Research report

Author: L. M. Tuk

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A comparison of the social network structure between two groups of captive Alouatta caraya.

Author: L. M. Tuk

Course: Animal health and management

Instructing party: Aeres University of Applied Sciences

Graduation coach: L. Spit

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Foreword

Before you lies the research report for my senior year thesis “A comparison of the social network structure between two groups of captive Alouatta caraya.”. This is part of my graduation process at Aeres University of Applied Sciences and serves to create a complete and clear picture of research conducted with two groups of howler monkeys at Port Lympne Park in the United Kingdom.

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It has taken me a long time to construct this paper and I am very thankful to Ms. Spit for her valuable feedback during its construction. I would also like to thank Ms. van der Vegt, as well as Ms. Spit for being there to bounce ideas off and for answering all of my questions.

My gratitude goes out to the ever so helpful staff at Port Lympne and the Aspinall Foundation and I would specially like to thank Ms. De Pasquale Wood for her help and Ms. Conti for her enthusiasm regarding my research, helping me identify the monkeys and providing information as well as our enjoyable and insightful conversations.

Laura Tuk
Dronten, May 2018

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Summary

Howler monkeys (genus *Alouatta*) are new world monkeys native to Central and South America. Although the overall population of howler monkeys is declining due to habitat loss and the illegal trade, their status, as categorised by the IUCN Red List of Threatened Species (2017), ranges from Least Concern to Endangered. Howler monkeys usually end up in captivity through the illegal wildlife trade and their subsequent confiscation and relocation to rescue centres or zoos. Most individuals kept in captivity are black howler monkeys (*Alouatta caraya*), which is why this paper focuses on this species.

There are many factors which can influence animals' behaviour in captivity, such as the lack of space, predators and the lack of threat of starvation. Gathering information on social structures and group dynamics can be very helpful in captive animal management. Very limited research has been conducted on captive howler monkeys and little is known about howler monkeys' social network structures, in situ as well as ex situ.

This paper uses the social network analysis technique to explore the social network structure of two groups of captive *Alouatta caraya* at Port Lympne reserve. Social network analysis (SNA) is a collection of network analysis techniques with which to create a clear visual or mathematical representation of a group's social network. SNA assumes the importance of relationships among all individuals in a network and takes into account their individuality as well as their influence on the network as a whole (Wasserman S, 1994).

The two goups of *Alouatta caraya* at Port Lympne were observed for eight hours each over a period of a week in May 2018. The focal animal sampling technique (Mills and Nankervis, 1999) was used meaning that every relevant behaviour, as noted in an ethogram, was written down at the moment of observation.

During this research no evidence was found of a linear hierarchy in the two groups of *Alouatta caraya* at Port Lympne reserve. However, the older animals seem to be dominant over the younger ones, as do males over females. Although both groups consist of parents and their four young, and the sort of interactions and directionality of those interactions are similar, one group is very well-connected and cohesive whereas the other group is much less so.

Samenvatting

Brulapen (genus *Alouatta*) zijn apen van de Nieuwe Wereld, afkomstig uit Centraal- en Zuid-Amerika. De brulapen populaties nemen af door het verlies van hun natuurlijke leefomgeving en de illegale handel. De IUCN Rode Lijst van bedrijgde soorten (2017) categoriseerd de soorten brulapen van niet bedreigd tot bedreigd. Brulapen komen vaak in gevangenschap terecht door de illegale handel in wilde dieren waarna ze in beslag genomen worden en verplaatst worden naar opvangcentra of dierentuinen. Zwarte brulapen (*Alouatta caraya*) worden het meest in gevangenschap gehouden en daarom is deze studie op deze soort gericht.

Er zijn veel factoren die invloed kunnen hebben op het gedrag van dieren in gevangenschap zoals het gebrek aan ruimte, natuurlijke vijanden en de het feit dat de dieren niet zullen verhongeren. Informatie over sociale structuren en groeps dynamieken kan helpen in het managen van dieren in gevangenschap. Er is weinig onderzoek gedaan naar brulapen in gevangenschap en er is weinig bekend over de sociale netwerk structuur, zowel in het wild als in gevangenschap.

Dit onderzoek maakt gebruik van de sociale netwerk analyse technique om de sociale netwerk structuur van twee groepen *Alouatta caraya* in Port Lympne te onderzoeken. Sociale netwerk analyse (SNA) is een collectie van network analyse technieken waarmee een duidelijk visueel of mathematisch beeld gecreëerd kan worden van het sociale netwerk van een groep. SNA gaat uit van het belang van relaties tussen individuen in een netwerk en houd rekening met hun individualiteit en de invloed die zij hebben op het netwerk als geheel (Wasserman S, 1994).

De twee groepen *Alouatta caraya* in Port Lympne zijn beide acht uur lang geobserveerd gedurende een periode van een week in mei 2018. Er is gebruik gemaakt van de focal animal sampling techniek (Mills and Nankervis, 1999) waarbij ieder relevant gedrag, zoals weergegeven in een ethogram, werd genoteerd op het moment van observatie.

Dit onderzoek heeft geen bewijs van een lineaire hierarchie gevonden in de twee groepen *Alouatta caraya* in Port Lympne. De oudere dieren lijken dominant te zijn over de jongeren en de mannen lijken dominant te zijn over de vrouwen. Ondanks dat beide groepen uit ouders en hun vier jongen bestaan, en de interacties en richtingen van deze interacties op elkaar lijken, is een groep erg dicht met elkaar verbonden terwijl de andere groep dit in veel mindere mate is.

