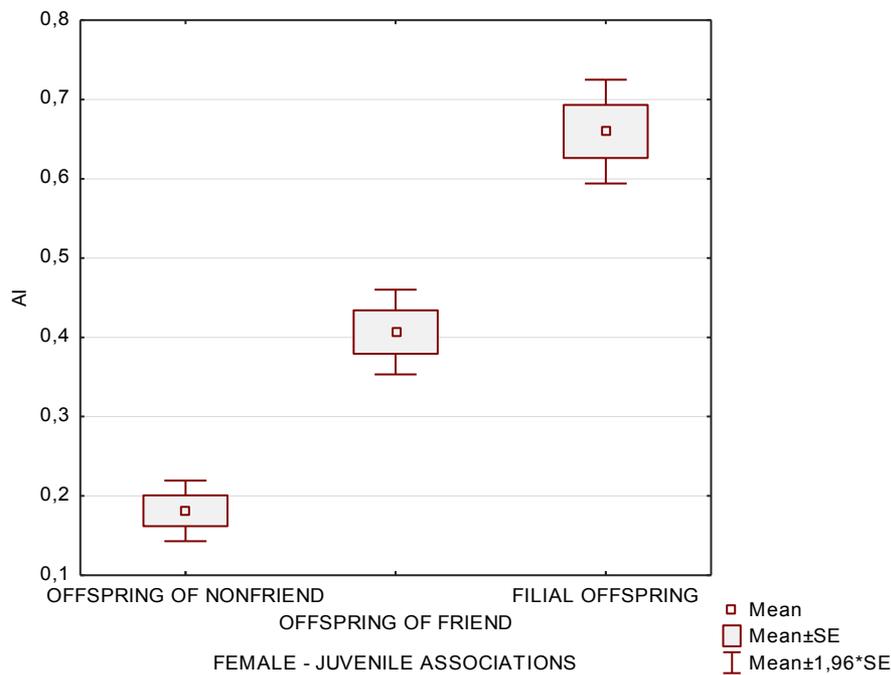

Figure 4. Differences in AI in female-juvenile associations showing the difference between AI with filial calf, calf of a friend and calf of a non-friend. N values for specific association types are: offspring of non-friend N = 36, offspring of friend N = 6, filial offspring N = 7

Mean AI (ii) 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 (iii) in three dyads of female giraffes (Baobába – Hanča AI = 0.46, Běla Uršula – Dáša AI = 0.54, Liduška Beau Cou – Terka
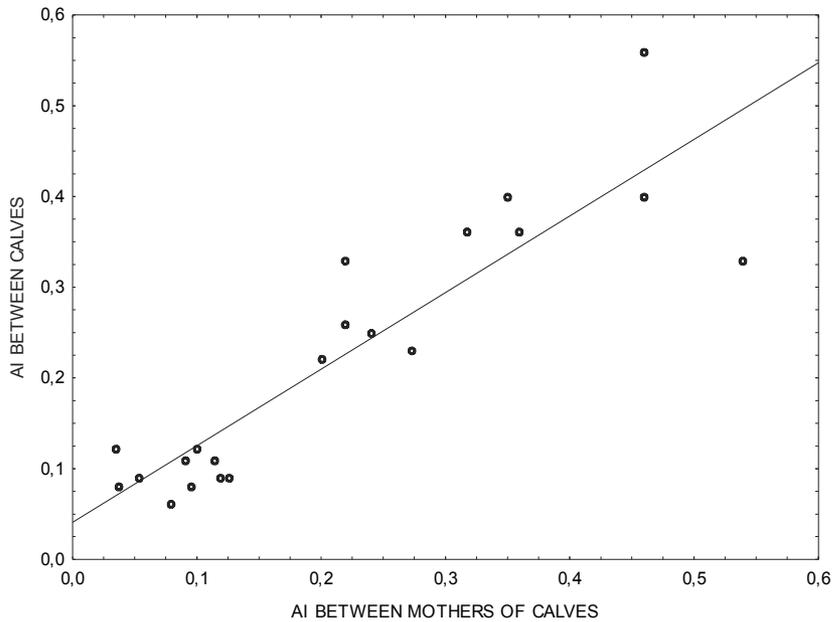
Figure 5. The higher the AI between mothers, the higher the AI between their calves.

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.

(iv) Adult female giraffes were associated more often with the calves of familiar females than with the calves of other adult females (H $_{(2, n=49)}$ = 26.25, p < 0.001; Figure 4). 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).

