

Research article

Behaviour and social bonds of African elephant calves under different holding systems in European zoos

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Abstract

Husbandry conditions of elephants in zoos have been discussed for many years. The European studbooks for African *Loxodonta africana* and Asian elephants *Elephas maximus* recommend certain conditions, which participating institutions constantly aim to improve. Housing, feeding, group social composition and the amount of human intervention with zoo elephants has changed over time. Decisions to adjust husbandry conditions require empirical data to validate potential benefits. This study evaluates possible differences in the social and general behaviour of nine African elephant calves depending on three management systems or holding conditions 'free contact', 'protected contact' and 'no contact' in four zoos. For each calf, interactions with the mother and other herd members were investigated and the social and general behaviour was described using the next-neighbour method and an ongoing behavioural record applying an ethogram. Statistical analysis was performed with a Kruskal-Wallis test. Results reveal no significant differences in calves' interaction with their mothers and other herd members or their social and general behaviour between management systems. However, general differences in the spatial distancing of calves in zoos and calves living in situ were found. The calves in this study kept greater distances (up to 5 m) at an age of 6 to 48 months, while in situ calves of the same age are known to stay within reaching distance of the closest herd member. Data testify that choice of holding system does not influence social behaviour or distance of calves. However, possible differences in the development of social behaviour between in situ versus ex situ calves should be further investigated.

Introduction

Elephant management systems

There is a long history of keeping elephants in zoos and various management systems dictating how carers interact with and treat elephants have been applied over recent decades (Bechert et al. 2019; Clubb and Mason 2002; Dale 2010; Garaï and Kurt 2006; Kowalski et al. 2010; Kurt 1994, 2006; Meehan et al. 2016; Olson 1994; Veasey 2006; Williams 2019). Currently, there are three different management systems. The most common is 'protected contact'. 'Free contact' is less common and 'no contact' is very rare (Bossy 2019; EAZA

2019; Meehan et al. 2016). The three concepts differ in the way zookeepers take care of and interact with the elephants, also resulting in differences in the construction of the elephant enclosures (Olson 2004; Proctor and Brown 2015; Riddle and Stremme 2011).

Free contact, also referred to as hands-on, is a management system in which zookeepers directly interact with the animals whilst entering the same space without barriers. The keeper acts as a dominant member of the social system of the elephants. There are no protective barriers between animals and humans during training and medical care. This gives the

carers immediate access to the animals' different body parts, i.e. for medical treatment, ultrasound examination and transport training (Bossy 2019; Lundberg et al. 2001; Samson 2000; Tanner 2000). Keepers lead the elephants in person and thereby direct them. However, as direct contact with these large animals has undeniable risks for keepers' safety, this management system requires intense training and perfect obedience of the elephants. Keepers in most facilities are only allowed to enter the elephant enclosure carrying an ankus, a stick with a metal spike at the top, to defend themselves if attacked by an elephant. Keepers apply the ankus to lead the elephants and correct them during training. Criticism of the ankus is widespread; it is often regarded as an instrument that can potentially hurt the animals and cause stress for them. Only a minority of zoos still keep their elephants under free contact (Bossy 2019; EAZA 2019).

In 2019, the European Association of Zoos and Aquaria (EAZA) required zoos to stop keeping elephants in free contact conditions. Several advantages of the two other management systems motivated this decision. Firstly, elephants are free to move and react as they please and without human guidance in the other management systems. Secondly, free contact is considered insecure for both elephants and keepers and requires an excessive amount of strict training and obedience. Zoos that still handle their elephants in free contact have been requested to switch to protected contact by 2030 (Bossy 2019; EAZA 2019).

Under protected contact, elephants are taken care of and trained through bars, a separating fence or special training walls or cages. The main principle of protected contact is the voluntary work of the animals with the zookeepers during training sessions and medical care. Only operant conditioning is used to train the animals. Keepers are not allowed to enter the elephant enclosure at the same time as the animals at any time (Desmond and Laule 1993; Harris et al. 2008; Laule and Whittaker 2000). This enormously reduces the risk for the keepers. Protected contact is the most frequently used management system in European zoos (EAZA 2019).

The third management system is no contact, in which there is no contact between zookeepers and elephants other than the provision of food and water and the cleaning of stables and enclosures. This means that elephants are not being trained. Most zoos that practise this system let the elephants roam freely in their inside and outside enclosures and only open and close gates for feeding and cleaning purposes, to prevent keepers and animals being in the same area (Laule and Whittaker 2000). In terms of human contact, this management system most closely resembles natural conditions.

Elephants living in zoos are in general familiar with intense interaction with humans, while contact with humans in situ is much rarer and strongly differs (EAZA 2019; Hoerner et al. 2023). Additionally, herd composition in zoos may differ. Some breeding herds consist of unrelated females and their offspring and occasionally the offspring might only be related paternally (EAZA 2019). In both free and protected contact systems, calves observe their mothers and the other herd members interacting with keepers. The calves learn how their mothers react and adopt this behaviour (Desmond and Laule 1991, 1993; Harris et al. 2008; Laule and Whittaker 2000). In protected contact systems, calf training starts when they approach the fence and are willing to interact with the keepers (Desmond and Laule 1991, 1993; Harris et al. 2008; Laule and Whittaker 2000). In free contact systems, calves must learn to respect humans as sensitive and vulnerable beings early in their lives. Later on, they will be trained in direct contact (Bossy 2019).