Chapter 1 Introduction

Howler monkeys (genus *Alouatta*) are new world monkeys that belong to the *Atelidae* family. New world monkeys are most easily recognised by their flat noses with side-facing nostrils and their prehensile tails, a feature which only occurs within some new world monkey species. The exact number of howler monkey species is unclear, however, most sources categorise ten or eleven species and subspecies (CITES 2018; IUCN 2017). They are native to Central and South America with most of the species inhabiting multiple countries. Although the overall population of howler monkeys is declining due to habitat loss and the illegal trade, their status, as categorised by the IUCN Red List of Threatened Species (2017), ranges from Least Concern to Endangered. The listing depends on the species.

Howler monkeys are considered folivores. Their diet consists of different plant parts and flowers and is supplemented with fruits, both ripe and unripe (Estrada, 1984; Estrada, Juan-Solano, Ortíz Martínez, & Coates-Estrada, 1999; Pozo-Montuy and Serio-Silva, 2006). Because of their diet howler monkeys are well known for their specialised gut and intestinal microbiotics and elongated caecum. They have a very large gut transit time which makes fermentation of the high amounts of fibre in their diet possible (Chivers, 1994; Anapol & Lee, 1994).

In situ

Howler monkey species differ in multiple aspects such as colour, size and sociality. Group sizes range from two to twenty individuals, depending on the species. A group usually consists of multiple males and females but always more females than males (Mendes, 1989; Miranda & Passos, 2005; Treves, 2001). Males may compete to impregnate females but usually only the dominant male will succeed. The presence of multiple males in a group helps to collectively defend the group during encounters with other animals. Males who are closer related to each other will generally exhibit less agonistic behaviour towards each other (Oklander et al., 2014). Howler monkeys, males and females, migrate from their natal groups, temporarily living solitary or immediately forming new groups or integrating into existing groups (Calegaro-Marques & Bicca-Marques, 1996; Miranda, 2004; Miranda and Passos, 2005; Oklander, Kowalewski, & Corach, 2010). Because most *Alouatta* migrate, groups will usually consist of multiple unrelated individuals (Oklander et al., 2014). It is unclear exactly why howler monkeys migrate and why they migrate at different ages.

In most cases the males are dominant, although there are also reports of groups with a dominant female (Chiarello, 1995; Mendes, 1989; Miranda et al., 2004; Treves, 2001). Even in groups with a dominant male cases have been reported of females driving out (dominant) males from groups. No research is available on this subject specifically but it is suspected that this behaviour is an attempt of, most often pregnant, females to avoid infanticide (Mendes, 1989; Miranda et al., 2004). Like in many different primate species, infanticide has been observed in howler monkeys (Calegaro-Marques & Bicca-Marques, 1996; Clarke, 1983; Clarke, Zucker, & Glander, 1994). It often occurs after a male takes over a group and is thought to be a way how new dominant males shorten the interbirth interval and make sure their genes are passed on instead of another male's genes. Most of the infants that are killed belong to high-ranking females whom only the previous dominant male would have fathered offspring with, thus minimising the risk of a new dominant male killing his own offspring (Clarke, 1983). Although research on multiple groups of *Alouatta caraya* shows that most females copulate with all males within a group as well as with males from other groups, infants are typically fathered by only one dominant male (Oklander, Kowalewski, & Corach, 2014).

Ex situ

Howler monkeys usually end up in captivity through the illegal wildlife trade and subsequent confiscation and relocation to rescue centres or zoos. As from 2012, the ISIS-ZIMS database has contained information on 70 zoological institutions worldwide in possession of howler monkeys, of which 58 have held black howler monkeys (*Alouatta caraya*), the reason why this paper focuses on this species.

Howlers rarely breed in captivity (Crokett, 1998; Gomes, 2003). Of all the species, *Alouatta caraya* have been bred most successfully in captivity (Gomes & Bicca-Marques, 2003). It is essential to gather more insight into the factors that affect reproductive success in captivity when it comes to endangered animals, as breeding programs and reintroduction programs can help to ensure a species' survival. One of the main factors that have been shown to play an important role in captive breeding is social grouping (Farmer, Plowman, & Leaver, 2011). As wild groups of *Alouatta* usually consist of unrelated individuals it is important to note that reproductive success in captivity has been found to be higher in *Alouatta* that are kept in family groups than those who are kept in mixed groups or in pairs (Farmer, Plowman, & Leaver, 2011).

Very limited research has been conducted on captive howler monkeys. Research suggests that captive males are generally dominant over females, the same as in the wild. Overall females exhibit more affiliate behaviour such as allogrooming and are less competitive. In cases where they do become competitive, such as over special food items, it is usually the males who act as control animals (Benton, 1976). Many factors can influence the social behaviour of animals that are kept in captivity. Captive animals have limited space compared to animals in situ and they no longer have the ability to migrate, as howlers do in situ. Also, predators or starvation do not pose a threat. All of these factors can change behaviour and group dynamics in captivity.

Gathering information on social structures and group dynamics can be very helpful in captive animal management. For example, recognising key individuals in a social network, who may be particularly important to the cohesion of the network, can provide a good indication of the results of removing certain individuals from a group (Kraus et al. 2007; Krause and Ruxton, 2002). Removing one or more group members may be necessary for medical purposes or when animals are exchanged between zoos or other institutions. Knowing the structure of a network can give insight into how animals adapt to changing environments (Krause & Croft & James, 2007). This could also help in establishing groups of animals and aid in breeding programs.