(v) The higher was the AI between females, the higher was the AI of their calves (Spearman coef. = 0.86, p < 0.001; Figure 5).

DISCUSSION

During our study we recorded 88 groups of two or more individually recognised giraffes. (i) The average number of individuals in a group was more than seven. This was slightly higher than in most of the studies from the wild, where usually five to six giraffes formed a group (Le Pendu et al., 2000; Leuthold and Leuthold, 1978; Shorrocks and Croft, 2009; van der Jeugd and Prins, 2000; VanderWaal et al., 2014). The number of individuals seen together in a group varied from two to 17. Group size in Bandia reserve could have been affected by limited space in fenced area, resulting in slightly larger group size. Nevertheless, giraffe density, home-range size, and group stability was found to differ across different habitats (van der Jeugd and Prins, 2000). The group size of observed giraffes in the Bandia

reserve was comparable to those in the native range of other subspecies.

All but one sightings of solitary individuals were males. This corresponds to general grouping patterns of giraffes in other studies. Males may be found in groups or solitary, but females are mainly aggregated, even in a different habitat (Bercovitch and Berry, 2012, 2013; Carter et al., 2013a; Le Pendu et al., 2000). 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 (Pratt and Anderson, 1982).

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 to 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, 2013; Carter et al., 2013a).

(ii) The highest values of AI in mother-calf dyads corresponds to with findings from both captive and wild populations (Bashaw et al., 2007; Bercovitch and Berry, 2012). Giraffe cow reactions to their dead calves provide evidence that a mother-calf bond develops from birth (Bercovitch and Berry, 2012; Strauss and Muller, 2013) and may persist for years (Carter et al., 2013b). 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.

We reported the mean AI among adult females as 0.22 ± 0.15, similar to other studies using the same AI formulae (Bercovitch and Berry, 2012; Perry, 2011). Cape giraffes in Bandia showed higher associations among females than wild Thornicroft's giraffe in Luangwa, Zambia, 0.17 ± 0.15 (White and Smith, 2007; Bercovitch and Berry, 2013). Moreover, we found strong relationship (AI > 0.4) in three of 21 possible giraffe female dyads, corresponding to results of Bashaw et al. (2007). Surprisingly, each of the females had just one preferred "friend", resulting in formation of three dyads of "friends" and one remaining female with strong relationship to her filial calf only. The familiar females made only dyads; no trio with strong relationship was reported. Nevertheless, the number of females in our study was very low and the level of "strong relationship" was set up arbitrary. The formation of relationships among adult female giraffe should be further tested.

Regardless the limits of the method used for associations measures, the female dyads shown non-random preference to spend time with specific individual in the same group. Patterns of giraffes associations are variable. It is possible that long-lived females experience social preferences and avoidances based on previous experiences over many years with known conspecifics (Carter et al., 2013b). It is also possible that mother–daughter or sister relationships could persist through the time (Bashaw et al., 2007). Potential advantages gained by females from associating strongly with a particular female include increased reproductive output, increased survival and psychological wellbeing (Leuthold, 1979). Stronger bonds among females may have adaptive function due to reciprocity and allomaternal care. As we do not know genetic relationships among adult and subadult individuals, we cannot assess whether the strong association persists there for years as in wild populations.

(iv) In our study 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 a *crèche* 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 a 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). Nevertheless, relatedness and stable composition of the herd in captivity could increase these allomothering activities.

(v) The strength of the relationship between calves depended on the strength of relationship between their mothers. This corresponds with results of Bercovitch and Berry (2013) that 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 for a long time.

CONCLUSIONS

Our research has shown that even with a small number of founders the translocation of Cape giraffes to new environment was successful. Females showed normal reproducing pattern and their social system was similar to native range and as in other giraffe subspecies across different environment. We confirmed that giraffes show non-random social preferences and that the relationships among females influence the relationships among their calves.

ACKNOWLEDGEMENTS

REFERENCES

Al Ogoumbrabe N. (2002): Les aires protégées au Sénégal: étude du cas de la Réserve de faune de Bandia: adaptation des animaux sauvages introduits et aspect socio-économique, UCAD Dakar.

Antonínová M., Nežerková P., Vincke X., Al-Ogoumrabe N. (2004): Herd structure of the giant eland (Taurotragus derbianus derbianus) in the Bandia Reserve, Senegal. Agricultura Tropica et Subtropica 37: 1-5.