Development and behaviour of African elephant calves in situ

African elephants are known for their complex social structures

and supportive social behaviour. The social behaviour of African elephant *Loxodonta africana* calves is well understood (Douglas-Hamilton 1972; Douglas-Hamilton and Douglas-Hamilton 1989; Lee and Moss 2011; Moss 2001). In situ African elephants live in matrilineal and herd members display close (tactile) bonds with calves (Lee and Moss 2011). This physical contact between mammals is important for their wellbeing, development and future breeding success (Dunbar 2010; Jablonski 2021).

The physical and behavioural development of African elephant calves is classified by Lee and Moss (2011) into seven age stages: 0–6 months, 7–12 months (0.5–1 year), 13–24 months (1–2 years), 25–36 months (2–3 years), 37–48 months (3–4 years), 49–60 months (4–5 years) and 60-plus months (more than 5 years). At the age of four years, they are not referred to as calves anymore, but as youngsters. The upper age limit for a youngster is mostly set to nine years, as most animals gain sexual maturity in situ around that age. Sex-specific differences in social behaviour exist and start to appear at the age of two years; however, these are not expressed significantly before the age of four years (Andrews et al. 2005; Archie et al. 2005, 2011; Lee and Moss 2011).

The seven age stages are associated with several behavioural steps. The calves learn how to use their trunks within the first 12 months of their lives. They tend to expand their physical distance from their mothers within their first four years. They display a peak in their playing behaviour from the age of three to four years. Calves shift from milk to solid food as their main source of food around the age of six to nine months. They approach agonistic behavioural patterns at the age of four, and finally mature at the age of six to nine years, also practising mating behaviour (Andrews et al. 2005; Archie et al. 2005, 2011; Lee and Moss 2011).

Calf survival strongly depends on the mother's care. If a mother dies while the calf is under 24 months old, the likelihood of calf survival is extremely low in situ (Archie et al. 2005, 2011; Lee and Moss 2011; Moss and Colbeck 2002). Mothers are central individuals with which calves are in frequent visual, tactile, olfactory and acoustic contact. During the first six months, calves spend approximately 56% of their time in contact distance (Charif et al. 2005; Lee and Moss 2011). This reduces when calves become older; however, it is not until they are well over two years old that they move more than 5 metres away from their mothers (Charif et al. 2005; Lee and Moss 2011). During the first years of life, close contact between the calf and the mother is maintained by both sides. This shifts after two years, when the contact becomes less intense and is maintained more by the mothers. At this age, sex-specific differences such as different playing behaviour arise (Charif et al. 2005; Lee and Moss 1986, 2011).

The close social bonds between elephants are also evident in the social distance of calves from other herd members. During the first two years, calves spend about 20% of their time within contact distance of the next non-mother elephant and only 10% of the time at a distance of more than five metres from any other individual (Lee and Moss 2011). In situ calves have been observed to spend an average of 58.11% of time in tactile contact with their mothers during the first four years (Hoerner et al. 2023).

Study aims

The three management systems free, protected and no contact are usually discussed and compared in terms of human and animal safety (Bechert et al. 2019; Clubb and Mason 2002; EAZA 2019). There are no studies on whether the different systems have any impact on the social behaviour of elephants as an indicator of welfare. From an ethological perspective, it seems vital to consider behavioural parameters to evaluate the influence of management systems on elephants. It is known that different keeping conditions affect mammal behaviour e.g. in chimpanzees (Bassett and Buchanan-Smith 2007).

Elephants are highly intelligent, display unique senses, have developed complex (social) behaviour and react very sensitively to their environment (Douglas-Hamilton 1972; Douglas-Hamilton and Douglas-Hamilton 1989; Estes 2012; Moss 2001; Pinter-Wollman et al. 2009; Schulte 2000). Naturally, this applies also to conditions in zoos. While human-elephant contact is almost non-existent in the wild, a certain kind of relationship between keepers and elephants in zoos exists and can have a positive effect on the animals' wellbeing (Carlstead et al., 2019). Different management systems and human-elephant contact may have an impact on behaviour.

In this study, the three management systems for elephants in European zoos were compared in terms of their influence on social and general behaviour as well as distance keeping in African elephant calves. Additionally, the elephants' behaviour was investigated in terms of the space provided to the animals in the different facilities. Possible differences are evaluated and assessed for their welfare impacts in terms of species-specific behaviour in zoo elephants.

Material and methods

Animals

To compare the social behaviour and development of African elephant calves in the three management systems, three elephant calves were observed in each system, resulting in a sample size of nine calves. The facilities for free and protected contact provided the animals with hay throughout most of the day. However, short intervals where no hay was provided may also occur. In the no contact facility the elephants' outside enclosure was a grass field; therefore elephants had access to food throughout the day.

While elephants in the no contact outside enclosure stood on grass throughout the day and had no access to the stables, elephants in free and protected contact systems were inside and outside during the day. In their inside enclosures they stood on sand, concrete and bark mulch, and in the outside enclosures on earth.

Calves were selected to represent a homogenous distribution in terms of age, sex and number of playmates (calves of age suitable for playing). The age limit was set at four years because after this sex-related behavioural differences become significant (Lee and Moss 2011).

As the sizes of the elephant enclosures of this study differ, behavioural data can also be applied to ethological differences in terms of enclosure sizes. Heterogeneity in terms of herd and enclosure size has an impact on data analysis.

Full information on the elephant calves of this study at the time of data collection is shown in Table 1.

