Inside the Zoo: Captive Giraffes' Changes in Social Ties Throughout Membership Variations

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By

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Table of Contents

Abstract

Many animals live in gregarious, fission-fusion societies where group size and composition are continually changing. Despite this, many studies have suggested that captive animals are capable of maintaining long term social bonds with others. In captive giraffes, effects on their social bonds during membership transitions have not been studied thoroughly, however, prior research does show that social bonds are a defining factor in non-captive animals. Captive giraffe social network patterns were investigated at the Jacksonville Zoo and Botanical Gardens using all occurrence behavioral data. Based on previous research, I hypothesized that when one of the individuals in the group was removed, the previous significant social ties would remain significant. Specifically, I expected there would not be significant changes within the group in how they interact. Furthermore, I expected same age groups and same sex groups to be defining variables across the two data sets, in regard to social organization. The data was analyzed using R's package StatNet and SNA to develop their social network patterns and determine if there is any significance. There were significant social ties found within some members of the group before Sir Isaac was removed, but after his removal no significant ties were found. There was also a significant difference in the rate of interactions between same sex individuals when the two datasets were compared. Furthermore, there was significant reciprocity within both datasets. These results imply that there were in fact differences in individual social ties with the removal of Sir Isaac. Limitations include that this was a case study and there was no breeding male. The aforementioned results hint at the fact that captive giraffes are not exhibiting the same behaviors as wild giraffes.

Keywords: social network analysis, animal welfare, zoo animal behavior, husbandry, kinship

Inside the Zoo: Captive Reticulated Giraffes' Social Network Changes Throughout Varying Membership Status

It is acknowledged that individual patterns of social organization in many gregarious animals are non-random (VanderWaal et al., 2014), meaning that animals do exhibit personal social preferences. Strong social bonds have been found in many animals, including birds (Kohn, 2016), primates (Larson et al., 2018), and giraffes (Carter et al., 2013b). The patterns of social preferences throughout all members of a group, or a social network, ultimately determine the social organization of the group (Hinde & Atkinson, 1970). Within this social organization, individuals often occupy different and distinct positions that are defined by their individual relationships and preferences of others (Hinde & Atkinson, 1970). Social preferences have been defined as patterns of associations where an individual will most likely direct their social behaviors towards another specific individual (Crook et al., 1976).

Social preferences can be measured in many ways such as proximity, nearest neighbors, and interactions (Green et al., 1989; Horwich et al., 1982; L'Heureux et al., 1995). Another way of analyzing social interactions is through analyzing social networks, which focuses on individuals in the context of their group. Understanding how individuals affect their group and how the group, in return, affects them has important implications for things like disease transmission, mating opportunities, and gene flow (Boe & Faerevik, 2003; Craft et al., 2011; Hashimoto et al., 2001; Altmann et al., 1996). Social preferences and personal bonds can also help show that a permanent, multiple animal dynamic might be beneficial to captive animals. Many researchers have focused on what happens in the wild or looked for "naturalistic" settings to study animals to learn more about their socialization. Due to this, the literature on captive, fission-fusion dwelling animals is lacking.

Literature Review

Forming of social preferences.

Mammals tend to form societies that are complex systems influenced by the individual relationships that develop within the system (Crook et al., 1976). Being raised in a social group affects learning of typical behavior, i.e., their natural group influences their learning of behaviors (Boe & Faerevik, 2003). When an individual is a part of a group, they tend to acquire similar observable behavioral traits to the other animals they are around and vice versa.

During a period when an individual constructs their social network, they are constantly receiving feedback from their environment and giving their environment feedback as well; they are learning to prune their preferences (Flynn et al., 2013). For example, when an animal is young, they socialize with many individuals, and based on the feedback (i.e., a display of aggression or engaging in social play) decide what socialization ties should be pruned and which should be kept. In mice, this accredited to the animal's biological plasticity that are learned at a very young age (Williamson et al., 2016). The individual might modify these behaviors to fit the social group or shape the social groups to fit their chosen behaviors, as has been found in rhesus monkeys (Hinde & Atkinson, 1970). For instance, one individual might groom others while in one group, but not when that same individual is in another group. It also allows for them to account for negative interactions by assisting them to tailor their social preferences (Stanley et al., 2018). If a social preference occurs over an extended time period, it is then considered to be a relationship or a tie (Durrell et al., 2004; Wey et al., 2008).

Measurement of social preferences.

To measure social preferences, researchers can use a social network model to get a better understanding what is going on within a group. Social network models are a system that can be

composed of nodes (individuals) and their ties (connections). A tie is defined as a relationship between two nodes (Wey et al., 2008). In a social network specifically, ties can be used to define social interactions. A social network model provides information about a social group and can help quantify the group and individuals' interactions. It also allows for models of the structure of the group to be composed.