Little is known about howler monkeys' social network structure, in situ as well as ex situ. The results of some researches are conflicting or confusing. Howler monkey groups in situ consist of mainly unrelated individuals, but research shows that captive family groups produce more offspring than non-related in situ groups. It is unclear who the dominant individuals are in groups and if there are strict hierarchies.

What we do know about howler monkeys is that they are notorious for their difficulty adapting to captivity. As mentioned before, there are many reasons for gathering information on social structures within captive animal management. When it comes to howler monkeys, one important issue is stress. They are particularly susceptible to stress and avoiding stress is of vital importance when keeping howler monkeys in captivity (Benton, 1976). There are numerous different stressors and many of them are to do with sociality. Positive social interaction results in a decrease of stress and helps to build stronger bonds between individuals. Agonistic behaviour causes distress in primates (Abbott et al., 2003; Moberg & Mench, 2000). It is well known that a lack of cohesion and

excessive agonistic behaviour within a social group translates into group instability (McCowan B, Beisner BA, Capitanio JP, Jackson ME, Cameron AN, et al., 2011).

To gather more information on howler monkeys' social network structures in captivity, and in hope of aiding in captive howler monkey management, this paper uses the social network analysis technique to explore the social network structure of two groups of captive *Alouatta caraya.*

Social network analysis (SNA) is a collection of network analysis techniques which allow for incorporation of a range of relevant factors to create a clear visual or mathematical representation of a groups' social network. Factors of influence to an individual's behaviour include age, sex, social status and connections (Krause et al. 2007). Behaviour is not static or random but predictable when one looks at individuals' specific behavioural patterns, keeping the aforementioned factors in mind. SNA assumes the importance of relationships among all individuals in a network and takes into account their individuality as well as their influence on the network as a whole (Wasserman S, 1994).

As most howler monkeys kept in captivity are of the species *Alouatta carya*, this paper focuses solely on this species. Two groups of *Alouatta caraya* at Port Lympne Reserve (UK) were observed using a variety of SNA techniques to explore the possible effect of this network structure on group stability by looking at a multitude of factors such as the group cohesion and connectedness of individuals within the network.

Chapter 2 Research design

Subjects

The subjects are black howler monkeys (*Alouatta caraya*) divided into two separate family groups, Louie's group (Figure 1) and Tolkien's group (Figure 2), at Port Lympne Reserve in the United Kingdom. Each group is kept in a different enclosure; far enough apart to avoid the groups seeing each other but close enough to hear each other's howls. Multiple individuals are implanted or castrated to avoid pregnancies, this is represented by an (I) or (C) in the family trees below.

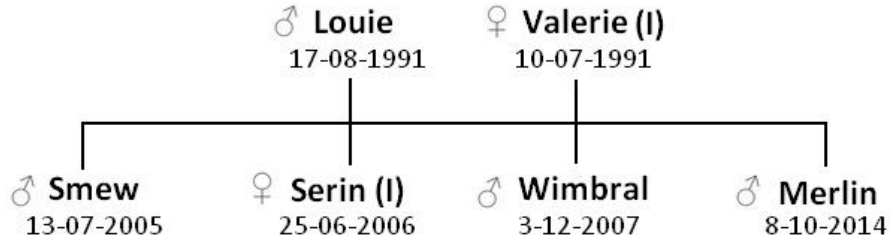


Figure 1 Family tree of Louie's group

Important to note is that Legolas (Tolkien's group) has bad eyesight which can influence his behaviour.

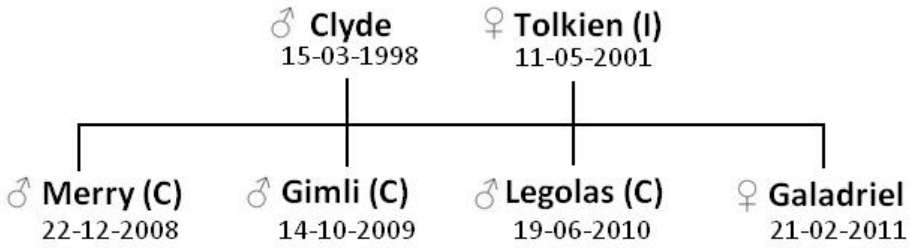


Figure 2 Family tree of Tolkien's group

Materials

- Digital camera (Nikon D90)
- Pen and paper
- Excel with the NodeXL template

Procedure

Both groups of animals were observed during different times of the day and in slightly different weather conditions; temperatures ranging from 12 to 19 degrees during rain, sun and clouds. Each group was observed for eight hours during a period of a week in May 2018. As planned, the first day a digital camera (Nikon D90) was used on a tripod to record the groups, which would make it possible to re-examine the footage and observe behaviour displayed by multiple animals simultaneously at a later date. However, as the animals were generally very calm and easy to observe simultaneously this was unnecessary and the camera was not used after the first day of observation. The layout of the

enclosures also made it difficult to position the camera in such a way that all of the enclosure would be clearly visible. Every interaction was simply written down at the time of observation.

Observation took place from behind the safety barriers placed around the enclosures. This limited the visibility of the enclosure and resulted in several blind spots in each enclosure.