Ethological data collection

Observations for this study were performed between 2020 and 2021. The observation time for each calf was a total of 15 hours, resulting in 45 hours for each holding system. In direct contact systems data were only collected when keepers were not in the enclosure and not in contact with the elephants, when elephants wandered freely within their entire enclosure. Observations were performed during the working hours of the keepers, spread over the day, covering all times of day within the working hours of the keepers. The 15 hours of observation for each calf were spread over two weeks, observing approximately 1.5 hours a day. All observations took place during late summer and early autumn.

For an ethological analysis of calf behaviour, four categories were measured. Firstly, the calves' distance to their mothers was estimated by the observer to investigate the calf-mother relation (Kappeler 2020; Krull 2000; Martin and Bateson 2007; Naguib and Krause 2020; Randler 2018). The distance was divided into five

categories: tactile contact, <1 m, 1–3 m, 3–5 m and >5 m (Lee and Moss 2011). Data were recorded at 60-second intervals.

Secondly, next-neighbour analysis was used to measure the calves' general distance to their closest neighbour to evaluate the calves' bond to herd members other than their mothers (Kappeler 2020; Krull 2000; Martin and Bateson 2007; Naguib and Krause 2020; Randler 2018). Distances to next-neighbour were estimated by the observer using the categories tactile contact, <2 m, 2–4 m, and >4 m (Lee and Moss 2011) at 60-second intervals.

Thirdly, the calves' social behaviour and relationships within the herd were evaluated by differing affiliative and agonistic contacts. The amount of affiliative and agonistic contact was counted, noting whether the calves were the initiator or recipient of the contact. Behaviour was categorised according to Poole and Granli's (2021) ethogram, labelling the animal's behaviour focusing on the initiating animal. Data were collected continuously during the whole observation time (Kappeler 2020; Krull 2000; Martin and Bateson 2007; Naguib and Krause 2020; Randler 2018).

Finally, the general behaviour of all calves was observed at 60-second intervals by applying an ethogram based on Poole and Granli (2011, 2021) listing eight behavioural categories: eating, drinking, suckling, locomotion, locomotion trunk, comfort behaviour (stretching, scratching, throwing sand and mud on oneself, rolling in sand/mud), sleeping (including standing and lying rest) and playing.

Data were classified numerically (Agestri 2007; APA 2013; Bortz and Döring 2006; Naguib and Krause 2020) and statistical analysis was performed using SPSS Version 29. As graphical analysis showed that all data were unevenly distributed, a Kruskal-Wallis calculation was used to detect statistically significant differences between the three management systems and the different space elephants had in the four facilities where data were collected. In addition, an exact test (Monte Carlo simulation) was calculated taking into account the small sample size (Cohen 1988; Hope 1968; Kubinger et al. 2009; Siegel and Castellan 1988; Tomarken and Serlin 1986). As no significance was detected, post-hoc tests were not calculated (Benjamini and Hochberg 1995; Hochberg 1988). The significance level was set to $P \leq 0.05$ (Fritz et al. 2012; Ryan 2013).

Results

Distance to mother

Figure 1 shows the distribution of contacts between calves and their mothers in all three management systems, none of which display significant differences. Whilst the pattern of distance to the mothers was comparable in all three management systems, a notable result is the high number of records of <1 m distance in free contact (nearly 50%) and no contact (nearly 40%) in comparison to protected contact (nearly 30%). Yet of all distances observed, <1 m was the most frequent in all three systems and exceeded tactile contact.

The lowest variation in the frequency of all maintained distances was seen in protected contact systems. Calves kept greater distances (1–3 m, 3–5 m and >5 m) from the mothers in all three management systems but the larger distance categories (3–5 m and >5 m) were not observed as frequently. However, calves in free contact showed a higher percentage of >5 m than 3–5 m which was comparable in protected and lower in no contact systems.

Calves living in free contact systems tend to have less tactile contact with their mothers (mean of 6.16%) than calves living in protected (mean of 18.15%) and no contact (mean of 13.99%) systems. However, calves living in free contact systems spend most of their time in the second distance category <1 m (mean of 48.54%), which is more than calves in protected contact (mean

Table 1. List of elephant calves.

Elephant	Sex	Management system	Size of enclosure in m ²	m ² / elephant	Date of Birth	Age at data collection*	Number of individuals calf lives with	Number of playmates**
Tu	F	Free contact	3,565	445.625	16 Mar 2016	47-48 month	8	2
Gu	M	Free contact	3,565	445.625	20 Apr 2019	11-12 month	8	1
Ts	M	Free contact	3,565	445.625	06 Mar 2020	6 month	8	2
Ch	F	Protected contact	1,442	240.33	14 Apr 2017	48 month	6	2
El	F	Protected contact	2,957	492.833	20 Sep 2019	11 month	6	1
Ku	M	Protected contact	1,442	240.33	05 Apr 2021	6 month	6	2
To	M	No contact	25,000	1,315.789	29 Aug 2018	47 month	19	2
Ma	F	No contact	25,000	1,315.789	22 Feb 2020	18 month	19	2
Ne	M	No contact	25,000	1,315.789	08 Jan 2021	7 month	19	1

*differences in age between the three sample groups were not significant: Kruskal Wallis analysis (P=0.368). **elephants of up to 108 month of age.

of 27.02%) and no contact (mean of 33.52%). Thus, the overall distance to the mothers is also small for calves living in free contact.

The calves' position relative to their mothers was analysed for differences between the management conditions and the available enclosure space. No significant differences were detected (Table 2).

Next-neighbour

In Figure 2 similar (non-significant) observations in the distance parameters of tactile contact and <2 m are seen as in the data for the position of the mother. Again, calves living in free contact tend to have less tactile contact with their next neighbours than calves living in protected or no contact.