Bashaw M. J. (2011): Consistency of captive giraffe behavior under two different management regimes. Zoo Biology 30: 371-378.

Bashaw, M. J., Bloomsmith, M. A., Maple, T. L., and Bercovitch, F. B. (2007): The structure of social relationships among captive female giraffe (Giraffa camelopardalis). Journal of Comparative Psychology 121(1):·46-53.

Bejder L., Fletcher D. (1998): A method for testing association patterns of social animals. Animal Behaviour 56: 719-725.

Bercovitch F. B., Bashaw M. J., del Castillo S. M. (2006): Sociosexual behavior, male mating tactics, and the reproductive cycle of giraffe Giraffa camelopardalis. Hormones and Behavior 50: 314-321.

Bercovitch F. B., Berry P. S. M. (2010): Ecological determinants of herd size in the Thornicroft's giraffe of Zambia. African Journal of Ecology 48: 962-971.

Bercovitch F. B., Berry P. S. M. (2012): Herd composition, kinship and fission–fusion social dynamics among wild giraffe. African Journal of Ecology 51: 206-216.

Bercovitch F. B., Berry P. S. M. (2013): Age proximity influences herd composition in wild giraffe. Journal of Zoology 290: 281-286.

Brown D.M., Brenneman R.A., Koepfli K.-P., Pollinger J.P., Mila B., Georgiadis N.J., Louis E.E., Grether G.F., Jacobs D.K., Wayne R.K. (2007): Extensive population genetic structure in the giraffe. BMC Biology 5: 57. doi:10.1186/1741-7007-5-57

Cairns S. J., Schwager S. J. (1987): A comparison of association indices. Animal Behaviour 35: 1454-1469.

Cameron E., Dutoit, J. (2005): Social influences on vigilance behaviour in giraffes. Animal Behaviour 69: 1337-1344.

Carter K. D., Brand R., Carter J. K., Shorrocks B., Goldizen A. W. (2013a): Social networks, long-term associations and age-related sociability of wild giraffes. Animal Behaviour 86: 901-910.

Carter K. D., Seddon J. M., Frere C. H., Carter J. K., Goldizen A. W. (2013b): Fission-fusion dynamics in wild giraffes may be driven by kinship, spatial overlap and individual social preferences. Animal Behaviour 85: 385-394.

Ciofolo I., Ambouta K., Le Pendu Y. (2009): The last West African giraffes: insured survival or threatened future ? Revue D Ecologie-La Terre Et La Vie 64: 351-358.

Ciofolo I., Le Pendu Y., Gosser A. (2000): The giraffes of Niger, the last West African giraffes. Revue D Ecologie-La Terre Et La Vie 55: 117-128.

Dupuy A. R. (1972): Essai de réintroduction de Girafes au Parc national du Niokolo Koba (Sénégal) Dakar. Notes Africaines, IFAN Dakar No 133: 21-26.

Estes R. D. (1991): The Behavior Guide to African Mammals. Including Hoofed Mammals, Carnivores, Primates. University of California Press, 640 p.

Fennessy J. (2009): Home range and seasonal movements of Giraffa camelopardalis angolensis in the northern Namib Desert. African Journal of Ecology 47: 318-327.

Fischer J., Lindenmayer D. B. (2000): An assessment of the published results of animal relocations. Biological Conservation 96: 1-11.

Ginsberg J. R., Young T. P. (1992): Measuring association between individuals or groups in behavioural studies. Animal Behaviour 44: 377-379.

GreeneT. V., Manne S. P., Reiter L. M. (2006): Developing models for mother–infant behaviour in Black rhinoceros and Reticulated giraffe Diceros bicornis michaeli and Giraffa camelopardalis reticulata at Brookfield Zoo, Illinois. International Zoo Yearbook 40: 372-378.

Groves C., Grubb P. (2011): Ungulate Taxonomy. Johns Hopkins University Press.

Hassanin A., Ropiquet A., Gourmand A. L., Chardonnet B., Rigoulet J. (2007): Mitochondrial DNA variability in Giraffa camelopardalis: consequences for taxonomy, phylogeography and conservation of giraffes in West and central Africa. Comptes Rendus Biologies 330: 265-274.

Hejcmanová P., Hejcman M., Camara A. A., Antonínová M. (2010): Exclusion of livestock grazing and wood collection in dryland savannah: an effect on long-term vegetation succession. African Journal of Ecology 48: 408-417.

