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The nocturnal behaviour of African elephants (Loxodonta africana) in Aalborg Zoo and how changes in the environment affect them

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Abstract

Elephants' nocturnal behaviours are an important part of their welfare in captivity. For this reason, this study investigates whether the nocturnal behaviour of three African elephants' (*Loxodonta africana*) in Aalborg Zoo is affected when exposed to different conditions and if they are affected differently. Camera footage was used to log the elephants' behaviours at night during a control period and during two periods with different impacts, which consisted of six nights respectively. Every night, the elephants were captured on video from 8 pm to 8 am and the behaviours were subsequently logged every second following an ethogram containing seven behaviours. This study was not able to show an effect ($p > 0.05$) on the elephants' nocturnal behaviour related to an increase in visitor activity during the Autumn holiday. However, a significant increase in the duration of the sway behaviour was found after the shift from daylight saving time to standard time. This study also found that the elephants show individual norms within the behaviours such as interaction with food and abnormal behaviours. The lack of statistical evidence for changes in nocturnal behaviour related to visitor activity, may be due to other external factors influencing the nocturnal behaviour of the elephants. Swaying behaviour was affected by the shift to standard time of all three elephants. Individual differences in nocturnal behaviours indicate that the three elephants have different animal personalities.

Keywords: ethogram, behaviourism, captivity, personality, stereotypy

Introduction

One of the biggest challenges when looking at African elephants (Loxodonta africana) from an animal husbandry perspective, is managing elephants' welfare (Veasey, 2006). Several parameters separate the behaviours of wild elephants from behaviours of elephants in captivity. This could be caused by the limited space in the zoos and reduced possibility for activities. Lack of space and restrictions in social contact between conspecifics may be the main reasons for changes in behaviour of elephants in captivity (Adams & Berg, 1980, Leighty et al., 2009). In the wild, African elephants live together in herds consisting of 5 to 10 related adult females and their offspring (Bonaparte-Saller & Mench, 2018). In these herds, hierarchical ranks occur and are dominated by the matriarch, the oldest female (Bonaparte-Saller & Mench, 2018; Schulte, 2000).

Wild elephants sleep considerably less during the night compared to elephants in captivity, and wild elephants do not return to sleep that night if they are disturbed (Gravett et al., 2017). They also have several days where they do not lie down at all which causes less sleep (Schiffmann et al., 2018). The commencement and end of the sleep seem to be affected by environmental implications, such as the risk

of predation. Furthermore, wild elephants will find new places to sleep every night because they walk many miles and spend a lot of time eating (Gravett et al., 2017). Wild elephants spend most of the night standing, which could be due to their search for food (Wilson et al., 2006; Stokes et al., 2017). Besides eating and drinking, elephants interact with each other within their group and rest by standing or lying down (Wilson et al., 2006; Shyne 2006). They rest for about 25% of the day in either a standing or lying position, while the younger elephants rest more than the older ones in a group (Wilson et al., 2006).

In zoos, African elephants lie down for two hours a day on average (Gravett et al., 2017). Recumbent rest will most likely happen during the night and has the primary function of sleep (Gravett et al., 2017). In both captivity and the wild, elephants will lie down more during the night than during the day. Elephants in zoos can experience disturbances from external factors such as visitor activity during the day which may have a negative impact on their amount of sleep when lying down (Schiffmann et al., 2018). This observation may form a basis for testing how additional stress caused by an increase in the number of visitors in the zoo, will affect the sleeping behaviour in a group of unchained African elephants (Schiffmann et al., 2018).

Specific stimuli can over time create repetitive patterns of behaviour known as stereotypical behaviour (Shyne, 2006). Such behaviour in elephants is thought to be provoked by repression of natural behaviours such as limitations in finding a partner or the need to walk many miles per day. Other factors that cause changes in stereotypical behaviour may be human contact with zookeepers and individual isolation (Shyne, 2006; Greco et al., 2016; Yasui et al., 2012). Elephants in captivity are most active from between 6 am and 7 am and 6 pm to midnight (Brockett et al., 1999). Feeding behaviour seems to be the most common behaviour which increases between 5 pm to 12 am for elephants in captivity and peaks at midnight for wild elephants (Wilson et al., 2006). Some of the elephants' behaviours seem to be affected by the handlers' daily events. Especially the stereotypical behaviour swaying (a rocking movement from side to side) is directly linked to the handlers' scheduled arrival and depart (Wilson et al., 2006; Stokes et al., 2017).

Groups of elephants in captivity are often not related to each other and may be living with different species. The number of individuals in a group is a lot smaller than in the wild and often consists of adults. However, the groups are still divided into ranks and dominated by a matriarch (Schulte, 2000). In relation to the elephants' complex social behaviour, they express a variety of individual differences relative to behavioural traits (Yasui et al., 2012). Differences between individuals' behaviour across time and contexts is defined as animal personality (Dingemanse et al., 2010). Personality traits in animals are possible to investigate by observing the aggregation of related behaviours in animals in the wild. Aggregations of behaviours may be caused by environmental and social stress, and individuals may act differently to these stimuli (Horback et al., 2013).

The aim of this study is to investigate whether the nocturnal behaviour of the three African elephants in Aalborg Zoo is affected when exposed to different conditions during the Autumn holiday and the shift from daylight saving time to standard time. Furthermore, to investigate whether the three elephants are affected differently, which can be interpreted as animal personality between the elephants.

Methods

Participants

This study investigated three female African elephants housed in Aalborg Zoo, Denmark. The elephants were approximately two years old in 1985 when they arrived in Aalborg Zoo, hence all three elephants Tanja, Maj, and Bibi were 36 years old during the study.

Setting

The elephants' indoor enclosure was connected to an outdoor enclosure which was separated into two sections. The indoor enclosure was divided into three sections, one enclosure for each elephant. The sizes of the indoor enclosures are shown in Fig. A1, while Fig. A2 shows enclosure 1. Due to low temperatures, the zoo staff closed the gate to the outdoor enclosure during the night.

During the night, the largest elephant regarded as the matriarch was separated from the remaining elephants in one of the three indoor enclosures. The remaining elephants spent their nights together in connected enclosures. However, the matriarch had the opportunity to interact with the other elephants through the rails. The separation of the elephants was due to conflicts between the matriarch and the former matriarch.

Procedure

Data was collected 12 hours from 8 pm to 8 am from permanently installed cameras during three periods consisting of a control period, and two periods with different impacts. The control period consisted of six nights from October 6th to 12th 2019 and was compared to a period of six nights during the Autumn holiday from October 13th to 19th 2019, and a period of six nights after the shift from daylight saving time to standard time from October 27th to November 2nd 2019. This totaled 216 hours of material for each elephant. During Autumn holidays the zoo visitor activity increased with 164%. Once a day during the Autumn holiday, children were allowed in the outdoor enclosures as a part of a zoo visitor activity, while the elephants were kept in the indoor enclosures. No children were allowed in the enclosure Monday and Thursday, with the purpose of reducing the level of stress the elephants were exposed to. The comparison between the control period and the shift to standard time included changes in feeding times and the indoor light schedule. The animal personality was tested during the control period, the Autumn holiday, and the shift to standard time.

Analysis

Behavioural analyses were performed based on the video footage of the elephants. For the behavioural study, an ethogram inspired by Hacker (2015) was created. The ethogram is shown in Table A1. To ensure consensus in the notations between the observers, a concordance test was made. Behaviour from the ethogram in Table 1 was noted every second it occurred, during the observation.

Statistical tests were performed on the collected data to determine the differences between the control period and the two periods with different impacts. Due to non-normal distribution, non-parametric statistics were used to evaluate the data. The non-normal distribution is partly due to large outliers and other factors such as leptokurtosis or platykurtosis. Leptokurtosis is when the data has a lot of points near the median, describing a larger potential for outliers which is seen when the kurtosis is above the value 3. Platykurtosis is when few points are near the median, describing a lesser potential for outliers which is seen when kurtosis is below the value 3.

A Mann-Whitney test was used to assess the significance of the data by evaluating the differences between the control period and the two observed periods' median (Mann, 2007). The median is used as a mean for the behavioural length if the data is non-normally distributed. Levene's test was performed to assess the homogeneity of the variance by using the median (Brown & Forsythe, 1974). Skewness and kurtosis were used to assess the distribution of the data. Skewness was used to measure the symmetry of the data, where a positive skewness means that the data is right-skewed, whereas a negative skewness means that the data is left-skewed (Mann, 2007). Kurtosis was performed to measure whether the data had a leptokurtic or platykurtic distribution relative to a normal distribution (Mann 2007).