Table 3 summarises the statistical analysis of the calves' next-neighbour, showing no significant differences for management conditions and space per elephant.

Social behaviour

Figure 3 shows the percentages of time spent initiating and receiving affiliative and agonistic behaviour. Calves only initiated and received minor agonistic behaviour but mainly initiated and received affiliative behaviour, again without significant differences between management conditions or space provided.

The Kruskal-Wallis calculation detected no significant differences in affiliative and agonistic behaviour both initiated and received by the calves among the different management conditions (Table 4).

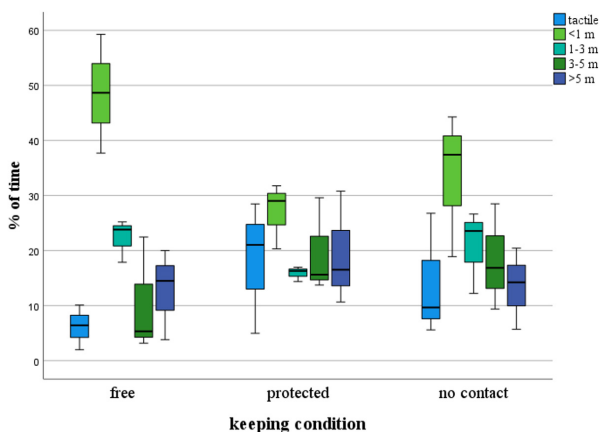


Figure 1. Percentage of time calves spend in a distance category to mother, depending on management condition.

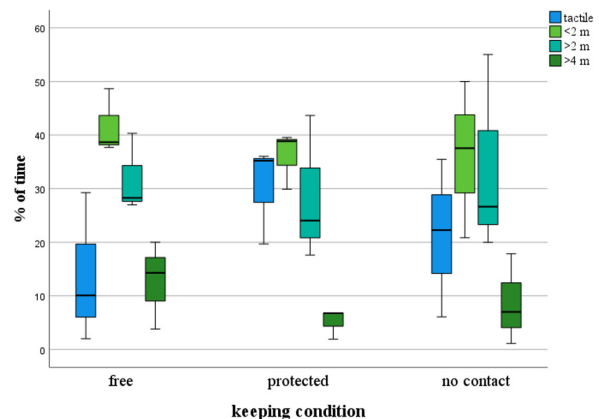


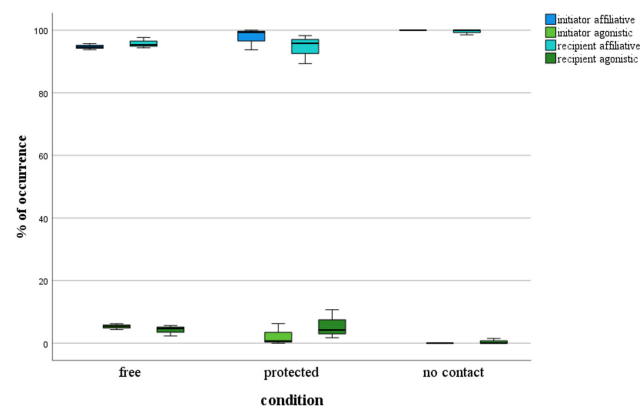
Figure 2. Percentage of time calves spend in a distance category to next-neighbour, depending on their management condition.

Table 2. Kruskal-Wallis calculation for the position of calves to their mothers, depending on different management conditions and depending on m²/elephant.

management condition		tactile	<1 m	1-3 m	3-5 m	>5 m	
Kruskal-Wallis H		1.156	4.622	2.756	1.689	0.622	
df		2	2	2	2	2	
Asymptotic Significance		0.561	0.099	0.252	0.430	0.733	
Monte Carlo Significance	Significance	0.630	0.099	0.296	0.510	0.825	
	99% Confidence Interval	Lower Bound	0.617	0.092	0.284	0.497	0.816
		Upper Bound	0.642	0.107	0.307	0.523	0.835
m ² /elephant		tactile	<1 m	1-3 m	3-5 m	>5 m	
Kruskal-Wallis H		2.956	4.622	2.655	1.889	2.422	
df		3	3	3	3	3	
Asymptotic Significance		0.399	0.202	0.431	0.596	0.490	
Monte Carlo Significance	Significance	0.472	0.195	0.517	0.704	0.613	
	99% Confidence Interval	Lower Bound	0.459	0.185	0.504	0.693	0.601
		Upper Bound	0.485	0.205	0.530	0.716	0.626

General behaviour

Statistics show no significant differences in any of the eight behavioural categories depending on the management conditions or space provided in the respective zoos. The percentage of time that the elephant calves spent on a certain behaviour are presented in Table 5. Many behaviours were only observed on a few occasions for all three management systems. Prominent differences are only present in the major behavioural category of eating. The behavioural category playing tends to be displayed less in no contact conditions and more frequently in the other two systems.

**Figure 3.** Percentage of affiliative and agonistic behaviour initiated and received by calves, depending on management condition.

Discussion

Distance to mother

The results of this study demonstrate that management systems for the husbandry of elephants in zoos have no influence on the spatial distance between mothers and their calves. In all three management systems calves stayed mainly at <1 m distance from their mothers. Thus, it can be assumed that the urge to stay close to the mother is present for calves in all three management conditions.