Among animals, relationships can be studied in many ways, one of which being social interactions (Wey et al., 2008). Ties can have weights representing the strength of the relationship among individuals. A significant tie is defined as an individual having a regular occurring relationship with another individual at a higher rate than would be expected based on the existence of no social preferences (Farine & Whitehead, 2015; Wey et al., 2008). Within this measure, there can also be a difference in the directionality of ties. Individual A can be significantly tied to individual B, but individual B might not be significantly tied to individual A. Social network models help researchers quantify the social relationships animals present and better understand social organization among them.

Influences within a group.

Another aspect of social organizations for ungulates, such as giraffes, is that individuals fluidly move from one social group to another to fit their current needs, exhibiting fission fusion. As a result, many individuals exhibit unique behavioral tendencies due to being exposed to different social groups; this suggests that individual members of a group can, in fact, influence other members of the group (Cote et al., 2010).

Animals do have clear social connections throughout membership changes and environmental changes (Carter et al., 2013a). Wild giraffes have been found to exhibit differential social preferences based off of many factors like gender, status, and age (Carter et al.,

2013a). As previously stated, through developing social preferences, individuals can associate with many members of different groups, solely based off of individual preferences (Stanley et al., 2018). This can also cause individuals to act differently based on their current group membership, leading to social conformity. Social conformity is defined as animals comprising their own behavior to the extent that certain, exact behaviors can be witnessed throughout the group (Claidière & Whiten 2012). Social conformity has been found to be driven by individual differences based on the concept of behavioral plasticity (Fürtbauer & Fry, 2018), which is defined as the ability to change and acquire new behaviors, differing from one's previous behaviors (Gherardi et al., 2012). These implications are why researchers believe that group cohesion and behavioral synchrony are widespread throughout the animal kingdom and what might cause the social ties to remain after a member is taken from a group.

In fission-fusion societies, group living is a common thing to observe, and social conformity is implemented as a way to keep group cohesion (Fürtbauer & Fry, 2018; Lecheval et al., 2018). Social network analyses, in the wild, provide opportunities to observe and analyze the naturality of social relationships in between animals, including their behavior, group structure, and specificity of their social bonds (McCarthy et al., 2019). While wild giraffes have been studied thoroughly, there remains a gap in the literature about what role environmental influences and changing environments play in the forming and maintaining of social bonds.

Stability in the group.

Furthermore, social networks are comprised of individual and group characteristics, which have been found to be constant even after disturbances throughout the social network (Formica et al., 2017). This means that observable group characteristics are found throughout the network, no matter if the group membership fluctuates. Social bonds can fluctuate greatly; it

has been found that something as mundane as the seasons can influence these social networks (Prehn et al., 2019). Ungulates have been found to exhibit flexible group patterns based on habitat, resources, and predation (Jarman, 1974). When habitats are good and resources are plenty, ungulates tend to socialize more than when resources are scarce, and habitats are bad. It has also been found that indirect social connections (a friend of a friend) can influence the third party's behavior (Brent, 2015). In many mammals, males are the sex that disperse upon sexual maturity (Primates: Altmann et al., 1996; Giraffes: Prehn et al., 2019). Prior literature might also point to the fact that undesirable traits (such as an abnormality in physical appearance) can lead to an individual being evicted, much like has been seen in humans (Popescu et al., 2011).

Wild giraffes' social bond's stability and robustness has been studied intensely, and it has been found that their social ties appear to be stable over time. Though older studies of giraffes concluded that social bonds can be loose and temporary (Le Pendu et al., 2000), it has since been found that there is a clarity to their social interactions (Prehn et al., 2019). For example, there are distinct sex and age differences within the ungulates. Female social behaviors wax and wane with the seasons, whereas males appear to maintain their social behaviors throughout the year (Prehn, et al., 2019). Females have been thought to associate differently based off of resource availability (Le Pendu et al., 2000). Young giraffes in the wild have been found to have more social ties than older giraffes (Le Pendu et al., 2000). When an animal is young, they socialize with many individuals, and based on the feedback from the other individual, they decide what socialization ties should be eliminated and which should be kept (Williamson et al., 2016). Overall, however, wild giraffes have clear, robust social bonds that can change with the seasons, but nevertheless remains significant (Prehn et al., 2019). Despite the extensive research on wild-

living giraffes, there remains a gap in the literature about how group membership changes influence captive animal's social networks when membership status changed.

Disease and wellness.