Data recording

A cross-sectional approach was used for this study because of time restriction (Rees, 2015). The animals were observed by using the focal animal sampling technique (Mills and Nankervis, 1999). Every relevant interaction, as noted in the ethogram in Table 1, was noted.

The aforementioned ethogram was used to classify and recognize behavioural categories, which are specific indicators of network stability and instability. During this research the animals were seen exhibiting certain relevant behaviours not present in the ethogram composed for the research proposal. Behaviours such as growling, showing teeth, retreating and licking have been added in italics in the ethogram found in Table 1.

Table 1 Ethogram

Category	Behaviours
Affiliation	**Allogrooming, playing, huddling, hugging, sharing, *licking***
Agonism	**Fighting, chasing, biting, displacement, pushing, grabbing, *avoiding, growling, showing teeth, retreating***
Sexual behaviour	**Mounting, courtship, mating**

Notation of data

The collected data is shown through various SNA (Social network analysis) methods such as graphs and sociometrics to create a graphic representation of behaviour and relationships (Wasserman S, 1994). According to sociometry, interactions between pairs or individuals are the basis upon which the structure of societies are built and can, as a result, affect society as a whole (Scott, 2000). Sociograms offer a uniquely effective way to visually represent different types of information such as group cohesion, the existence and absence of connections (relationships) and indirect connections (connections between pairs of individuals which result from their mutual direct connection to a third party) (Brent et al. 2011b).

To create a clear picture of the relations between the individuals, the different categories of behaviour are shown through weighted network digraphs (directed graphs). These graphs show the frequency of behaviour through the thickness of the lines connecting individuals, whilst the directionality of the behaviour is visualised through the use of arrows. In the example shown in figure 3, individual B instigated more frequent contact with individual D than with individual A. In the example, individual A is called a key individual - an individual who bridges relationships - as A is the only one to interact with individual C whilst also interacting with the other group members. These connections, called edges, can be further elaborated by adding the frequency of behaviour.

Graphs such as figure 3 are a clear and simple way to show both the existence and absence of connections. Both are important as the removal of individual A in this example could result in a complete absence of social contact for individual C. The removal of key individuals can lead to fragmentation of networks which creates instability.

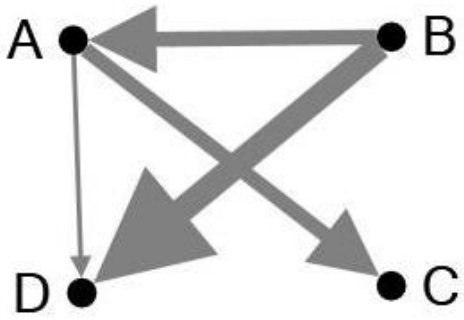


Figure 3 digraph

Table 2 Sociomatrix for a directed and weighted graph

	A	B	C	D
A	-	2	0	0
B	0	-	0	0
C	2	0	-	0
D	1	3	0	-

Table 2 shows a sociomatrix, which contains the same information as the digraph in Figure 3. The different representation of the same data can sometimes create a clearer picture and be easier to read, depending on the size of the network. A digraph will create a much clearer picture of relationships between 50 individuals than a sociomatrix, whereas a sociomatrix is often easier to read in cases of smaller networks. The thickness of the edges in figure 3 is translated into numbers in Table 2, which is a more specific way to represent this information.

In Social Network Analysis individuals are called nodes or vertices and relationships are called connections or edges. A number of different sociomatrices have been constructed for the following indices:

- **Node degree**—the number of edges one individual has to other individuals in a network.
- **Indegree**—the number of interactions an individual receives.
- **Outdegree**—the number of interactions an individual initiates.
- **Betweenness centrality**— this gives an indication of the importance of an individual within a network. A higher betweenness centrality means that an individual is responsible for a high number of social connections within a network.
  Calculation:
  $BC(v)=\Sigma_{u,v \in V}\left(\frac{\sigma uw\,(v)}{\sigma uw}\right)$
  σ_{uw} = The total number of shortest paths between nodes u and w.
  $\sigma_{uw}(v)$ = The total number of shortest paths between nodes u and w that pass through v.
- **Connectivity / Cohesion** – the minimum number of nodes that need to be removed before the network becomes disconnected. A higher number indicates a better connected network.
- **Density**—a measure of the number of edges between individuals. In an unweighted network it is calculated by dividing the number of edges present by the total number of edges possible. A higher density value indicates a greater number of ties and therefore greater cohesion.
  Calculation: $D = \frac{Ties}{Possible\ ties}$

In the research proposal UCINET was mentioned as the program that would be used to process the results. However, the small amount of data and uncomplicated sociomatrices and indices that are necessary to show the results could easily be shown through the less complicated NodeXL template in Excel, which was ultimately used to process all of the collected data.

Chapter 3 Results

In order to answer the research question: 'What is the group structure of a group of captive howler monkeys (*Alouatta caraya*)?' we need to take a look at different types of interactions and networks which influence a group's structure, namely at affiliate contact such as grooming and playing and agonistic contact such as growling and retreating.

Affiliate behaviour

This can consist of a great many different interactions. The interactions listed in the ethogram and observed during this research are allogrooming, playing, huddling, hugging, sharing and licking. Table 3 shows the existence and absence of affiliate interactions between members of Tolkien's group. The existence of affiliate interaction is represented by a 1, the absence by a 0. The sociogram shows that Legolas is the only one of the children who did not instigate affiliate contact with his parents, although his parents did instigate affiliate contact with him.