The analysis only demonstrated non-significant trends in the distance between mothers and calves among the three management systems. However, patterns differ from data known for calves living in situ, which agrees with previous studies on differences between calves in situ and ex situ (Hoerner et al. 2023; Webber 2017). In the wild, calves were observed to not walk farther than 5 metres from their mothers before they are two years of age (Hoerner et al. 2023; Lee and Moss 2011). In contrast, the six calves of this study that were under the age of two years spent an average of 10.9% of the time at a distance of more than five metres from their mothers. A similar result was found by Hoerner et al. (2023). This is likely independent of the management system and suggests that these data are representative of calves living ex situ. Based on this difference between ex situ and in situ it can be argued that the lack of predators and perils in the zoo environment allows for a spatial detachment of calves from the mothers. The close (spatial) connection to the mother elephants that calves maintain in situ is crucial for their safety and food supply, and thus for their survival (Lee and Moss 2011; Moss 2001).

Next-neighbour

This study did not find significant differences between social distance of the elephant calves from other herd members in the three management conditions. However, this result is limited to a respectively small sample size and therefore is not empirical proof that management systems do not affect social distancing. The data show slight differences on an insignificant level: calves living in free contact have less tactile contact (mean 13.77%) than calves living in protected (30.3%) or no contact (21.27%) conditions.

Table 3. Kruskal-Wallis calculation for next-neighbours of calves, depending on different keeping conditions and m²/elephant.

management condition			tactile	<2 m	>2 m	>4 m
Kruskal-Wallis H			2.222	0.356	0.800	1.422
df			2	2	2	2
Asymptotic Significance			0.329	0.837	0.670	0.491
Monte Carlo Significance	Significance		0.378	0.879	0.716	0.541
	99% Confidence Interval	Lower Bound	0.366	0.871	0.705	0.528
		Upper Bound	0.390	0.888	0.728	0.553
m ² /elephant			tactile	<2 m	>2 m	>5 m
Kruskal-Wallis H			3.311	1.156	2.600	1.778
df			3	3	3	3
Asymptotic Significance			0.346	0.764	0.457	0.620
Monte Carlo Significance	Significance		0.385	0.859	0.542	0.716
	99% Confidence Interval	Lower Bound	0.372	0.850	0.529	0.704
		Upper Bound	0.397	0.868	0.554	0.727

Calves in free contact spend most of their time at a distance of <2 m (41.67%) from their next-neighbour, which is more than calves in the other management conditions (36.09% for protected and 36.13% for no contact). Therefore, the overall distance of calves from other herd members in free contact is slightly but not significantly larger than in the other management systems.

The data collected ex situ correspond with data from in situ. Lee and Moss (2011) describe calves living in situ spending

approximately 20% of their time at small distances from non-mother elephants and only about 10% of their time at a social distance of more than five metres from other herd members. The data from zoos show that the calves spend approximately 21.78% of their time at small distances from non-mother elephants and about 8.85% of their time at a distance of more than five metres. Hence, the social relationship to the herd in terms of distance kept by the calves in this study is equivalent to that of calves in the wild.

Table 4. Kruskal-Wallis calculation for agonistic and affiliative behaviour as initiator and recipient for calves, depending on different management conditions and m²/elephant.

management condition			affiliative initiator	affiliative recipient	agonistic initiator	agonistic recipient
Kruskal-Wallis H			40.582	4.582	5.468	5.468
df			2	2	2	2
Asymptotic Significance			0.101	0.101	0.065	0.065
Monte Carlo Significance	Significance		0.130	0.126	0.066	0.066
	99% Confidence Interval	Lower Bound	0.121	0.117	0.060	0.060
		Upper Bound	0.138	0.134	0.072	0.073
m ² /elephant			affiliative initiator	affiliative recipient	agonistic initiator	agonistic recipient
Kruskal-Wallis H			40.636	4.636	6.902	6.902
df			3	3	3	3
Asymptotic Significance			0.200	0.200	0.075	0.075
Monte Carlo Significance	Significance		0.179	0.179	0.014	0.014
	99% Confidence Interval	Lower Bound	0.170	0.169	0.011	0.011
		Upper Bound	0.189	0.188	0.017	0.017

Social behaviour

The affiliative and agonistic behaviour of calves is not different between the three management systems. According to the data, neither the management system nor the enclosure size had an impact on the calves' general behaviour.

The analysis of social behaviour also emphasises that relationships between calves and herd members are predominantly positive. These findings agree with other studies for zoo elephants as well as the social relationships known for calves in the wild, where young individuals are mainly treated with patience and care (Andrews et al. 2005; Douglas-Hamilton 1972; Douglas-Hamilton and Douglas-Hamilton 1989; Estes 2012; Meehan et al. 2016; Moss 2001; Pinter-Wollman et al. 2009; Schulte 2000).

General behaviour

Although there was no significant difference in general behaviour between management systems, minor differences for some of the parameters between systems as well as within the sample groups were evident (Table 5) e.g. in the category eating. Calves in no contact conditions spend more time eating than calves in the other two management systems. These differences may be explained by the differences in the enclosures. In the no contact facility enclosures, elephants stood on grass and therefore had

access to food throughout the day. In the other two management systems, elephants were provided with hay which needed to be refilled regularly. Therefore, intervals with no access to food occurred and might explain the difference observed.

Minor differences in the amount of playing behaviour between the sample groups may depend on herd size and number of playmates. Whilst all calves in this study had company other than their mother, not all had the same number of playmates (Table 1), which most likely has an impact on the amount of playing behaviour.

Overall, the general behaviour observed in the calves in this study resembles the behavioural patterns of calves living in situ, according to the literature (Andrews et al. 2005; Lee and Moss 2011; Moss 2001). However, Hoerner et al. (2023) detected significant differences between in situ and ex situ calves for several behavioural categories.