The difference in the duration of behaviours can be assessed with statistical tests like Mann-Whitney, which can be used to conclude if there is an individual variation between the elephants, interpreted as animal personality**.**

The data was tested twice, once with all the data, and then with only the interquartile range (IQR). IQR is a measure of variability and is useful for skewed data sets as it represents the range of the middle 50% of the data set.

A p-value of less than 0.05 shows a significant difference between the control period and the observed period. The number of days with a significant difference between the control period and the observed periods for all tests were calculated as a percentage shown in Table 2 and 3.

Results

Due to lack of data, it was not possible to test the behaviours abnormal, defecate, throw food and lying down. For this reason, Table 2 and Table 3 only contain the behaviours interaction with food, standing, and sway. The overall results for all behaviours are shown in Table A2 and A3.

In general, no trends were observed when comparing the control period and the period during the Autumn holidays (Table 2). However, statistical tests showed significant differences between days. This created heterogeneous data that showed that both periods had different factors that increased the duration of the behaviours, and the variance of the length of these behaviours on different days. This heterogeneity was shown by the Mann-Whitney and Levene's tests where the percentage of significant differences for the median and variance in the control period and Autumn holiday, varies between both the periods and the individual elephants. This variation between the periods was especially evident for the elephant Tanja, who seemed to have a high percentage of days with significantly large medians for both the control period and the Autumn holiday period. The differences in values for the median and variance between the periods showed the elephants behave differently in the two periods. The three elephants showed significant individual differences in interaction with food, swaying, and standing, for both Mann-Whitney and Levene's tests. The tests were also performed on just IQR to eliminate outliers which resulted in different values for the percentage of days with significant differences for the control period and the Autumn holiday, that depended on whether the IQR or all the sequences were used.

The four tests, Mann-Whitney, Levene's, skewness, and kurtosis showed no overall trends between the control period and the period where the shift to standard time occurred (Table 3).

The results for interaction with food, sway, and standing were heterogeneous, but the percentages of significant differences between the periods showed a tendency for the standard time to be significantly greater than the control period in Mann-Whitney and Levene's test. However, the heterogeneity between the two periods indicated a clear difference between the periods.

Average differences between the swaying behaviour for each elephant during the control period, the Autumn holiday period, and the period during the shift to standard time were evident (Fig. 3). The individual called Tanja did not seem to be affected by the different periods, as the swaying occurred about the same time for each period, and for about the same duration of time across the periods (Fig. 3a). For elephant Bibi, the swaying behaviour increased from 8521 seconds at the beginning of the Autumn holiday, to approximately 2 hours and 22 minutes towards the end of the period. No significant differences were found between the control period and the period after the shift to standard time (Fig. 3). Elephant Bibi started swaying 22596 seconds after 8 pm during the control period and 21470 seconds after 8 pm during the period when the shift to standard time occurred.

In general, elephant Bibi's swaying was delayed compared to the other two other elephants (Fig. 3b). Elephant Maj started to sway 12000 seconds after 8 pm after the shift to standard time, and approximately

8000 seconds after 8 pm during the Autumn holiday period. All three elephants lay down earlier in the week when the shift to standard time occurred compared to the control period (Fig. 4). On average, elephant Maj lay down 2774 seconds earlier during the shift to standard time, elephant Bibi 5050 seconds earlier, and elephant Tanja 4859 seconds earlier. No elephants were lying down after 39640 seconds for any of the periods.

Table 2: The table shows the percentage of significant values when comparing the control period and the period during the Autumn holiday, when performing the following tests: Mann-Whitney, Levene's, skewness and kurtosis tests. The table shows the data tested both with and without outliers for all three elephants. NS stands for non-significant.

		Mann-whitney		Levenes		Akewness		Kurtosis	
Behavior	**Elephant**	**With outliers**	**IQR**	**With outliers**	**IQR**	**With outliers**	**IQR**	**With outliers**	**IQR**
Interaction With Food	Tanja	C>A 33.3%	C>A 47.2%	C>A 36.1%	C>A 47.2%	C>A 25%	C>A 16.7%	C>A 13.9%	C>A 11.1%
		C<A 38.9%	C<A 44.4%	C<A 16.7%	C<A 44.4%	C<A 22.2%	C<A 25%	C<A 16.7%	C<A 22.2%
	Bibi	C>A 16.7%	C>A 16.7%	C>A 2.8%	C>A 22.2%	NA	NA	NA	C>A 2.8%
		NA	C<A 38.9%	NA	C<A 13.9%	C<A 2.8%	NA	C<A 5.6%	C<A 8.3%
	Maj	C<A 16.7%	C>A 25%	NA	C>A 30.6%	C>A 2.8%	NA	C>A 2.8%	NA
		C<A 22.2%	C<A 38.9%	C<A 30.6%	C<A 30.6%	NA	NA	NA	NA
Sway	Tanja	C>A 16.7%	C>A 19.4%	C>A 19.4%	C>A 19.4%	C>A 27.8%	NA	C>A 33.3%	C>A 2.8%
		C<A 27.8%	C<A 16.7%	NA	C<A 36.1%	C<A 2.8%	NA	NA	NA
	Bibi	C>A 5.6%	C>A 13.9%	C>A 8.3%	C>A 2.8%	C>A 8.3%	C>A 16.6%	C>A 5.6%	C>A 13.9
		NA	NA	NA	NA	C<A 11.1%	C<A 5.6%	C<A 38.9%	C<A 22.2%
	Maj	C>A 8.3%	C>A 22.2%	C>A 5.6%	C>A 13.9%	NA	C>A 13.9%	NA	C>A 30.6%
		C<A 2.8%	C<A 11.1%	NA	C<A 2.8%	C<A 2.8%	NA	C<A 19.4%	NA
Standing	Tanja	C>A 33.3%	C>A 41.7%	C>A 5.6%	C>A 38.9%	C>A 5.6%	NA	NA	NA
		C<A 22.2%	C<A 27.8%	C<A 11.1%	C<A 36.1%	C<A 13.9%	NA	C<A 19.4%	NA
	Bibi	C>A 8.3%	C>A 13.9%	C>A 2.8%	C>A 8.3%	C>A 13.9%	C>A 5.6%	C>A 16.7%	C>A 13.9%
		C<A 8.3%	C<A 27.8%	C<A 8.3%	C<A 19.4%	NA	NA	C<A 5.6%	NA
	Maj	C>A 2.8%	C>A 11.1%	C>A NA	C>A 8.3%	C>A 5.6%	NA	C>A 16.7%	NA
		C<A 30.6%	C<A 66.7%	C<A 13.9%	C<A 44.4%	NA	C<A 5.6%	NA	NA

Table 3: The table shows the percentage of significant values when comparing the control and the period during the shift to standard time when performing the following tests: Mann-Whitney, Levene's, skewness and kurtosis tests. The table shows the data tested with and without outliers for all three elephants. NS stands for non-significant.

		Mann-whitney		Levenes		Skewness		Kurtosis	
Behavior	**Elephant**	**With outliers**	**IQR**	**With outliers**	**IQR**	**With outliers**	**IQR**	**With outliers**	**IQR**
Interaction With Food	Tanja	C>S 25%	C>S 38.9%	C>S 13.9%	C>S 36.1%	C>S 22.2%	C>S 19.4%	C>S 8.3%	C>S 16.7%
		C<S 30.6%	C<S 33.3%	C<S 30.6%	C<S 38.9%	C<S 8.3%	C<S 5.6%	C<S 5.6%	C<S 8.3%
	Bibi	C>S 5.6%	C>S 13.9%	C>S 11.1%	C>S 11.1%	C>S NS	C>S NS	C>S NS	C>S NS
		C<S 19.4%	C<S 27.8%	C<S NS	C<S 13.9%	C<S NS	C<S NS	C<S NS	C<S NS
	Maj	C>S NS	C>S 13.9%	C>S 2.8%	C>S 13.9%	C>S 2.8%	C>S NS	C>S NS	C>S NS
		C<S 22.2%	C<S 30.6%	C<S 33.3%	C<S 38.9%	C<S NS	C<S NS	C<S NS	C<S NS
Sway	Tanja	C>S 13.9%	C>S 30.6%	C>S 8.3%	C>S 16.7%	C>S 22.2%	C>S 16.7%	C>S 27.8%	C>S 11.1%
		C<S 30.6%	C<S 33.3%	C<S 25%	C<S 36.1%	C<S 5.6%	C<S NS	C<S 2.8%	C<S 8.3%
	Bibi	C>S NS	C>S 5.6%	C>S NS	C>S NS	C>S 2.8%	C>S 5.6%	C>S 13.9%	C>S 13.8
		C<S 5.55%	C<S 8.3%	C<S 5.6%	C<S 5.6%	C<S 25%	C<S 2.8%	C<S 27.8%	C<S 5.6
	Maj	C>S NS	C>S NS	C>S NS	C>S NS	C>S NS	C>S 8.3%	C>S NS	C>S 19.4%
		C<S 11.11%	C<S 25%	C<S 8.3%	C<S 16.7%	C<S NS	C<S NS	C<S NS	C<S 11.1%
Standing	Tanja	C>S 27.8%	C>S 36.1%	C>S 16.7%	C>S 38.9%	C>S 2.8%	C>S NS	C>S NS	C>S NS
		C<S 25%	C<S 41.7%	C<S 22.2%	C<S 27.8%	C<S 8.3%	C<S 13.9%	C<S 8.3%	C<S 16.7%
	Bibi	C>S NS	C>S NS	C>S NS	C>S NS	C>S 8.3%	C>S NS	C>S 11.1%	C>S 2.8%
		C<S 2.8%	C<S 16.7%	C<S 8.3%	C<S 38.9%	C<S 2.8%	C<S 5.6%	C<S 16.7%	C<S 8.3%
	Maj	C>S NS	C>S 13.89%	C>S NS	C>S NS	C>S 11.1%	C>S NS	C>S 27.8%	C>S NS
		C<S 22.2%	C<S 41.7%	C<S 19.4%	C<S 33%	C<S NS	C<S 2.8%	C<S NS	C<S NS