Table 3 Sociogram affiliate interactions Tolkien's group

	Tolkien	Clyde	Merry	Gimli	Legolas	Galadriel
Tolkien	-	1	1	1	**0**	1
Clyde	1	-	1	1	**0**	1
Merry	1	1	-	1	1	1
Gimli	1	1	1	-	1	1
Legolas	1	1	1	1	-	1
Galadriel	1	1	1	1	1	-

A sociogram of the affiliate interactions in Louie's group are shown in table 4. The sociogram shows many less interactions than in Tolkien's group, showing that Louie's group is less connected through affiliate behaviour than Tolkien's group. Merlin is shown to be the main instigator of affiliate interactions, having done so with each member of the group, whereas Wimbral did not instigate any affiliate interactions.

Table 4 Sociogram affiliate interactions Louie's group

	Louie	Valerie	Smew	Serin	Wimbral	Merlin
Louie	-	**1**	0	0	0	**1**
Valerie	**1**	-	0	**1**	0	**1**
Smew	0	0	-	0	0	**1**
Serin	0	0	0	-	0	**1**
Wimbral	0	0	**1**	0	-	**1**
Merlin	0	0	0	**1**	0	-

As Merlin is the only one to instigate contact with every other individual he is a key member in this network, meaning that, were he to be removed from the group, its cohesion would decline and the group could very well separate into two or more cliques. This, as well as the directionality of affiliate interactions and the amount of times these interactions took place, is shown more clearly in the sociomatrix in figure 4.

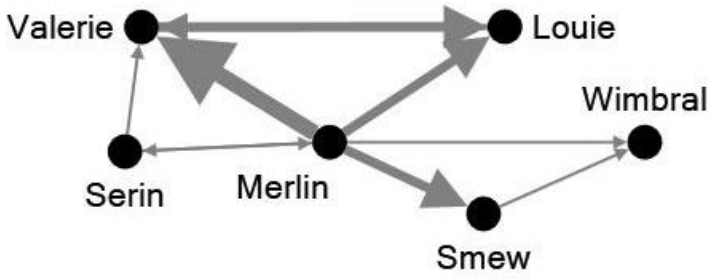


Figure 4 Affiliate behaviour Louie's group

Agonistic behaviour

During this research a greater variety of agonistic interactions was observed than affiliate interactions. Interactions which were observed and noted in the ethogram are: fighting, chasing, biting, displacement, pushing, grabbing, avoiding, growling, showing teeth and retreating. Simply looking at all of these agonistic behaviours together will not tell us all that much, as some are dominant in nature and others are submissive. Therefore these two categories are displayed separately.

Dominant interactions

Biting, chasing, pushing, growling and showing teeth were observed during this research. Tolkien's group, as shown in figure 5, displayed more dominant behaviour towards each other. Tolkien growled and showed her teeth to both Clyde and Merry multiple times. Pushing happened most often, an action where an individual would push others out of the way to be able to huddle up to an individual. Clyde and Merry have the highest node degree in this particular network structure, meaning that they receive and initiate the highest amount of interactions. Only one instance of dominant behaviour was displayed in Louie's group (Figure 6) where both parents (Valerie and Louie) chased Merlin.

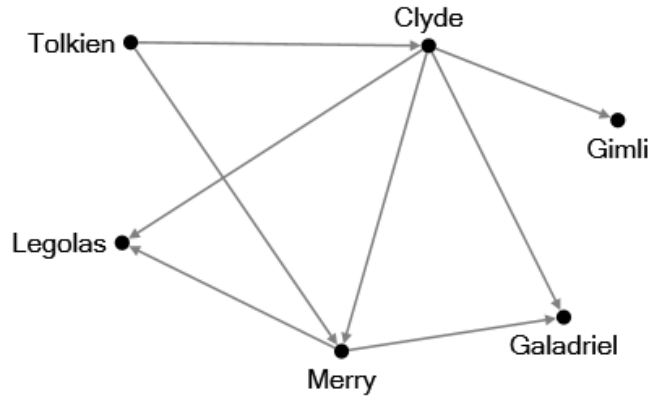


Figure 5 Dominant interactions Tolkien's group

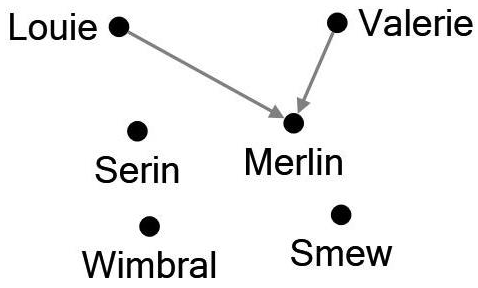


Figure 6 Dominant interactions Louie's group

One similarity between both groups is that, apart from the dominant behaviour between Tolkien and Clyde, every dominant interaction was top-down, meaning that it was instigated by an older animal and directed towards a younger animal. In Tolkien's group Merry, as the oldest child, directed dominant interactions towards his younger siblings. The only dominant interactions directed at him were instigated by his parents.

Submissive interactions

Avoiding, retreating, allogrooming and licking were observed during this research. All of the 'avoiding' and 'retreating' interactions were between Tolkien and Clyde, whereas the interactions between the other individuals all consisted of allogrooming and one instance where Merry licked

Clyde. Figure 7 shows us that Merry is the only one to receive and instigate submissive interactions with every other individual in the group, meaning that he has the highest node degree (number of connections).