Social behaviors and bonds can be beneficial to individuals involved but have been known to cause the spread of disease (Balasubramaniam et al., 2019). It has been found that group size has a positive correlation in disease transmission among animals (Côté et al., 1995). In deer a direct cause of disease spread was close living and feeding (Thompson et al., 2010). In contrast, social grooming can help mitigate the spread of diseases, and social bonds have been found to help moderate stress (Balasubramaniam et al., 2019; Border et al., 2019; Foister et al., 2018). In primates, social grooming has also been found to increase social cohesion (Kanngiesser et al., 2011). Subsequently, social cohesion has been found to decrease stress (Young et al., 2014), which is important as stress has been found to decrease animal's immune system causing them to contract diseases at a higher rate (Selye, 1955).

Overall, analysis of social networks has many implications in animal welfare. Animal welfare is defined in regard to how an animal is coping with the conditions in which it lives. Through analyzing their social networks, zoological organizations can use proper husbandry techniques and exhibit animals in a manner beneficial to their wellness. Studying captive animal's social ties could benefit captive facilities in many ways, such as: better husbandry techniques, higher reproductive success, and overall better welfare.

As social interaction is an essential factor in shaping an animal's life history, the ability to understand the social causes and consequences of husbandry practices is essential for understanding animal welfare in zoological organizations. Social interactions have also been found to enhance the health status of the animal, which ultimately is the goal for all zoological

organizations (Krause et al., 2002). Furthermore, stable social systems have been proven to reduce aggression across multiple environments (CôTé, 2000). Social network analysis methodology has helped identify the importance of group structure and associations, individual preferences, individuals that connect sub-groups, and individuals that are the cause of cohesion within the group (Krause et al., 2009). As such, scientists could take away an understanding of how to make zoological exhibits more beneficial to both the animals and humans. Researching social networks and social relationships can show the role that social interactions play in shaping the welfare of animals in captive settings (Boe & Faerevik, 2003). Prior research has shown that giraffes across multiple zoological facilities are capable of maintaining stable social bonds and could be generalized to most captive giraffe facilities (Bashaw, 2011). However, the literature on how these bonds are maintained throughout membership variation is lacking.

The present study.

Previously, giraffes have been described to have little to no social pattern and weak social bonds (Foster & Dagg, 1972). However, recent research has proven otherwise as a clear pattern of socialization based off of kinship and personal social preferences in wild giraffes (Carter, et al. 2013b; Bercovitch & Berry, 2013). Earlier research has also shown that the removal of a giraffe from a cohesive group in a zoological setting causes the remaining giraffes to display signs of stress and increases in stereotypical behavior (Tarou et al., 2000). This indicates that when a significant social bond is severed, it can lead to negative behavioral markers.

The Jacksonville Zoo and Botanical Gardens (JZBG) had a total of ten giraffes located in an exhibit that has outside access and a night house. There were three males and seven females; the males ages ranges from 1 year to 4 years and females ranged from 2 years to 19 years old. Out of the ten giraffes, five were paternally related off-springs from two of the adult females and

three have no relation to the other seven. Within this setting, a naturalistic occurrence of fusion-fission can be observed. The JZBG removed the eldest male, Sir Isaac. This simulates what might occur in the wild with group membership changing. In the wild, it is often seen that males leave their female siblings in search of a mate (Altmann et al., 1996). Thus, the present study has implications related to the animal's welfare due to the behavioral changes they might exhibit with losing one member and gaining another. Based on previous research, I hypothesized that when one of the individuals in the group was removed, the previous significant social ties would remain significant. Specifically, I expected there would not be significant changes within the group in how they interact. For example, the frequency of approaches would be approximately the same both before and after removal. Furthermore, I expected same age groups and same sex groups to be defining variables across the two data sets, in regard to social organization.

Methodology

Study Site and Subjects

The Jacksonville Zoo and Botanical Gardens (JZBG) giraffe exhibit is a fenced in area that is approximately 5,205.17 m^2, that includes a feeding station and a viewing platform (Figure 1). There is also a connected housing unit used to keep the giraffes from 16:00 - 10:00. Captive giraffes (N = 10) housed at the JZBG in Jacksonville, Florida were used for the study. The identification of each individual was done before data collection started using an ID chart comprised of their unique coat. Photographs of the giraffes were taken from multiple angles. A profile was then made of each individual including their name, sex, and age (Table 1). The average age for both sets of data was 8, ranging from 1 year to 19 years. During data set one collection, there were three males and seven females, five paternally related, belonging to two

mothers. During data set two collection, there were two males and seven females, four paternally related, belonging to two mothers; Sir Isaac was removed from this group. All had access to outside exhibits that have conjoining night houses. It is important to note that the JZBG did not have a breeding male giraffe while data was collected. The giraffes were fed according to their normal schedule and had access to water as needed. The project was approved by the JZBG research committee.