Limitations

The three sample groups in this study were not homogenous in terms of herd and enclosure size which might have biased the results. Due to the limited sample size in this study, it must be regarded as a case study.

Table 5. Means of time behavioural categories were displayed in the three management systems and Kruskal-Wallis calculation for the general behaviour of calves, depending on different management systems and m²/elephant.

Management condition		Eat	Drink	Suckle	Locomotion	Locomotion Trunk	Comfort	Sleep	Play
mean	Free	25.36	2.07	3.51	11.94	14.60	1.93	3.62	20.52
	Protected	28.52	0.68	5.01	11.12	17.01	1.52	1.25	16.19
	No contact	42.42	0.44	6.28	6.78	12.85	0.64	4.90	6.20
Kruskal-Wallis H		0.325	3.493	1.412	3.389	0.800	1.689	1.156	2.489
df		2	2	2	2	2	2	2	2
Asymptotic Significance		0.837	0.174	0.494	0.193	0.670	0.430	0.561	0.288
Monte Carlo Significance	Significance	0.879	0.191	0.534	0.236	0.716	0.510	0.630	0.336
	99% Confidence Interval								
	Lower Bound	0.871	0.180	0.521	0.225	0.705	0.497	0.617	0.324
	Upper Bound	0.888	0.201	0.547	0.247	0.728	0.523	0.642	0.348
m ² /elephant		Eat	Drink	Suckle	Locomotion	Locomotion Trunk	Comfort	Sleep	Play
mean	240.33	11.59	0.41	7.45	11.45	22.76	2.07	1.79	15.17
	520.125	36.98	0.81	3.78	10.95	14.14	1.25	0.97	16.7
	985.66	25.36	2.07	3.51	11.94	14.60	1.93	3.62	20.52
	1,263.16	42.42	0.44	6.28	6.78	12.85	0.64	4.90	6.20
Kruskal-Wallis H		1.156	3.854	1.866	3.489	1.000	2.778	1.511	2.844
df		3	3	3	3	3	3	3	3
Asymptotic Significance		0.764	0.278	0.601	0.322	0.801	0.427	0.680	0.416
Monte Carlo Significance	Significance	0.859	0.285	0.720	0.352	0.875	0.514	0.784	0.491
	99% Confidence Interval								
	Lower Bound	0.850	0.274	0.709	0.339	0.867	0.501	0.774	0.478
	Upper Bound	0.868	0.297	0.732	0.364	0.884	0.527	0.795	0.504

Conclusion

The results offer empirical ethological data for captive African elephant calves in free, protected and no contact management conditions under which elephants are kept in Europe. Spatial distances between calves and mothers and calves and other family members as well as social and general behaviours were measured to detect possible differences management conditions might generate. No disparities in the social and general behaviour of calves and their spatial distance from mother and non-mother elephants were identified in statistical analysis. No signs of hospitalism or inferior health conditions have been identified in any of the three elephant management systems. It seems that neither elephant management system nor space provided have an effect on the behaviour of elephant calves. The choice of husbandry must focus on safety measures, as contact between elephants and humans is always dangerous with the potential for harm to humans (Bossy 2019; EAZA 2019).

Calves in zoos tend to keep greater distances from their mothers than in situ (Hoerner et al. 2023), which may put them in danger if they were living in the wild (Estes 2012; Moss 2001). The reason for these larger distances might therefore be due to the mothers' knowledge of the protective environment in the zoos, which allows the calves to move farther away than calves in the wild are allowed. This difference displayed in the zoo environment most likely testifies to the cognitive abilities and adaptability of elephants under human care, as mothers adapt their behaviour towards their calves to the environment in which they raise them.

The results display slightly less tactile contact (albeit not on a significant level) between mothers and calves in free contact conditions. Tactile contact with mothers is highly important for calves (Dunbar 2010; Jablonski 2021) and it remains unknown whether reduced contact has a long-term impact on calf development. Further investigations on this issue are therefore important. If differences increase, it must be investigated whether direct contact between carers and animals is the reason, as this is the main difference between free and protected contact.

Long-term studies with higher numbers of research animals and a focus on further aspects of the (social) environment of zoo elephants, such as training sessions and herd composition, may provide insight to the differences in social behaviour of African elephant calves under human care.

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References

- Agresti A. (2007) *An Introduction to Categorical Data Analysis*, 2nd ed. Hoboken, New Jersey: Wiley-Interscience.
- American Psychological Association (APA) (2013) *Publication Manual of the American Psychological Association*, 6th ed. Washington, DC: American Psychological Association.
- Andrews J., Mecklenborg A., Bercovitch F.B. (2005) Milk intake and development in a newborn captive African elephant (*Loxodonta africana*). *Zoo Biology* 24(3): 275–281. doi:10.1002/zoo.20048
- Archie E.A., Moss C.J., Alberts S.C. (2005) The ties that bind: Genetic relatedness predicts the fission and fusion of social groups in wild African elephants. *Proceedings of the Royal Society B* 273(1586): 513–522. doi:10.1098/rspb.2005.3361
- Archie E.A., Moss C.J., Alberts S.C. (2011) Friends and relations: Kinship and the nature of female elephant social relationships. In: Moss C.J., Croze H., Lee P.C. (eds.). *The Amboseli Elephants: A Long-Term Perspective on a Long-Lived Mammal*. Chicago, Illinois: University of Chicago Press, 238–245.