Langman V. A. (1977): Cow-calf Relationships in Giraffe (Giraffa camelopardalis giraffa). Zeitschrift für Tierpsychologie 43: 264-286.

Le Pendu Y., Ciofolo I. (1999): Seasonal movements of giraffes in Niger. Journal of Tropical Ecology 15: 341-353.

Le Pendu Y., Ciofolo I., Gosser A. (2000): The social organization of giraffes in Niger. African Journal of Ecology 38: 78-85.

Leuthold B. M. (1979): Social organization and behaviour of giraffe in Tsavo East National Park. African Journal of Ecology 17: 19-34.

Leuthold B. M., Leuthold W. (1978): Ecology of the giraffe in Tsavo East National Park, Kenya. African Journal of Ecology 16: 1-20.

Nezerkova-Hejcmanova P., Hejcman M., Camara A. A., Antoninova M., Pavlu V., Cerny T., Ba A. T. (2005): Analysis of the herbaceous undergrowth of the woody savanna in the Fathala Reserve, Delta du Saloum National Park (Senegal). Belgian Journal of Botany 138: 119-128.

Nežerková P., Verner P. H., Antonínová M. (2004): The conservation programme of the Western giant eland (Taurotragus derbianus derbianus Gray 1847) in Senegal - Czech Aid Development Project. Gazella 31: 87-182.

Pérez I., Anadón J. D., Díaz M., Nicola G. G., Tella J. L., Giménez A. (2012): What is wrong with current

translocations? A review and a decision-making proposal. Frontiers in Ecology and the Environment 10: 494-501.

Perry S. (2011): Social behaviour in captive reticulated giraffes (Giraffa camelopardalis reticulata): Analysis of enclosure use and social interactions between giraffes housed at Whipsnade Zoo. The Plymouth Student Scientist, 4: 50-65.

Pratt D. M., Anderson V. H. (1982): Population, distribution, and behaviour of giraffe in the Arusha National Park, Tanzania. Journal of Natural History 16: 481-489.

Pratt D. M., Anderson V. H. (1985): Giraffe social behaviour. Journal of Natural History 19: 771-781.

Shorrocks B., Croft D. P. (2009): Necks and networks: a preliminary study of population structure in the reticulated giraffe (Giraffa camelopardalis reticulata de Winston). African Journal of Ecology 47: 374-381.

Strauss M. K. L., Muller Z. (2013): Giraffe mothers in East Africa linger for days near the remains of their dead calves. African Journal of Ecology 51: 506-509.

Tarou L. R., Bashaw M. J., Maple T. L. (2000): Social attachment in giraffe: Response to social separation. Zoo Biology 19: 41-51.

van der Jeugd H. P., Prins H. H. T. (2000): Movements and group structure of giraffe (Giraffa camelopardalis) in Lake Manyara National Park, Tanzania. Journal of Zoology 251: 15-21.

VanderWaal K. L., Wang H., McCowan B., Fushing H., Isbell L. A. (2014): Multilevel social organization and space use in reticulated giraffe (Giraffa camelopardalis). Behavioral Ecology 25: 17-26.

Vincke X., Hornick J. L., Njikam N. I., Leroy P. (2005): Wildlife management in Senegal: Comparison between the Niokolo Koba National Park and the private Reserve of Bandia. Gestion de la faune sauvage au Sénégal: Comparaison du Parc national du Niokolo Koba et de la Réserve privée de Bandia 149: 232-237.

Wey T., Blumstein D. T., Shen W., Jordán F. (2008): Social network analysis of animal behaviour: a promising tool for the study of sociality. Animal Behaviour 75: 333-344.

White D. J., Smith V. A. (2007): Testing measures of animal social association by computer simulation. Behaviour 144: 1447-1468.

White F. (1983): Vegetation of Africa: a descriptive memoir to accompany the UNESCO/AETFAT/UNSO vegetation map of Africa. UNESCO, Paris, 356 p.

Whitehead H. (2009): SOCPROG programs: analysing animal social structures. Behavioral Ecology and Sociobiology 63: 765-778.

Whitehead H., Bejder L., Andrea Ottensmeyer C. (2005): Testing association patterns: issues arising and extensions. Animal Behaviour 69: e1-e6.

Corresponding author:

Karolína Brandlová
Department of Animal Sciences and Food Processing
Faculty of Tropical AgriSciences
Kamýcká 129
165 21 Praha Suchdol
Czech Republic
Phone: +420 724 048 285
E-mail: brandlova@ftz.czu.cz