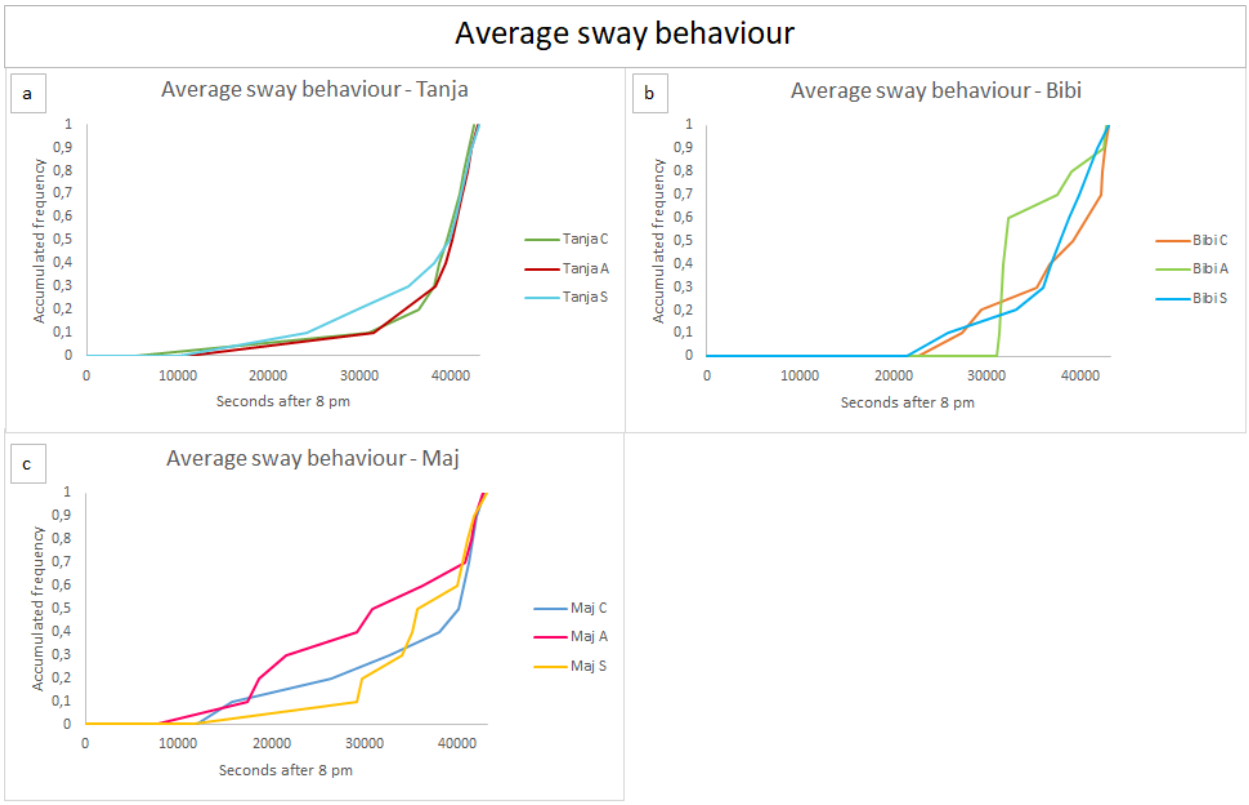

Figure 3 (a, b and c): The graphs show the average amount of time spent swaying for each elephant during the control period, the Autumn holiday, and when the shift to standard time occurred. The time is measured in seconds after 8 pm. n=6.

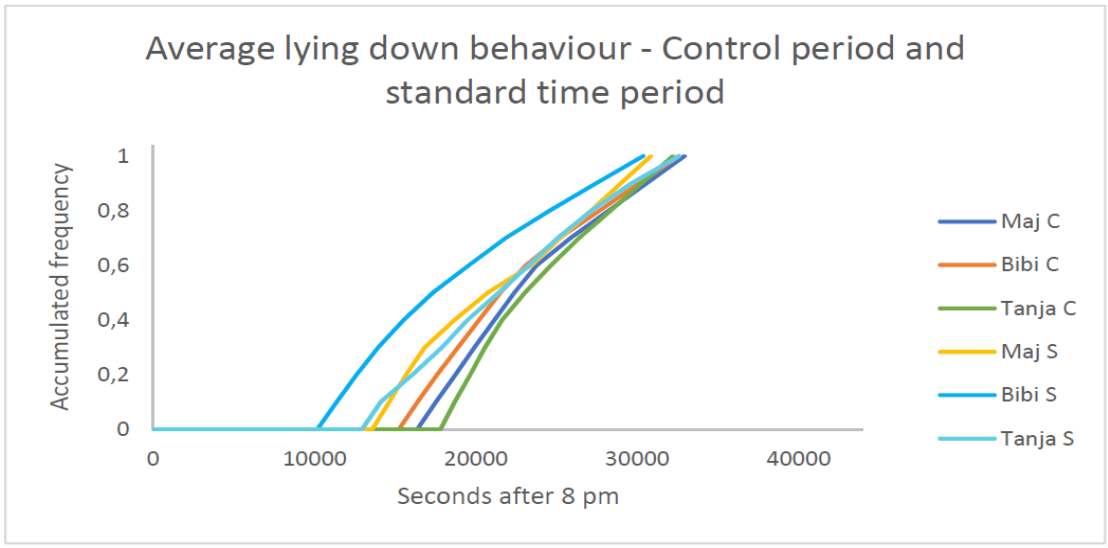

Figure 4: The average amount of time spent lying down for all three elephants during the control period and the period when the shift to standard time occurred. The time is measured in seconds after 8 pm. n=6.

Discussion

Will an increase in visitor activity during the Autumn holiday affect the elephants' nocturnal behaviours?

No differences were found between the control period and the Autumn holiday where the number of visitors increased with 164.4 % and children were allowed to clean the outside enclosure. The duration of the behaviours in both periods depend on the day, and show heterogeneity that can be caused by different factors affecting the behaviours such as irregularities in the daily husbandry routines, or removing their choice to stay outside or inside (Koyama et al., 2012). Also, the amount of days with significant differences for IQR, indicates that other factors than visitors influenced the behaviour of the three elephants from day to day. The significance is higher when the control period has a larger difference in IQR for the behaviours sway and interaction with food (Table 2). Behaviours are more predictable during the Autumn holiday meaning that other factors than the number of visitors affects the three elephants. This is in contrast to the standing behaviour where both Mann-Whitney and Levene's tests show a difference between the control period and Autumn holiday. However, the heterogeneity of data indicates that other factors than Autumn holiday visitors affects the difference in their standing behaviour.

Average time spent lying down was three hours during the control period (Table A4), which is more than the elephants observed in 49 zoos in a study by Holdgate et al., (2016). The observations from Holdgate et al. (2016) seem more comparable to the average lie down behaviour observed in the Autumn holiday period. Hence the elephants seem to lie down for a longer time during the control period than an average elephant. According to Schiffmann et al., (2018), this may be because the elephants felt safer during the control period than in the Autumn holiday period. However, other factors might affect elephants' lying behaviour such as the presence of humans, dominant social rank, physical problems or a solid ground (Schiffmann et al., 2018). The indoor enclosure in this study has a solid floor, and also the amount of hay the elephants can collect and lie on may affect their lying behaviour.