- Bassett L., Buchanan-Smith H.M. (2007) Effects of predictability on the welfare of captive animals. *Applied Animal Behaviour Science* 102(3–4): 223–245. doi:10.1016/j.applanim.2006.05.029
- Bechert U.S., Brown J.L., Dierenfeld E.S., Ling P.D., Molter C.M., Schulte B.A. (2019) Zoo elephant research: Contributions to conservation of captive and free-ranging species. *International Zoo Yearbook* 53(1): 89–115. doi:10.1111/izy.12211
- Benjamini Y., Hochberg Y. (1995) Controlling the false discovery rate: A practical and powerful approach to multiple testing. *Journal of the Royal Statistical Society. Series B (Methodological)* 57(1): 289–300.
- Bortz J., Döring N. (2006) *Forschungsmethoden und Evaluation: Für Human- und Sozialwissenschaftler*. Heidelberg, Germany: Springer Medizin Verlag.
- Bossy S. (2019) Elefantenhaltung vor dem Umbruch. *Pinguin* 24: 22–23.
- Carlstead K., Paris S., Brown J.L. (2019) Good keeper–elephant relationships in North American zoos are mutually beneficial to welfare. *Applied Animal Behaviour Science* 211: 103–111.
- Charif R.A., Ramey III R.R., Langbauer Jr. W.R., Payne K.B., Martin R.B., Brown L.M. (2005) Spatial relationships and matrilineal kinship in African savanna elephant (*Loxodonta africana*) clans. *Behavioral Ecology and Sociobiology* 57: 327–338.
- Clubb R., Mason G. (2002) *A Review of the Welfare of Zoo Elephants in Europe*. Oxford, UK: University of Oxford Animal Behaviour Research Group.
- Cohen J. (1988) *Statistical Power Analysis for the Behavioral Sciences*. Hillsdale, New Jersey: Lawrence Erlbaum Associates.
- Dale R.H.I. (2010) Birth statistics for African (*Loxodonta africana*) and Asian (*Elephas maximus*) elephants in human care: History and implications for elephant welfare. *Zoo Biology* 29(2): 87–103. doi:10.1002/zoo.20234
- Desmond T., Laule G. (1991) Protected contact elephant training. *AAZPA Annual Conference Proceedings* 606–613.
- Desmond T., Laule G. (1993) The politics of protected contact. *AAZPA Annual Conference Proceedings* 12–18.
- Douglas-Hamilton I. (1972) *On the Ecology and Behaviour of the African Elephant*. Oxford, UK: Ph.D. Thesis, University of Oxford.
- Douglas-Hamilton I., Douglas-Hamilton O. (1989) *Unter Elefanten: Abenteuerliche Forschungen in der Wildnis Zentralafrikas*. Bergisch Gladbach, Germany: Gustav Lübbe Verlag GmbH.
- Dunbar R.I.M. (2010) The social role of touch in humans and primates: Behavioural function and neurobiological mechanisms. *Neuroscience and Biobehavioral Reviews* 34(2): 260–268.
- EAZA (2019) *EAZA Position Statement of the Evolution of Elephant Management Systems at Member Zoos*. Amsterdam, Netherlands: European Association of Zoos and Aquaria.
- Estes R.D. (2012) *The Behavior Guide to African Mammals: 20th Anniversary Edition*. Oakland, California: University of California Press.
- Fritz C.O., Morris P.E., Richler J.J. (2012) Effect size estimates: Current use, calculations, and interpretation. *Journal of Experimental Psychology: General* 141(1): 2–18. doi:10.1037/a0024338
- Garai M., Kurt F. (2006) Sozialisation und das Wohlbefinden der Elefanten. *Zeitschrift des Kölner Zoo* 49: 85–102.
- Harris M., Sherwin C., Harris S. (2008) *The Welfare, Housing and Husbandry of Elephants in UK Zoos*. Bristol, UK: University of Bristol.
- Hochberg Y. (1988) A sharper Bonferroni procedure for multiple tests of significance. *Biometrika* 75(4): 800–802. doi:10.1093/biomet/75.4.800.
- Hoerner F., Rendle-Worthington J., Lawrenz A., Oerke A.-K., Damerau K., Borrágán Santos S., Hard T., Preisfeld G. (2023) Differences in Mother–Infant Bond and Social Behavior of African Elephant Calves Living In Situ and Ex Situ. *Animals* 13: 3051. https://doi.org/10.3390/ani13193051
- Hope A.C.A. (1968) A simplified Monte Carlo significance test procedure. *Journal of the Royal Statistical Society Series B Statistical Methodology* 30(3): 582–598. doi:10.1111/j.2517-6161.1968.tb00759.x
- Jablonski N.G. (2021) Social and affective touch in primates and its role in the evolution of social cohesion. *Neuroscience* 464: 117–125. doi:10.1016/j.neuroscience.2020.11.024
- Kappeler P. (2020) *Verhaltensbiologie*. Berlin, Germany: Springer-Verlag.
- Kowalski N.L., Dale R.H.I., Mazur C.L.H. (2010) A survey of the management and development of captive African elephant (*Loxodonta africana*) calves: Birth to three months of age. *Zoo Biology* 29(2): 104–119.
- Krull H.P. (2000) *Beobachtungs- und Protokollmethoden für Verhaltensbeobachtungen*. Krefeld, Germany: Zooschule Krefeld.
- Kubinger K.D., Rasch D., Moder K. (2009) Zur Legende der Voraussetzungen des t-Tests für unabhängige Stichproben. *Psychologische Rundschau* 60(1): 26–27. doi:10.1026/0033-3042.60.1.26