Merlin again has the highest node degree in this network, as shown in figure 8. Valerie, Louie and Serin are all connected through Merlin.

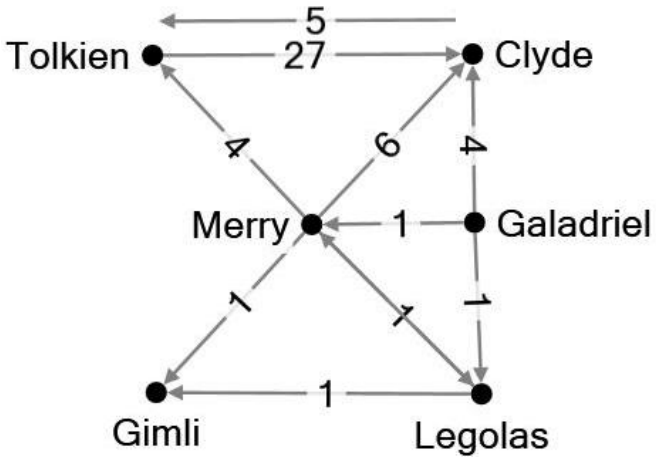


Figure 7 Submissive interactions Tolkien's group

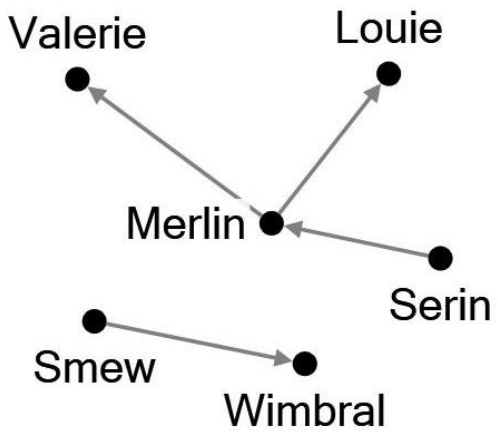


Figure 8 Submissive interactions Louie's group

In figures 5 and 6 we see only top-down dominant behaviour, which would make it logical to expect the reverse when it comes to submissive behaviour. However, Merry, who was dominant over his siblings, showed submissive behaviour to both his younger brothers Gimli and Legolas. Serin, the young female in Louie's group, showed submissive behaviour towards Merlin, who is eight years her junior, and Smew showed submissive behaviour towards Wimbral, who is two years his junior.

All interactions

Through the observation of both groups for the same amount of time one main difference immediately became apparent: the members of Tolkien's group interact far more often than those of Louie's group (207 versus 31 interactions).

Figures 9 and 10 contain a graphical representation of all social interactions between the members of both groups. In the lines of these graphs alone we can see a big difference in the groups' cohesion. The perfectly balanced line in the network of Tolkien's group (figure 9) shows that every individual was observed interacting with every other individual within their group, whereas Louie's group is less tightly connected. Yet again, even with all interactions combined, Merlin (figure 10) is shown to be a key individual in Louie's group.

Some indices to mathematically represent the groups' node degree, in- and out-degree and betweenness centrality are shown in tables 5 and 6. The in- and out-degree indices show the amount of interactions an individual receives and initiates. The node degree shows the number of group individuals an animal has been in contact with. For a network to be well connected these numbers need to be high, as is seen in Tolkien's group (table 5). The low numbers in Louie's group (table 6) indicate that most group members have only come in contact with two or three group members during the period of observation. The number in the betweennness centrality column shows the importance of particular animals within the network through the social interactions they are a part of. Ideally, in a well-connected network, every individual would play a big role within the network and these numbers would be low without much difference between the individuals. This is visible in

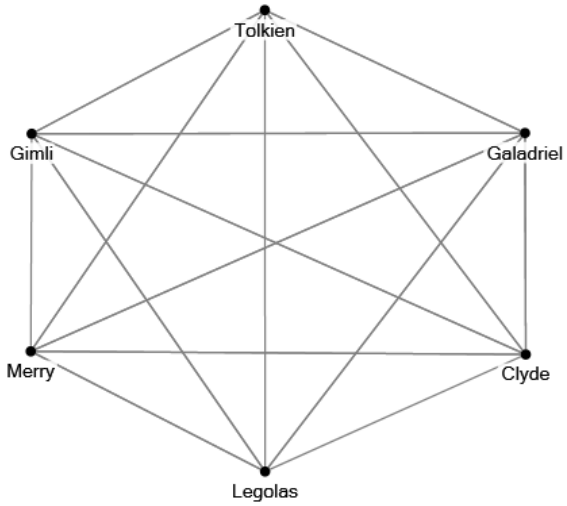
Tolkien's group, where each individual has a betweenness centrality of 0. In Louie's group Merlin rates as 6 whereas the others rate as 0 which indicates a low connection or cohesion within the network.