It should be considered that the determination of whether all data or just the IQR should be used for the statistical tests. This is because the results change if only IQR is used (Table 2). This is apparent for elephant Maj when she is standing and swaying, where elephant Maj's significant values more than doubles for Mann-Whitney and Levene's test, compared to the tests with all the data. Both methods leave out data. Hence, studies should be careful when choosing a method for collecting data, since our results show clear differences. These differences should especially be apparent for behaviours like throw food and lying down as they often are performed at either certain times at night, or at random times during the night, this can be seen when comparing Fig. A6, Fig. A8 and Fig. A10 or Fig. A5, Fig.A7 and Fig. A9. Another point to consider is the possibility of losing the indication of a disturbance of the elephant if using intervals or just IQR. According to Gravett et al., (2017), the elephants will only rest while lying down when feeling safe. This may lead to longer durations of standing if the elephants do not feel safe, since they will be resting in a standing position instead. These longer durations might be removed when using intervals or the IQR, which means the correlation between lying down and standing will be lost. Therefore, if one should choose to collect data in intervals, it is important to consider which intervals would be the best depending on which behaviours are relevant.

Due to the shift from daylight saving time to standard time affects the elephants' nocturnal behaviours?

The three elephants are in general lying down almost an hour earlier during the period when the shift to standard time occurred, compared to the control period (Fig. 4). This is consistent with the one-hour time shift, and this result shows that the behaviour lying down is not directly affected by the time and daily routines' time shift. In addition, it may support the theory by Wilson et al., (2006) and Okamura et al., (2002) that mammals like elephants have a circadian rhythm. Even though, the behaviour ends almost at the same time on average (Fig. 4). The stereotypical and abnormal behaviour of the three elephants differed between individuals.

Elephant Maj is the only elephant showing abnormal behaviour every day in every period, which makes Maj's data consistent throughout the days and weeks. This suggests that the abnormal behaviour for elephant Maj is more likely characterized as stereotypical behaviour, as Maj consistently showed behaviours such as tapping or standing with the trunk on the stomach, trunk in the mouth and holding on a metal wire. The stereotypical behaviour swaying is significantly higher for all three elephants in the standard time period than the control period (Table A2). The swaying behaviour is considered linked to the handlers' scheduled arrival and departing. Hence, the data supports that the change in time has an effect on the elephants' nocturnal routines for the swaying behaviour.

Do the three elephants in Aalborg Zoo have different behavioural patterns, interpreted as different personalities?

It is necessary to observe multiple elephants, to discuss whether individuals have different personalities (Yasui et al., 2012). The elephant Tanja seems to be more affected by the changes during the three periods compared to the other two elephants (Table 1 and 2). Since the elephant, Tanja has the highest percentage of days with significant differences for the behaviours interaction with food (72.2%), sway (44.5%), and standing (55.5%) (Table 1). The same pattern is observed for all the behaviours in Table 2. This pattern indicates different personalities between the elephant Tanja and the other two elephants since she is more susceptible to change. This individual variation the elephant Tanja displays, can according to Seltmann et al., (2019) be due to different personalities caused by their social rank within the herd.

This individual variation from the population might be caused by the isolation from the other two elephants during the night, or because of being the largest elephant in this population and can be regarded as the matriarch (Seltmann et al., 2019). The elephant Maj shows a tendency to be different from the other elephants when considering the behaviour abnormal (Table A2 and A3). The individual Maj is the only elephant to display significant differences of 11.2% (Table 1) and 13.9% (Table 2) between the periods. While the elephant Bibi shows no significant differences for the abnormal behaviour. These differences in the observation between the elephants for abnormal behaviour might be due to individual differences among the elephants. This is supported by Wolf et al., (2008), who found that the expression of individual responses is a sign of personality being expressed. This individual variation observed for the elephants Tanja and Maj indicates that the elephants have different behavioural patterns, which can be interpreted as animal personality.

Conclusion

The results indicated that the elephants' nocturnal behaviours were not simply affected by an increased visitor activity since other external factors seemed to influence how the elephants' nocturnal behaviours were expressed. When the shift to standard time occurred, significant differences between the duration and frequency of the sway behaviour were observed. This stereotypical behaviour seemed to be the only behaviour observed in this study that was affected by the shift to standard time in all three elephants in Aalborg Zoo. Significant variations were found between the behaviours of individual elephant's indicating differences in personality.

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Authors' contributions

All authors contributed equally

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Appendix

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The elephants' enclosure

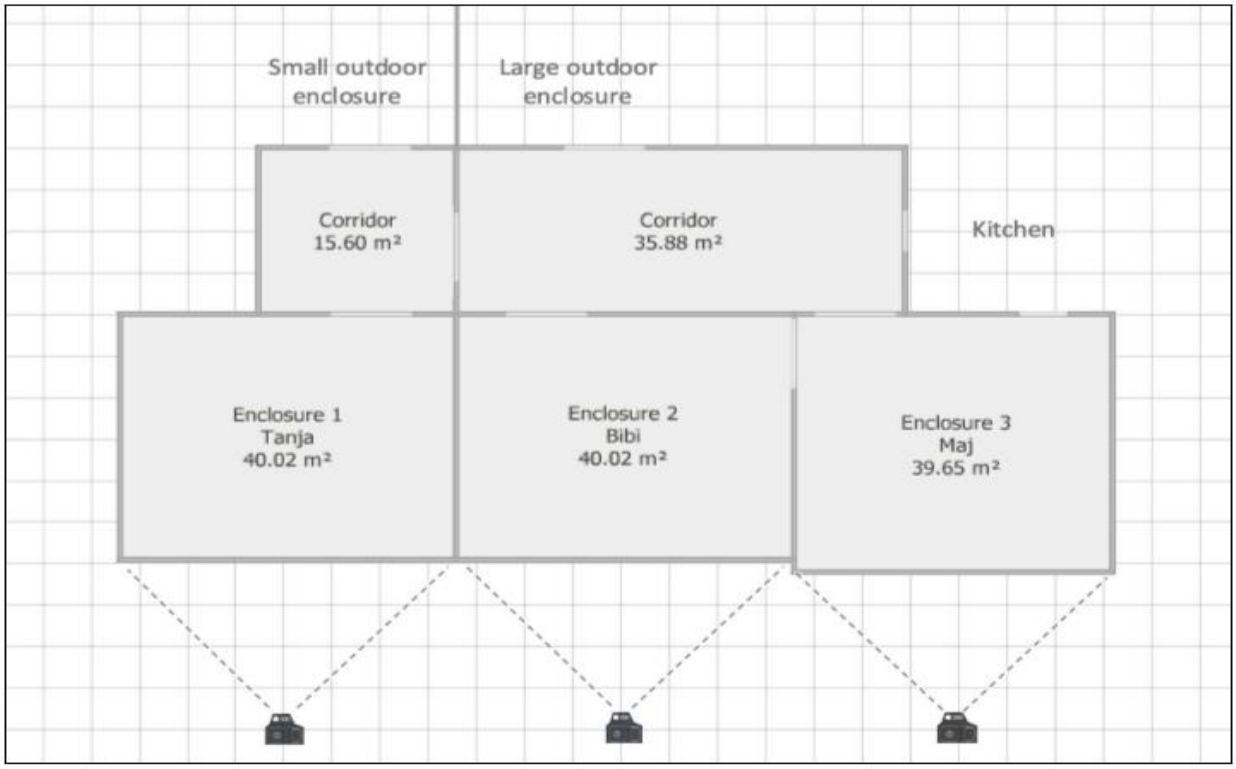

Figure A1: Sketch of the elephants' enclosures showing the orientation of the cameras and how the enclosures are connected to the outdoor enclosures and the kitchen.

Figure A2: Photo of enclosure 1 taken from the camera used when filming. The photo was taken during the daytime.

Ethogram

Table A1 - The ethogram used for the analysis of the elephants' nocturnal behaviours, inspired by Hacker (2015).

Behaviour	Description
Lying down	The elephant lied down.
Standing	The elephant stood with no leg movement. The elephant was not eating or drinking.
Interaction with food	Organized or ate food. Interaction with food was usually done with small piles of hay. Walked around inside the indoor enclosure.
Abnormal	Atypical or stereotypic behaviour included stomach- or head bobbing and when the elephants stood with their trunk in the mouth, or on their head.
Defecate	Excreted feces. The notation started when the tail lifted and ended when the tail was back in a relaxed position.
Throw food	The elephant used its trunk to throw food at itself.
Sway	The elephant stood on all four legs and moved its body in a rocking movement from side to side.