Procedure for Data Set One

All ten giraffes were on exhibit during this data collection period. They were observed, longitudinally, for 15 hours throughout the span of two months. All observations were recorded from the viewing platform (see star in Figure 1). Data was collected for one 50-minute observation period between 10:00 and 13:00 using zoo monitor software on an iPad. There were three kinds of focal sampling used throughout the observation period: all occurrence, proximity measure, and space usage.

During all occurrence sampling, a single individual was chosen at random and observed for five minutes. All self-directed behaviors and social interactions involving that individual was recorded. The behaviors recorded during each observation are outlined in the behavioral ethogram (Table 2). The main behavior that was used for data analysis purposes was an approach. An approach was recorded when one individual approached the focal individual within two neck lengths (Bashaw et al., 2007 & Carter et al., 2013a). This measurement reflects a close proximity to the focal individual. Proximity and space use measures were taken at the beginning of the five-minute interval when a new individual's sampling started. Proximity reflected which individual(s) was closest to the focal individual at the beginning of the interval. Space usage reflected where the focal individual was located at during the beginning of the interval. After the

focal period ended, another individual was chosen at random. Reliability was tested using ZooMonitor's reliability function. Researchers took data at the same time on the same individual and then ZooMonitor produced a percent of congruency. To pass the reliability test for this study, researchers were required to make a 95% on three separate occasions before they could start collecting data.

Procedure for Data Set Two

There were nine giraffes on exhibit during this data collection period. Sir Isaac was becoming sexually mature and to avoid incestual breeding, he was removed from the facility. The giraffes were observed, longitudinally, for 21 hours throughout the span of three months. All other procedures were the same as in the procedure for data set one.

Analysis

Data was taken on the iPad and then uploaded to ZooMonitor's server. It was then downloaded through a cloud onto a desktop, where it could be analyzed. The data was analyzed using R packages (R Core Team, 2017). A permutations test was used to determine which individuals had significant ties to other individuals, this was performed on both data sets. Approach rate was the dependent variable, while explanatory factors included an individual's significant ties to others within the group. This model is used in order to create a null distribution of approaches (Kohn, 2018). An exponential-family random graph model (ERGM) was conducted on both sets of data as part of the StatNet package (Handcock et al., 2018; Hunter at al., 2008; Silk et al., 2017). This model is used to assess the factors that produced the approach rates. Approach rate was the dependent variable, while explanatory factors included reciprocity. A nonparametric Wilcoxon singed-rank test was used to determine the group differences in rate of interactions by comparing the rates before Sir Isaac left the facility and after Sir Isaac left the

facility (Kohn et al., 2015). Approach rate was the dependent variable, while explanatory factors included an individual's sex and age. This model is used in order to distinguish if the group became more organized by sex and age after the departure of Sir Isaac. All of the priorly mentioned tests were based off of a within-subjects design. All assumptions of the tests ran were met. The difference in the hours collected within the data sets were accounted for.

Results

A permutation test was performed to see if there were any significant ties in data set one and two. The data was permuted by rows at least 100,00 times to create a null distribution, and determined if the observed distribution, fell within a 5% tail (meaning 95% of the observations calculated in the null distribution were below the observed interaction between those individuals). Data set one had four significant ties, while data set two had no significant ties. As previously stated, a significant tie is defined as an individual having a regular occurring relationship with another individual at a higher rate than would be expected based on the existence of no social preferences (Farine & Whitehead, 2015; Wey et al., 2008). For this study's purposes, a significant tie was measured according to the amount of approaches an individual made to another individual. Within data set one, Luna had a significant tie to Izzy ($P = 0.040$). Duke Junior had a significant tie to Izzy ($P = 0.040$). Izzy had a significant tie to Duke Junior ($P = 0.010$) and to Lily ($P = 0.039$). All null findings are listed in the supplementary results page.