Table 5 Indices of all social interactions Tolkien's group

	Node degree	In-degree	Out-degree	Betweenness centrality
Tolkien	5	4	5	0
Clyde	5	4	5	0
Merry	5	5	4	0
Gimli	5	4	5	0
Legolas	5	5	3	0
Galadriel	5	5	5	0

Table 6 Indices of all social interactions Louie's group

	Node degree	In-degree	Out-degree	Betweenness centrality
Louie	2	2	2	0
Valerie	3	3	2	0
Smew	2	3	1	0
Serin	2	1	2	0
Wimbral	2	2	0	0
Merlin	5	1	5	6



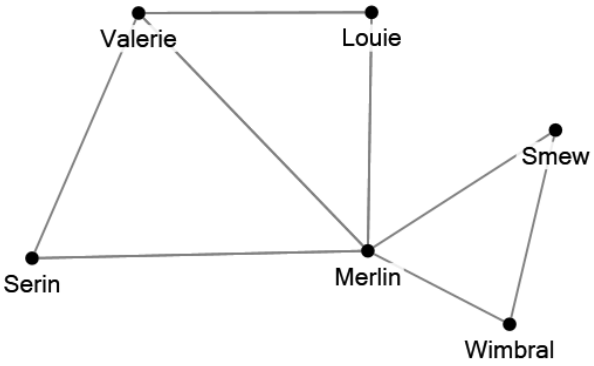


Figure 9 All interactions in Tolkien's group

Figure 10 All interactions in Louie's group

To summarise the effect of all social interactions within the two groups, and the effect this has on the groups' cohesion and density, several indices have been calculated and shown in table 7. As expected the cohesion within Louie's group is very low as opposed to the high cohesion in Tolkien's group. Merlin, a key individual, is the only individual to connect the group, which results in this low number (1). Both the average degree and graph density should also, ideally, be as high as possible, which they are in Tolkien's group.

Table 7 Indices of all social interactions

	Cohesion	Average degree	Graph density
Tolkien's group	5	5	1
Louie's group	1	2,667	0,533

Chapter 4 Discussion

The goal of this research is to determine the form of the social network of two captive groups of *Alouatta caraya* to better understand this species' sociality and to better take this into consideration when managing captive *Alouatta caraya.*

Results
During the observation period, Tolkien's group displayed many more affiliate and agonistic interactions than Louie's group (207 versus 31 interactions). No sexual behaviour was observed, which could be explained by both the short period of observation and the use of contraception in both groups. Affiliate behaviour consisted mostly of huddling, playing and allogrooming, which are important forms of social contact to maintain relationships and a hierarchy.

Dominant behaviour was shown to be top-down (older animals dominant over younger animals) in both groups with the exception of the parents in Tolkien's group. As a result submissive behaviour would be expected in the opposite direction (down-top) which was not the case. The parents in neither group showed submissive behaviour to their children, but submissive behaviour was shown amongst the children despite their age. Merry (oldest male child), who was dominant towards all his younger siblings, displayed submissive behaviour towards his younger brothers. Interestingly, none of the young females received any submissive interactions but they did instigate these, also to younger males.

Normally, by looking at submissive and dominant behaviours we learn about a group's hierarchy. No linear hierarchy became apparent in this research. Older animals seemed to be dominant over younger ones but submissive interactions were seemingly random with the exception of submissive interactions between parents and children. Between the young, the females seemed to be submissive towards the males.

Tolkien's group is very well connected, although Legolas seems less well connected than the other group members. He instigated the least amount of contact and was observed spending a lot of time exploring by himself. Incidentally he was also the only individual who was observed going on the ground of the enclosure. Louie's group is far less connected with a low cohesion rate and fewer connections between the individuals. Wimbral is the least connected individual in the group, not instigating any contact.

Research process and method
Several small changes took place between the research proposal and eventual research process and method. Several interactions were added to the ethogram and apart from day one no camera was used to record the animals. Neither of those changes hindered the research process or results. As no ethogram for howler monkey behaviour specifically was available, and no clear picture of the animals' enclosures was available before the start of observation, neither of these points could have been avoided.

Howler monkeys spend the majority of their day resting and sleeping and will generally not show as many interactions in an as short amount of time as, for example, the neighbouring group of baboons did. Due to time restrictions each group was observed for eight hours, which is not enough time to guarantee insight into the complete network structure of these two family groups.

Although both groups have an inside enclosure, which they can access whenever they want and in which it was impossible to observe their behaviour, Louie's group had an additional large blind spot on the roof of the inside enclosure. Louie's group spent a lot of time in either blind spot, making it impossible to observe them during this time (<15% of observed time). The group would retreat to these blind spots, most likely to rest. As all animals would spend this resting time in relatively close quarters, it is likely that more affiliate behaviour such as huddling and allogrooming would have been displayed during this time. Although most members of Louie's group were usually observed in the same area together (outside or inside) they interacted far less often than those of Tolkien's group.

One big advantage during the periods of observation was the quiet in the area of the enclosures. Not many visitors were in the park during this period and few visited the areas where the enclosures are situated. This meant that the animals' behaviour was not influenced by these outside disturbances. The primate keepers, who have regular contact and interact with the animals, also influence their behaviour. I was careful to not interact with the animals at all, which resulted in them ignoring me and exhibiting their behaviour as if I was not there.

Comparison to literature

In situ groups usually consist of multiple males and females but always more females then males (Mendes, 1989; Miranda & Passos, 2005; Treves, 2001). In captivity family groups have higher reproductive success rates. Both parents at Port Lympne have produced and raised offspring successfully.