Statistical tables

Table A2: The table shows the percentage when the control period is significantly bigger or smaller than the Autumn holiday for each elephant, for all the behaviours. The table shows data for Mann-Whitney, Levene's, skewness and kurtosis tests with or without outliers. NS stands for non-significant.

		Mann-Whitney		Levene's		Skewness		Kurtosis	
Behaviour	Elephant	With outliers	IQR	With outliers	IQR	With outliers	IQR	With outliers	IQR
Abnormal	Tanja	C>A 2.8% NS	C>A 11.1% NS	NS NS	NS NS	--- ---	C>A 27.8% C<A 16.7%	--- ---	C>A 13.9% C<A 33.3%
	Bibi	NS NS	--- ---	NS NS	NS NS	NS NS	--- ---	C>A 13.9% NS	--- ---
	Maj	C>A 2.8% C<A 8.3%	C>A 22.2% C<A 19.4%	NS C<A 8.3%	C>A 2.8% C<A 13.9%	NS C<A 16.7%	NS NS	NS C<A 16.7%	NS NS
Defecate	Tanja	NS NS	NS C<A 2.8%	C>A 5.6% NS	NS NS	C>A 5.6% NS	C>A 5.6% C<A 22.2%	C>A 16.7% C<A 2.8%	C>A 5.6% C<A 11.1%
	Bibi	NS NS	NS NS	NS C<A 8.3%	NS C<A 5.6%	--- ---	--- ---	C>A 19.4% C<A 5.6%	C>A 11.1% C<A 27.8%
	Maj	NS NS	NS NS	--- ---	--- ---	--- ---	--- ---	--- ---	--- ---
Throw food	Tanja	C>A 8.3% NS	--- ---	C>A 27.8% C<A 8.3%	--- ---	C>A 11.1% C<A 19.4%	NS NS	C>A 30.6% C<A 41.7%	C>A 11.1% C<A 22.2%
	Bibi	C>A 13.9% NS	C>A 13.9% NS	C>A 8.3% NS	C>A 5.6% NS	C>A 8.3% C<A 13.9%	C>A 11.1% C<A 27.8%	C>A 16.7% C<A 11.1%	C>A 5.6% C<A 13.8%
	Maj	--- ---	--- ---	--- ---	--- ---	--- ---	--- ---	--- ---	--- ---
Interaction with food	Tanja	C>A 33.3% C<A 38.9%	C>A 47.2% C<A 44.4%	C>A 36.1% C<A 16.7%	C>A 47.2% C<A 44.4%	C>A 25% C<A 22.2%	C>A 16.7% C<A 25%	C>A 13.9% C<A 16.7%	C>A 11.1% C<A 22.2%
	Bibi	C>A 16.7% NS	C>A 16.7% C<A 38.9%	C>A 2.8% NS	C>A 22.2% C<A 13.9%	NS C<A 2.8%	NS NS	NS C<A 5.6%	C>A 2.8% C<A 8.3%
	Maj	C>A 16.7 % C<A 22.2%	C>A 25% C<A 36.1%	NS C<A 19.4%	C>A 30.6% C<A 30.6%	C>A 2.8% NS	NS NS	C>A 2.8% C<A NS	NS NS
Sway	Tanja	C>A 16.7% C<A 27.8%	C>A 19.4% C<A 16.7%	C>A 19.4% NS	C>A 19.4% C<A 36.1%	C>A 27.8% C<A 2.8%	NS NS	C>A 33.3% NS	C>A 2.8% NS
	Bibi	C>A 5.6% NS	C>A 13.9% NS	C>A 8.3% NS	C>A 2.8% NS	C>A 8.3% C<A 11.1%	C>A 16.6% C<A 5.6%	C>A 5.6% C<A 38.9%	C>A 13.9% C<A 22.2%
	Maj	C>A 8.3% C<A 2.8%	C>A 22.2% C<A 11.1%	C>A 5.6% NS	C>A 13.9% C<A 2.8%	NS C<A 2.4%	C>A 13.9% NS	NS C<A 19.4%	C>A 30.6% NS
Standing	Tanja	C>A 33.3% C<A 22.2%	C>A 41.7 % C<A 27.8 %	C>A 5.6% C<A 11.1%	C>A 38.9% C<A 36.1%	C>A 5.6% C<A 13.9%	NS NS	NS C<A 19.4%	NS NS
	Bibi	C>A 8.3% C<A 8.3%	C>A 13.9% C<A 27.8%	C>A 2.8% C<A 8.3%	C>A 8.3% C<A 19.4%	C>A 13.9% NS	C>A 5.6% NS	C>A 16.7% C<A 5.6%	C>A 13.9% NS
	Maj	C>A 2.8% C<A 30.6%	C>A 11.1% C<A 66.7%	NS C<A 13.9%	C>A 8.3% C<A 44.4%	C>A 5.6% NS	NS C<A 5.6%	C>A 16.7% NS	NS NS
Laying	Tanja	NS NS	NS NS	--- ---	NS C<A 2.8%	--- ---	--- ---	NS NS	--- ---
	Bibi	NS NS	NS NS	NS NS	NS NS	--- ---	--- ---	--- ---	--- ---
	Maj	NS NS	NS NS	--- ---	--- ---	--- ---	--- ---	C>A 13.9% NS	NS NS

--- = Test not performed - Sample size too small

Table A3: The table shows the percentage when the control period is significantly bigger or smaller than the switch to standard time for each elephant, for all the behaviours. The table shows data for Mann-Whitney, Levene's, skewness and kurtosis tests with or without outliers. NS stands for non-significant.

		Mann-Whitney		Levene's		Skewness		Kurtosis	
Behaviour	**Elephant**	**With outliers**	**IQR**	**With outliers**	**IQR**	**With outliers**	**IQR**	**With outliers**	**IQR**
Abnormal	Tanja	NS	NS	NS	NS	NS	C>S 19.4%	C>S 8.3%	C>S 19.4%
		NS	NS	NS	NS	C<S 11.1%	C<S 5.6%	C<S 22.2%	C<S 8.3%
	Bibi	---	---	---	---	---	---	---	---
		---	---	---	---	---	---	---	---
	Maj	NS	C>S 8.3%	C>S 2.8%	C>S 5.6%	NS	NS	NS	NS
		C<S 13.9%	C<S 30.6%	C<S 13.9%	C<S 5.6%	NS	NS	NS	NS
Defecate	Tanja	C>S 8.3%	C>S 2.8%	C>S 8.3%	NS	C>S 11.1%	C>S 38.9%	C>S 22.2%	---
		C<S 2.8%	C<S 5.6%	C<S 2.8%	NS	NS	C<S 16.7%	NS	---
	Bibi	NS	NS	NS	NS	---	---	C>S 16.7%	NS
		NS	NS	NS	C<S 8.3%	---	---	C<S 11.1%	C<S 27.8%
	Maj	---	---	---	---	---	---	---	---
		---	---	---	---	---	---	---	---
Throw food	Tanja	C>S 5.6%	---	C>S 16.7%	C>S 16.7%	C>S 22.2%	C>S 8.3%	C>S 22.2%	NS
		NS	---	NS	NS	C<S 13.9%	C<S 19.4%	C<S 22.2%	C<S 16.7%
	Bibi	C>S 5.6%	C>S 8.3%	C>S 5.6%	NS	C>S 5.6%	NS	C>S 25%	C>S 11.1%
		NS	NS	NS	NS	C<S 22.2%	C<S 47.2%	C<S 16.7%	C<S 16.7%
	Maj	NS	NS	---	---	---	---	---	---
		C<S 11.1%	C<S 11.1%	---	---	---	---	---	---
Interaction with food	Tanja	C>S 25%	C>S 38.9%	C>S 13.9%	C>S 36.1%	C>S 22.2%	C>S 19.4%	C>S 8.3%	C>S 16.7%
		C<S 30.6%	C<S 33.3%	C<S 30.6%	C<S 38.9%	C<S 8.3%	C<S 5.6%	C<S 5.6%	C<S 8.3%
	Bibi	C>S 5.6%	C>S 13.9%	C>S 11.1%	C>S 11.1%	NS	NS	NS	NS
		C<S 19.4%	C<S 27.8%	NS	C<S 13.9%	NS	NS	NS	NS
	Maj	NS	C>S 13.9%	C>S 2.8%	C>S 13.9%	C>S 2.8%	NS	NS	NS
		C<S 22.2%	C<S 30.6%	C<S 33.3%	C<S 38.9%	NS	NS	NS	NS
Sway	Tanja	C>S 13.9%	C>S 30.6%	C>S 8.3%	C>S 16.7%	C>S 22.2%	C>S 16.7%	C>S 27.8%	C>S 11.1%
		C<S 30.6%	C<S 33.3%	C<S 25%	C<S 36.1%	C<S 5.6%	NS	C<S 2.8%	C<S 8.3%
	Bibi	NS	C>S 5.6%	NS	NS	C>S 2.8%	C>S 5.6%	C>S 13.9%	C>S 13.9
		C<S 5.6%	C<S 8.3%	C<S 5.6%	C<S 5.6%	C<S 25%	C<S 2.8%	C<S 27.8%	C<S 5.6
	Maj	NS	NS	NS	NS	NS	C>S 8.3%	NS	C>S 19.4%
		C<S 11.1%	C<S 25%	C<S 8.3%	C<S 16.7%	NS	NS	NS	C<S 11.1%
Standing	Tanja	C>S 27.8%	C>S 36.1%	C>S 16.7%	C>S 38.9%	C>S 2.8%	NS	NS	NS
		C<S 25%	C<S 41.7%	C<S 22.2%	C<S 27.8%	C<S 8.3%	C<S 13.9%	C<S 8.3%	C<S 16.7%
	Bibi	NS	NS	NS	NS	C>S 8.3%	NS	C>S 11.1%	C>S 2.8%
		C<S 2.8%	C<S 16.7%	C<S 8.3%	C<S 38.9%	C<S 2.8%	C<S 5.6%	C<S 16.7%	C<S 8.3%
	Maj	NS	C>S 13.9%	NS	NS	C>S 11.1%	NS	C>S 27.8%	NS
		C<S 22.2%	C<S 41.7%	C<S 19.4%	C<S 3%	NS	C<S 2.8%	NS	NS
Laying	Tanja	C>S 8.3%	NS	C>S 5.6%	NS	---	---	NS	---
		NS	NS	C<S 5.6%	NS	---	---	C<S 13.9%	---
	Bibi	NS	NS	NS	NS	---	---	NS	NS
		NS	NS	NS	NS	---	---	NS	NS
	Maj	NS	NS	NS	NS	---	---	C>S 16.7%	NS
		NS	NS	NS	NS	---	---	NS	NS