An exploratory analysis (ERGM) was done on the data following the permutation test. Within Data set one (with Sir Isaac), 218 approaches were observed during this period. The average number of approaches per individual was 21.800. The ERGM was used to establish if there was any reciprocity within the group. There was significant reciprocity within the sample (ERGM: coefficient = 1.913, $SE = 0.219$, $Z = 8.741$, $P < 0.000$). This means that when one

individual approached another, the receiver of the approach also approached the actor later in the observational period. Within data set two (without Sir Isaac), 110 approaches were observed during this period. The average number of approaches per individual was 12.222. There remained significant reciprocity within the sample (ERGM: coefficient = 1.568, $SE = 0.285$, $Z = 5.504$, $P < 0.000$). The Wilcoxon signed-ranks test was used to establish if the group composition became more organized by sex or age. There was a significant increase in rate of interactions between the females and between males when the datasets were compared (Wilcoxon signed-ranks test: $V = 4.500$, $P = 0.038$, $r = 0.692$), whereas there was no significant difference in the rate of interactions between same age groups when the datasets were compared (Wilcoxon signed-ranks test: $V = 7.500$, $P = 0.083$, $r = 0.178$). A network plot was done of the data before Sir Isaac was removed (Figure 2) and after Sir Isaac was removed (Figure 3) to show the shift in the network plot.

Discussion

As social network analysis aids in strong bonds being identified, captive management can use these analyses to preserve significant dyadic bonds. In prior research, wild giraffes were found to have clear significant ties no matter the statuses of others (Carter, et al., 2013b). Data on what occurs to social networks when a captive giraffe is permanently taken from a zoological facility is lacking. The present study aimed to fulfill that gap by presenting a case study on what the social network looked like before and after membership changed. I hypothesized that when one of the individuals in the group was removed, the previous significant social ties would remain significant. Specifically, I expected there would not be significant changes within the group in how they interact. For example, the frequency of approaches would be

approximately the same both before and after removal. Furthermore, I expected age and sex to be defining variables across the two data sets.

Significant social ties

The permutation test showed that in data set one there were significant social ties while data set two had no significant social ties. What the findings of the present study suggest is that when an individual is removed permanently from a captive scenario, the social ties do in fact change significantly. Sir Isaac was not found to have any significant ties; however, his departure did affect the significant social ties. There was also a drastic difference in approaches recorded without him there. In data set one there were 218 approaches in a 15-hour period, while in data set two, there were 110 approaches in a 21-hour period. The average approach rate per individual was decreased by half. Prior research has shown that wild giraffes do maintain long-term significant bonds (Carter et al., 2013a; Formica et al., 2017).

The ERGM suggests that with or without the presence of Sir Isaac, we are still seeing a significant rate of reciprocity in approach behaviors; this suggests that no matter if membership changes, reciprocity still remains intact. Prior literature has shown reciprocity to be found in primates (Voelkl & Kasper, 2009), but not studied within giraffes. Because there is no prior research on reciprocity in giraffes in regard to sociality, this information could be used to reinforce the idea that individuals do have specific preferences throughout varying membership changes; furthermore, it shows that an individual who interacts with another individual is more than likely to be the recipient of the same behavior.

The Wilcoxon signed-ranks test showed that there was a difference in sex-to-sex interactions when Sir Isaac was removed from the group. This suggests that females interacted more with females and males interacted more with males when he was removed, showing that

there were same-sex preferences. An explanation for this could be that Sir Isaac was the eldest male and was starting to exhibit breeding behaviors (i.e., interacting with females). However, when he was removed, that left only two, 1 year old males in the herd, who significantly interacted with each other. Furthermore, the females left that were of breeding age no longer had the opportunity to interact with a sexually mature male; these factors could account for it to appear that same-sex preferences emerged. Prior literature shows that giraffes do assort by sex, especially females when the resources change (Le Pendu et al., 2000). In this case, the resource would be the only breeding male, when he was removed the females might have interacted more with each other due to the lack of the need to compete.

Research Implications

Group membership changes within captivity might not promote stable social bonds, as suggested by individuals in the present study approaching each other less and not maintaining significant bonds after the removal of a group member. Due to these findings, captive keeping facilities could try to limit the removal of individuals in order to not disrupt the stable social bonds established. A thorough review of the effects across multiple facilities should be done to help inform and guide the Association of Zoos and Aquariums' and the Species Survival Plan Programs' ideas about how to achieve genetic diversity without harming the welfare of captive giraffes.

While both of these organizations consider sociality when moving individuals from one facility to another, they could use information like this to better assess their current methodology. Prior research has shown that in primates, social structure can be predicted by the genes of the animals and age (Altmann et al., 1996). Furthermore, behavior and social structures can also predict genetic measures such as reproductive success and relatedness in group living. Social

network analyses aid in predicting chronic aggression in some animals and have also shown that tool use can be passed to future generations due to their exposure to these behaviors (Hobaiter et al., 2014). Mate choice patterns in social domains have been found to shift with environmental changes; a male will choose different females under different situations, proving a mutualistic relationship in-between environment and social mate choices (Cohen, 2020). Looking at genetic make-up *and* animals' sociality would help better inform the Species Survival Plan Program on which animals could be removed from specific social groups in captive facilities.