In most cases the males are dominant, although there are also reports of groups with a dominant female (Chiarello, 1995; Mendes, 1989; Miranda et al., 2004; Treves, 2001). Even in groups with a dominant male, cases have been reported of females driving out (dominant) males from groups. When it comes to male or female dominance, no clear result has been found during this research though it seems that the young males are dominant over the young females.

It is important to recognise key individuals in a social network who may be particularly important to the cohesion of the network, as this can provide a good indication of the results of removing certain individuals from a group (Kraus et al. 2007; Krause and Ruxton, 2002). This research shows that removing Merlin from Louie's group could result in fragmentation of the group. Based on the results, it is possible that Tolkien's group will most likely stay well-connected when one or more individuals are removed from the network.

Chapter 5 Conclusion and recommendations

The goal of this research is to determine the form of the social network of two captive groups of *Alouatta caraya* and to better understand and take into consideration this species' sociality when managing captive *Alouatta caraya.*

Conclusion
During this research no evidence was found of a linear hierarchy in the two groups of *Alouatta caraya* at Port Lympne reserve. However, the older animals seem to be dominant over the younger ones, as do males over females.

Although both groups consist of parents and their four young, and the sort of interactions and directionality of those interactions are similar in each group, the frequency with which these interactions take place is very different. One group showed to be very well-connected and cohesive with all members interacting with each other and exhibiting affiliate behaviour whilst the other group showed a much lower level of cohesion with several individuals not interacting with each other at all. This lesser connected group was shown to contain one key individual who, if removed from the group, could cause the network to fragment into cliques and/or unconnected individuals.

Although this research did not give definitive new insights into *Alouatta caraya's* social network structure, it does inform us, in part, about the social network structure of the two groups at Port Lympne reserve and the individuals' pattern of interaction with others. This could help the staff make better informed decisions when it comes to removing individuals from the groups, adding newcomers or recognising sudden changes in individuals' or a group's behavioural patterns.

Recommendations
The main problem, which undermines the result's credibility, is the short amount of time that the animals were observed during this research. To gather better insight into the social network structure, the animals would need to be observed longer and over a longer period of time. The animals should also be observed in all parts of their enclosure, because the blind spots during this research prevent many interactions from being observed.

To gather proper insight into the species it would be good to observe more separate groups to see if there are strong similarities between groups or if the social network structure is very different depending on the group, as was found in this research.

Lastly, for Port Lypmne, the main recommendation would be to be aware of the fact that removing Merlin from Louie's group could result in fragmentation.

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Appendix I : Evaluation

Name: Laura Tuk Date: 19-04-2018

Title report:

A comparison of the social network structure between two groups of captive *Alouatta caraya*.

ASSESSORS: Tick the box of the items which are not sufficient!

1. Use of English:
☐ Does not contain more than 3 grammar errors, spelling mistakes or typos per 1000 words*
When more than 3 mistakes per 1000 words are found, the report will be marked a fail.
☐ Contains correct punctuation*
☐ Is attuned to the chosen target group (appropriate style)*
☐ Shows a functional and business-like writing style*
☐ Is not written in the "I" form*

2. The report:
☐ Report is properly bound, no staples (hard copy)*
☐ Is free of plagiarism* (check exam regulations)

3. The cover:
☐ Displays the title
☐ Author(s) is/ are mentioned

4. The title page:
☐ Title is specific*
☐ Author(s) is/ are mentioned in alphabetical order*
☐ Date and place of publication are mentioned*
☐ The sponsor/orderer of the report is mentioned*

5. The preface:
☐ Contains personal reason for writing
☐ Contains acknowledgement ("I" form permitted in the preface)

6. Table of contents:
☐ All parts of the report are numbered*
☐ The summary and appendices are included
☐ Table of contents is clear
☐ Page numbers are consistent

7. The summary:
☐ Is a concise version of the entire report
☐ Contains conclusions
☐ Does not contain personal opinions
☐ Is well structured
☐ Is written business-like
☐ Follows the table of contents

8. The introduction:
☐ Is chapter 1*

□ Invites the reader to read
□ problem demarcation and justification are clear and specific*
□ The problem context is clear and to the point*
□ The aim of the research and the report is clear and specific*
□ Research methods/ data collection are described *
□ The function of the chapters in the report is concisely described *

9. The (construction of the) core:
□ Chapters, paragraphs and subparagraphs are numbered and clearly structured (with a maximum of three levels)*
□ Enumeration levels are clearly distinguishable*
□ Chapters and (sub) paragraphs have a fitting title
□ A chapter covers at least one page
□ New chapters start on a new page
□ Sentences are typed in sequence, without hard return within the paragraph
□ Figures are numbered and have a fitting title, which is put below the figure.*
□ Tables are numbered and have a fitting title, which is put above the table*
□ Figures and tables are referred to in the text*
□ Each appendix is specifically referred to in the content
□ Pages are numbered*
□ Pages have a functional layout

10. The discussion of results:
□ Contains a review of relevant sources
□ Valid argumentation is provided
□ Contains a critical evaluation of own findings

11. The conclusions and recommendations:
□ The conclusions are based on relevant facts and / or discussion
□ The recommendations are based on relevant facts and / or discussion
□ Does not contain any discussion or information that does not appear elsewhere in the report text*

12. References:
□ The text is written according to the APA-rules * (check intranet Library)

13. The list of sources:
□ Is drawn up according to the APA-rules* (check intranet Library)

14. The appendices:
□ Are all numbered
□ Each have an appropriate title
□ Do not contain the author's own analyses.