--- = Test not performed - Sample size too small

Table A4: The table shows the time each elephant spends lying down on average during the control period, Autumn holiday and the shift to standard time.

Hours of lying down	**Control period**	**Autumn holiday**	**Standard time**
Maj	3.2 hours	2.1 hours	2.9 hours
Bibi	3.2 hours	2.07 hours	3.6 hours
Tanja	2.7 hours	1.6 hours	3.2 hours

The average accumulated curves for selected behaviours

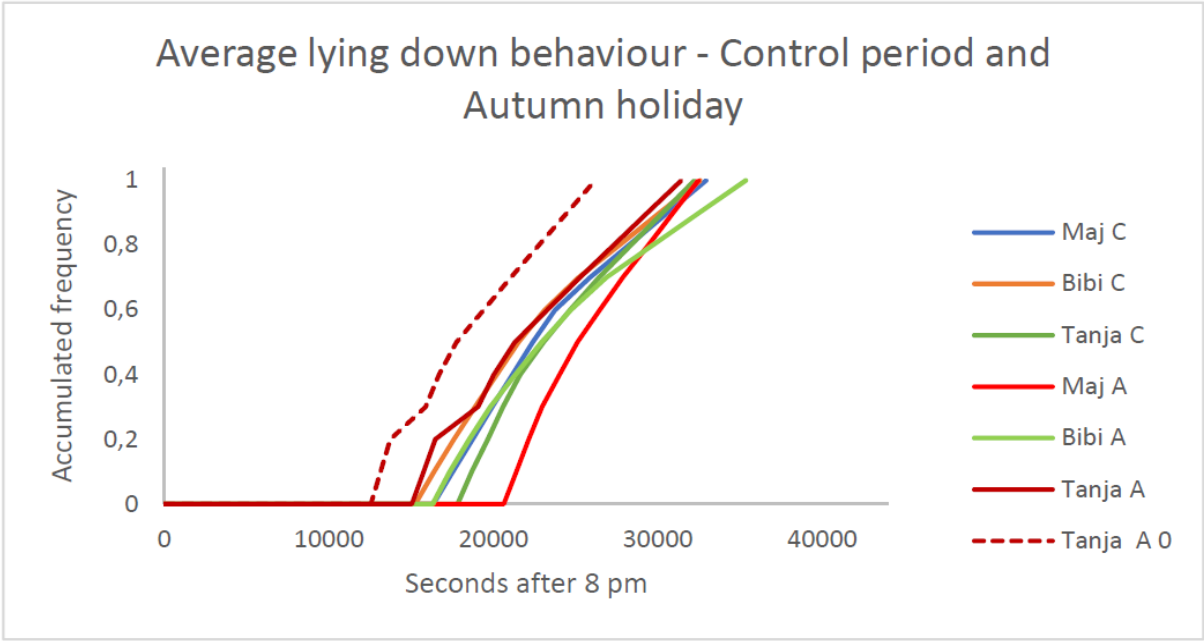

Figure A3: The average time spent lying down for each elephant during the control period and the Autumn holiday. C stands for the control period, A stands for Autumn holiday and S stands for the period during the shift to standard time. The time is measured as seconds after 8 pm. The dotted line shows the data for Tanja for the Autumn holiday without a zero point, which means n=5. For the full-lines n=6.

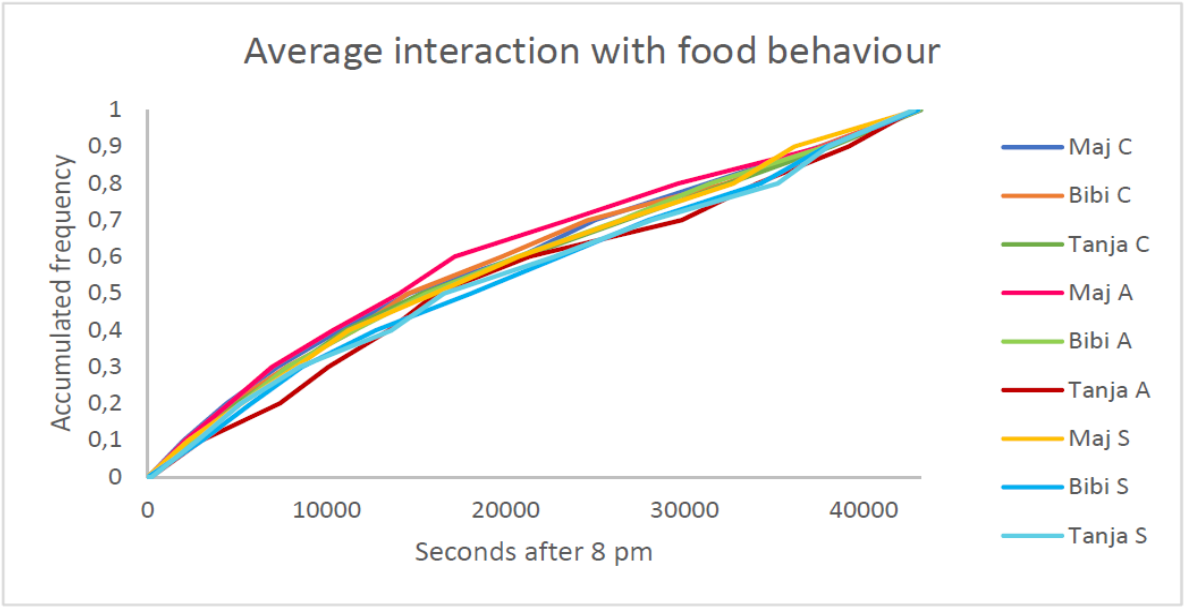

Figure A4: This graph shows the average time of the behaviour interaction with food during the control period, Autumn holiday and the shift to standard time for each elephant. C stands for the control period, A stands for Autumn holiday and S stands for the period during the shift to standard time. The time is measured in seconds after 8 pm. n=6.