Furthermore, with the Association of Zoos and Aquariums' new regulations for animal welfare requiring that assessments be done before any "major life event" occurs in a zoological setting, they could extend it so that zoos are doing an assessment before individuals are removed, during the waiting period, and after new individuals are added. This might ensure that the animals return back to their baseline.

Limitations and Confounds

With any study, there is noted limitations and confounds. Confounds for this study include there was no breeding male within the JZBG's herd and an injury to a member of the herd occurred that left Ivy mostly immobile throughout part of data collection one and all of data collection two. Another confound could be seasonal changes. Limitations for this study include that it was a case study and the herd had varying numbers of individuals during the sampling periods. Another limitation is that there was no comparison group, which would have likely ruled out some of the confounding variables.

Future Directions

The existing guidelines of removing individuals from their birthing place could be reexamined, and a review of the effects across multiple zoos could benefit the overall wellness of

the captive kept giraffes. Existing literature suggests that wild giraffes are capable of maintaining long term bonds (Formica et al., 2017). Is the shift in stable bonds at the JZBG due to membership changes that are permanent? In the wild, members of herds tend to leave and return throughout the seasons (Prehn et al., 2019). The results of the present study implies that there might be something different occurring in the captive giraffes' social ties when a member is removed that is not seen in the wild. Future studies could broaden this study from a single case study, to multiple studies that include many zoos. This study could also be replicated to include a giraffe population with a high-ranking, breeding male, and see if the departure of another member carries the same weight. Furthermore, seasonality is a known factor that affects wild giraffes' sociability, the present study's mentioned data was taken within two different seasons, which could have had an effect on the giraffes' sociability (Prehn et al., 2019).

Wild giraffes exhibit changes in their social dynamics, yet their social bonds appear to be stable (Prehn et al., 2019). Yet, at the JZBG this is not what is found. The significant ties did not maintain throughout membership variation and they did not exhibit the same order as wild giraffes. Organizations like the Species Survival Plan Program and the Association of Zoos and Aquariums could further investigate what is exactly going on with captive managed giraffes and how could they better maintain stable social bonds within captive facilities.