- Kurt F. (1994) Elefanten in Zirkus und Zoo. In: *Staatliches Museum für Völkerkunde in München* (ed.). Mensch und Elefant. Frankfurt am Main, Germany: Umschau-Verlag, 117–133.
- Kurt F. (2006) Die Geschichte der Haltung von Elefanten in Menschenobhut. *Zeitschrift des Kölner Zoo* 49(2): 59–81.
- Laule G., Whittaker M. (2000) Protected contact – Beyond the barrier. *Proceedings of the American Zoo and Aquarium Association Annual Conference* 1–6.
- Lee P.C., Moss C. (2011) Calf development and maternal rearing strategies. In: Moss C., Croze H., Lee P.C. (eds.). *The Amboseli Elephants: A Long-Term Perspective on a Long-Lived Mammal*. Chicago, Illinois: University of Chicago Press, 224–237.
- Lee P.C., Moss C.J. (1986) Early maternal investment in male and female African elephant calves. *Behavioral Ecology and Sociobiology* 18: 353–361. doi:10.1007/BF00299666
- Lundberg U., Szdzyu K., König I. (2001) Beobachtungen zur Verhaltensontogenese Afrikanischer Elefanten (*Loxodonta africana*) im Tierpark Berlin-Friedrichsfelde. *Milieu Berlin* 10: 392–408.
- Martin P., Bateson P.P.G. (2007) *Measuring Behaviour: An Introductory Guide*, 3rd ed. Cambridge, UK: Cambridge University Press.
- Meehan C.L., Hogan J.N., Bonaparte-Saller M.K., Mench J.A. (2016) Housing and social environments of African (*Loxodonta africana*) and Asian (*Elephas maximus*) elephants in North American zoos. *PLoS ONE* 11(7): e0146703. doi:10.1371/journal.pone.0146703
- Moss C.J. (2001) The demography of an African elephant (*Loxodonta africana*) population in Amboseli, Kenya. *Journal of Zoology* 255(2): 145–156. doi:10.1017/S0952836901001212
- Moss C., Colbeck M. (2002) *Das Jahr der Elefanten: Tagebuch einer afrikanischen Elefantenfamilie*. München, Germany: Sierra bei Frederking and Thaler Verlag.
- Naguib M., Krause E.T. (2020) *Methoden der Verhaltensbiologie*. Berlin, Germany: Springer-Verlag.
- Pinter-Wollman N., Isbell L.A., Hart L.A. (2009) The relationship between social behaviour and habitat familiarity in African elephants (*Loxodonta africana*). *Proceedings of the Royal Society B* 276(1659): 1009–1014. doi:10.1098/rspb.2008.1538
- Poole J., Granli P. (2011) Signals, gestures, and behavior of African elephants. In: Moss C.J., Croze H., Lee P.C. (eds.). *The Amboseli Elephants: A Long-Term Perspective on a Long-Lived Mammal*. Chicago, Illinois: University of Chicago Press, 109–124.
- Poole J., Granli P. (2021) *The Elephant Ethogram. Elephants Voices*. Available online at <https://elephantvoices.org/elephant-ethogram/ethogram-table/overview.html>
- Proctor C.M., Brown J.L. (2015) Influence of handling method on adrenal activity in zoo African and Asian elephants. *Journal of Zoo and Aquarium Research* 3(1): 1–5. doi:10.19227/jzar.v3i1.100
- Olson D. (1994) Research and captive elephant management. *American Association of Zoological Parks and Aquaria Annual Conference Proceedings* 364–368. Wheeling, West Virginia: AZA.
- Olson D. (2004) *Elephant Husbandry Resource Guide*. Lawrence, Kansas: Allen Press.
- Randler C. (2018) *Verhaltensbiologie*. Stuttgart, Germany: UTB GmbH.
- Riddle H.S., Stremme C. (2011) Captive elephants – An overview. *Journal of Threatened Taxa* 3(6): 1826–1836. doi:10.11609/JoTT.o2620.1826-36
- Ryan T.P. (2013) *Sample Size Determination and Power*. Hoboken, New Jersey: John Wiley and Sons Inc.
- Samson J. (2000) “Can’t you be more like Kubwa?” Tale of an elephant birth in Indianapolis. *Journal of the Elephant Managers Association* 11(3): 210–215.
- Schulte B.A. (2000) Social structure and helping behavior in captive elephants. *Zoo Biology* 19(5): 447–459. doi:10.1002/1098-2361(2000)19:5%3C447::AID-ZOO12%3E3.0.CO;2-%23
- Siegel S., Castellan N.J. (1988) *Nonparametric Statistics for the Behavioral Sciences*, 2nd ed. Boston, Massachusetts: McGraw-Hill.
- Tanner R. (2000) *Dicke Haut und zarte Seele. Pfliegeranwesenheit während/ kurz nach der Geburt, in der Prägephase*. Steinfurth, Germany.
- Tomarken A.J., Serlin R.C. (1986) Comparison of ANOVA alternatives under variance heterogeneity and specific noncentrality structures. *Psychological Bulletin* 99(1): 90–99. doi:10.1037/0033-2909.99.1.90
- Veasey J. (2006) Concepts in the care and welfare of captive elephants. *International Zoo Yearbook* 40(1): 63–79. doi:10.1111/j.1748-1090.2006.00063.x
- Webber C.E. (2017) *A Comparison of Behavioural Development of Elephant Calves in Captivity and in the Wild: Implications for Welfare*. Stirling, UK: Dissertation, University of Stirling.
- Williams E., Carter A., Hall C., Bremner-Harrison S. (2019) Social interactions in zoo-housed elephants: Factors affecting social relationships. *Animals* 9(10): 747. doi:10.3390/ani9100747