Accumulated curves for selected behaviours

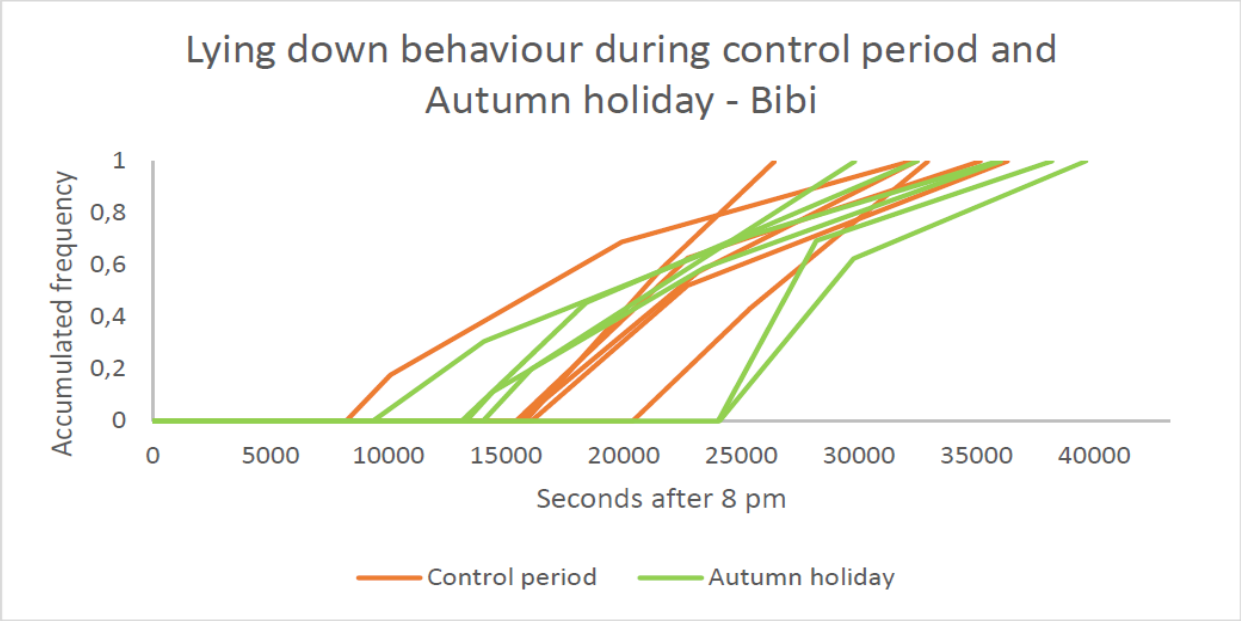

Figure A5: This graph shows the amount of the behaviour laying down occurs for the elephant Bibi during both the control period which is shown in an orange colour and the Autumn holiday in a green colour. Each of the days during the two periods are shown. The time is measured in seconds after 8 pm. n=6.

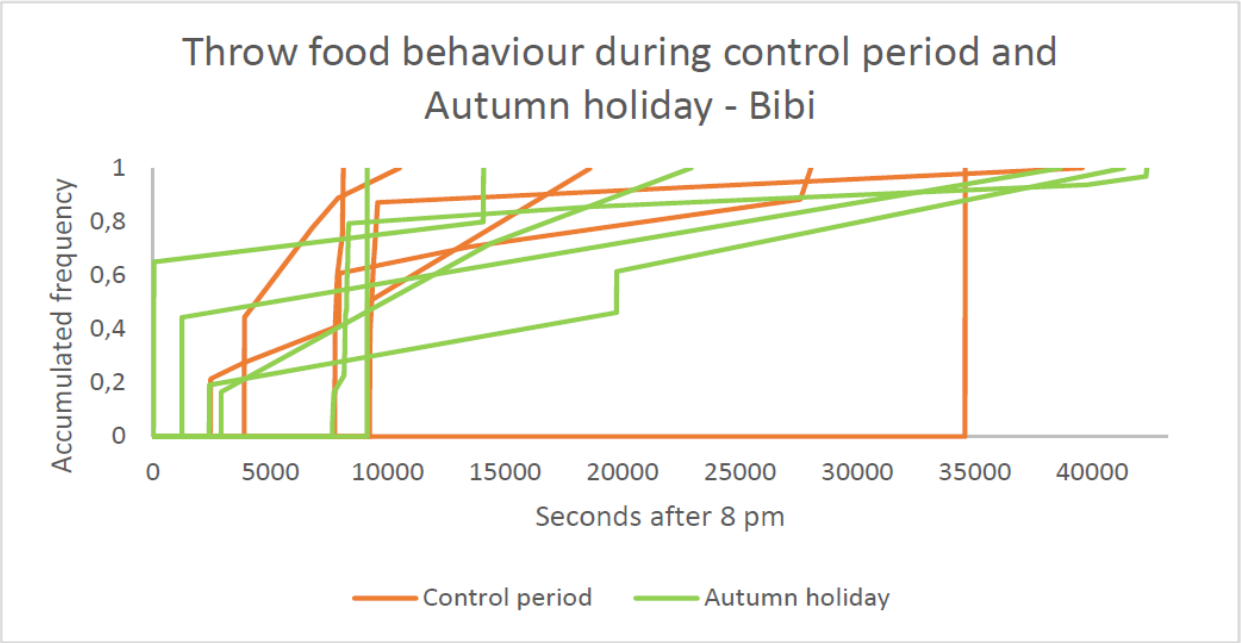

Figure A6: This graph shows the amount of the behaviour throwing food occurs for the elephant Bibi during both the control period and the Autumn holiday. Each of the days during the two periods are shown. The time is measured in seconds after 8 pm. n=6.

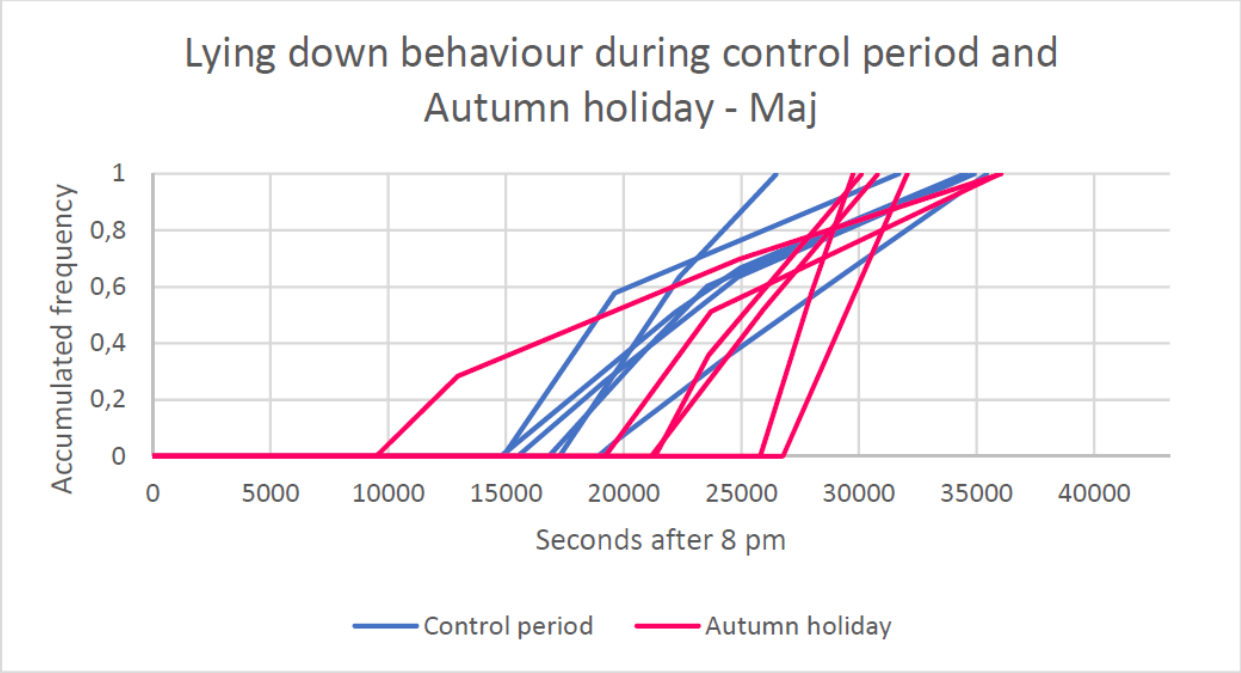

Figure A7: This graph shows when the amount of the behaviour lying down occurs for the elephant Maj during both the control period which is shown in a blue colour and the Autumn holiday in a pink colour. Each of the days during the two periods are shown. The time is measured in seconds after 8 pm. n=6.