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Figure 1

Jacksonville Zoo and Garden's Giraffe Exhibit

Figure 2

Network Plot with Sir Isaac

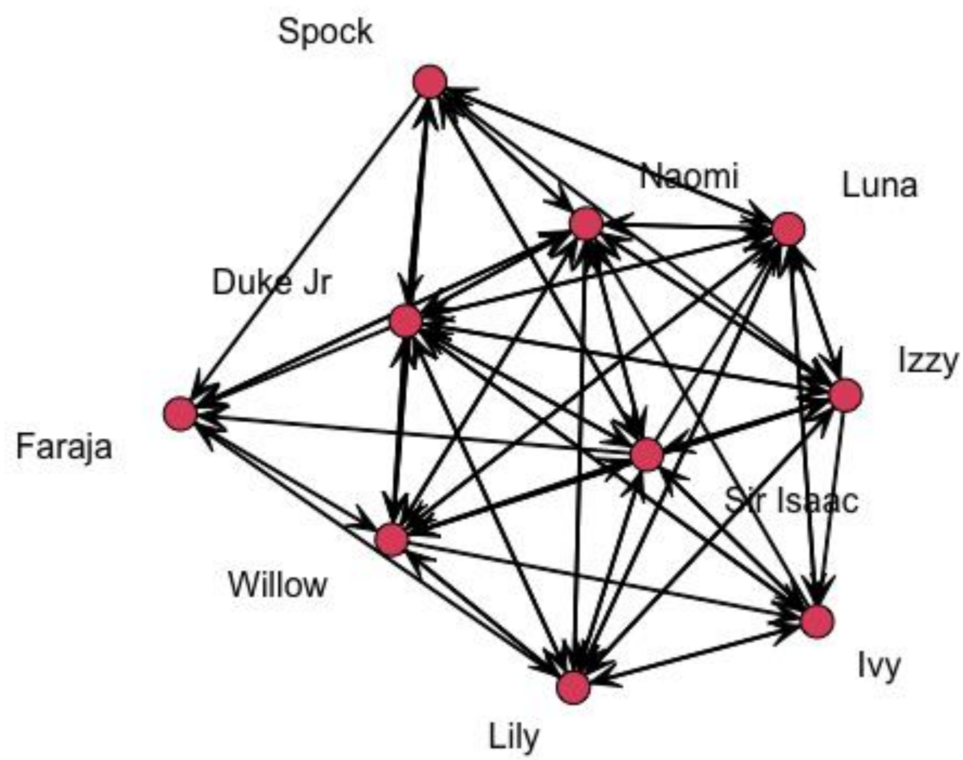

Figure 3

Network Plot without Sir Isaac

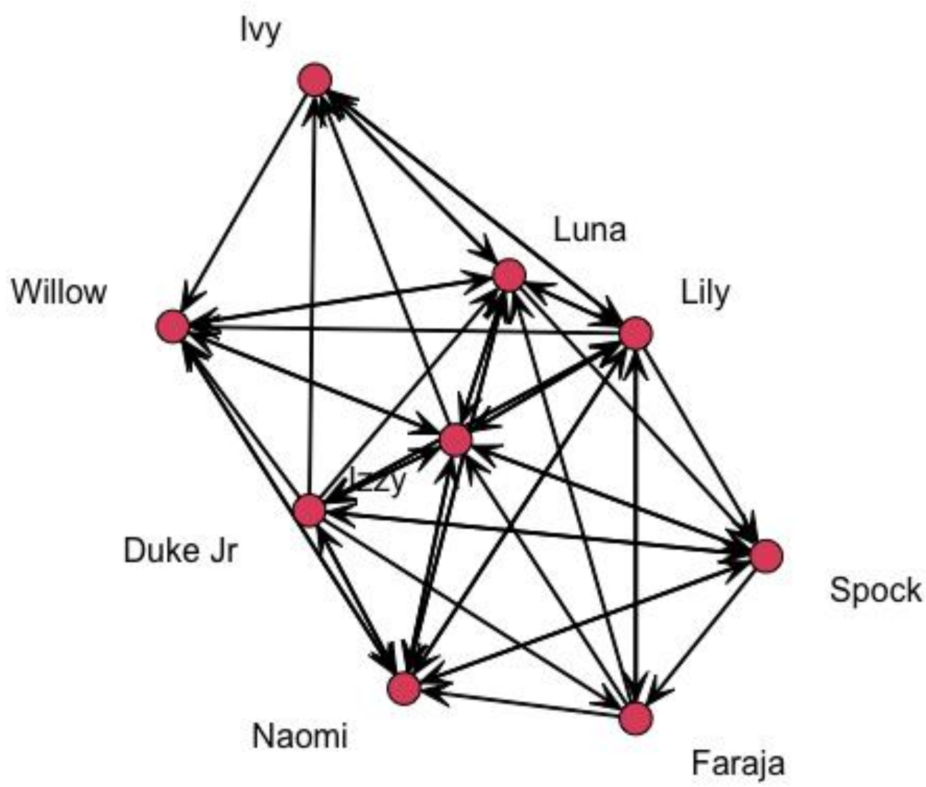

Table 1

Giraffe Profiles

Name	Sex	Age
Izzy	Male	1
Duke Junior	Male	1
Ivy	Female	2
Lily	Female	4
Sir Isaac*	Male	4
Willow	Female	4
Luna	Female	12
Faraja	Female	14
Naomi	Female	14
Spock	Female	19

*Present for data set one, but not for data set two

Table 2

Behavioral Markers Recorded on an All-Occurrence Basis for the Focal Individual

Social Behaviors	Definition
Mount	Focal individual mounts, successfully, another giraffe
Nuzzling	Social behavior that involves rubbing against another animal, sometimes leading to an entwining of the necks.
Displacement	An individual standing behind another one, proceeds to push or move the other animals from where the original individual was standing
Approach	Individual moves to proximity with another animal. Individual must appear to be moving directly towards another animal
Social Play	Focal individual frolics with another animal (running beside another individual or leaping beside another individual)
Approach (Contact)	Focal individual moves to contact with another animal.
Necking	Focal individual rubs necks with another giraffe
Head Rub	Focal individual rubs head on any part of another animal's body
Sentinel	Focal individual approaches another animal that is lying and stands in proximity to them
Urine Testing	Focal individual licks the urine of another animal

Attempted Mount	Focal individual attempts to mount another giraffe
Co-Feeding (Other)	Focal individual is feeding at the same time as another animal within proximate measures
Copulation	Focal individual engages in sex
Nursing	Focal individual suckles on udders of another giraffe
Rejective Mother	Focal individual rejects nursing attempt
Displace	Focal individual displaces another individual
Displaced	Focal individual is displaced by another individual
Sparring	Focal individual stands next to another animal and repeatedly throws head or neck towards another individual
Avoid	Focal individual moves away in avoidance when another individual approaches
Co-feeding (Feeders)	Focal individual is feeding at the same time as another animal within proximate measures
Contact Yield	Focal individual is the receiver of aggression
Bumping	Focal individual strikes at any part of another individual