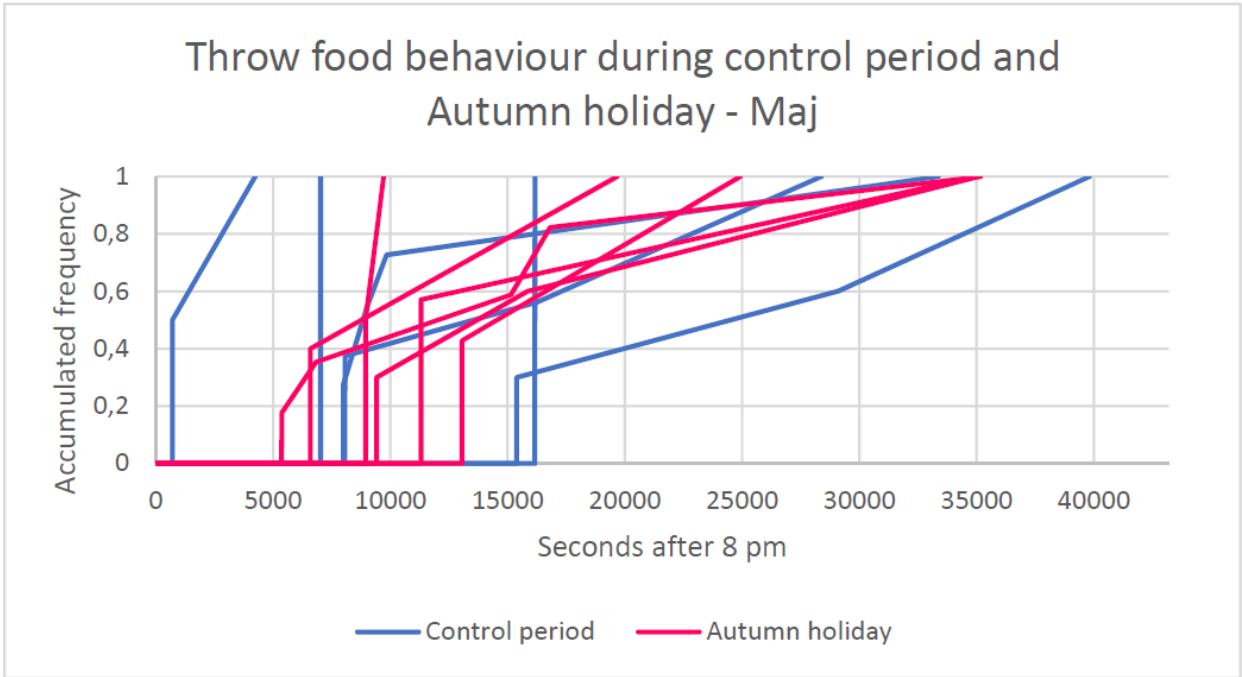

Figure A8: This graph shows when the amount of the behaviour throw food occurs for the elephant Maj during both the control period which is shown in a blue colour and the Autumn holiday in a pink colour. Each of the days during the two periods are shown. The time is measured in seconds after 8 pm. n=6.

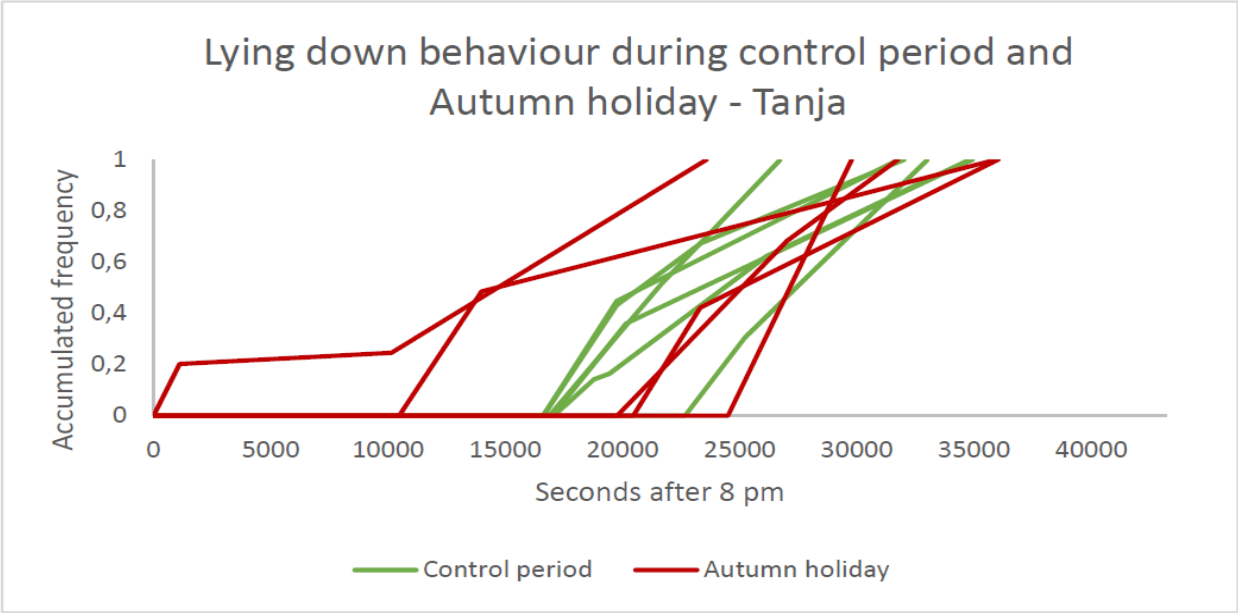

Figure A9: This graph shows when the amount of the behaviour lying down occurs for the elephant Tanja during both the control period which is shown in a green colour and the Autumn holiday in a red colour. Each of the days during the two periods are shown. The time is measured in seconds after 8 pm. n=6.

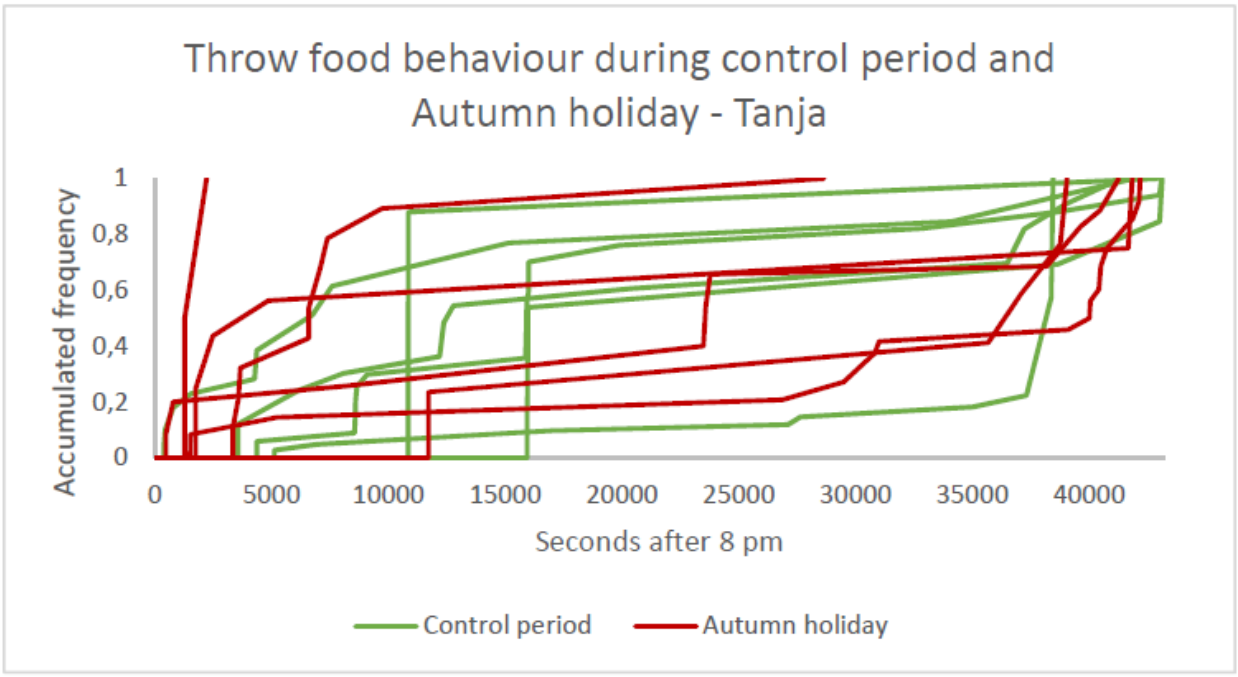

Figure A10: This graph shows when the amount of the behaviour throw food occurs for the elephant Tanja during both the control period which is shown in a green colour and the Autumn holiday in a red colour. Each of the days during the two periods are shown. The time is measured in seconds after 8 pm. n=6.