Aggression	Focal individual makes contact with another individual in an aggressive manner (biting, kicking, head butting)
Not Visible	Focal individual moves out of sight - note what time
Other	Focal individual exhibits other behavior than listed

Non-social behaviors	Definitions
Standing	An individual is standing two neck lengths from another individual not interacting
Locomotion	An individual is walking/running
Browsing	An individual is looking for food (usually with their head lowered, but can be them extending their necks to reach a tree)
Station use	An individual is at the designated feeding station, interacting with guest
Feeders	An individual is at any of the given feeder stations, eating
Water	An individual is at any of the given water stations, drinking

Supplementary Results

A Wilcoxon signed-ranks test showed that there was no significant difference in the rate of interactions between same age groups when the datasets were compared (Wilcoxon signed-ranks test: $V = 7.5$, $P = 0.083$). This means that their sociality was not assorted by age. A permutation test was performed to see if there were any significant ties in data set one and two, data set one had four significant ties, data set two had no significant ties. For data set one: Izzy was not found to have any significant ties to Ivy ($P = 0.518$), Sir Isaac ($P = 0.698$), Willow ($P = 0.520$), Luna ($P = 0.231$), Faraja ($P = 1.000$), Naomi ($P = 0.229$), and Spock ($P = 1.000$); Duke Junior was not found to have any significant ties to Ivy ($P = 0.391$), Lily ($P = 0.389$), Sir Isaac ($P = 0.108$), Willow ($P = 0.701$), Luna ($P = 0.110$), Faraja ($P = 0.700$), Naomi ($P = 0.394$), and Spock ($P = 0.700$); Ivy was not found to have any significant ties to Izzy ($P = 0.100$), Duke Junior ($P = 0.521$), Lily ($P = 0.391$), Sir Isaac ($P = 0.111$), Willow ($P = 0.100$), Luna ($P = 0.230$), Faraja ($P = 1.000$), Naomi ($P = 0.702$), and Spock ($P = 1.000$); Lily was not found to have any significant ties to Izzy ($P = 0.388$), Duke Junior ($P = 0.390$), Ivy ($P = 0.388$), Sir Isaac ($P = 0.228$), Willow ($P = 0.228$), Luna ($P = 0.517$), Faraja ($P = 0.699$), Naomi ($P = 0.231$), and Spock ($P = 1.000$); Sir Isaac was not found to have any significant ties to Izzy ($P = 0.518$), Duke Junior ($P = 0.701$), Ivy ($P = 0.519$), Lily ($P = 0.519$), Willow ($P = 0.390$), Luna ($P = 0.391$), Faraja ($P = 0.699$), Naomi ($P = 0.233$), and Spock ($P = 0.702$); Willow was not found to have any significant ties to Izzy ($P = 0.522$), Duke Junior ($P = 0.110$), Ivy ($P = 0.230$), Lily ($P = 0.231$), Sir Isaac ($P = 0.391$), Luna ($P = 0.111$), Faraja ($P = 1.000$), Naomi ($P = 0.392$), and Spock ($P = 0.702$); Luna was not found to have any significant ties to Izzy ($P = 0.040$), Duke Junior ($P = 0.518$), Ivy ($P = 0.517$), Lily ($P = 0.109$), Sir Isaac ($P = 1.000$), Willow ($P = 0.389$), Faraja ($P = 1.000$), Naomi ($P = 0.229$), and Spock ($P = 0.519$); Faraja was not found to have any

significant ties to Izzy (*P* = 1.000), Duke Junior (*P* = 1.000), Ivy (*P* = 1.000), Lily (*P* = 1.000), Sir Isaac (*P* = 1.000), Willow (*P* = 0.702), Luna (*P* = 1.000), Naomi (*P* = 0.700), and Spock (*P* = 1.000); Naomi was not found to have any significant ties to Izzy (*P* = 0.388), Duke Junior (*P* = 0.389), Ivy (*P* = 1.000), Lily (*P* = 0.111), Sir Isaac (*P* = 0.697), Willow (*P* = 0.230), Luna (*P* = 0.231), Faraja (*P* = 0.701), and Spock (*P* = 0.699); Spock was not found to have any significant ties to Izzy (*P* = 0.517), Duke Junior (*P* = 0.699), Ivy (*P* = 1.000), Lily (*P* = 1.000), Sir Isaac (*P* = 0.521), Willow (*P* = 0.697), Luna (*P* = 0.390), Faraja (*P* = 0.388), and Naomi (*P* = 0.699). In data set two no significant ties in between any individuals was found.