Understanding the nocturnal behaviour of a semi-captive herd of African elephants

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1. Abstract

Elephant populations have been put at threat due to anthropogenic factors, resulting in the reduction of natural ranges, fragmentation and isolation. These factors have led to the formation of various institutes, insuring the safety and welfare of elephants are retained. Elephants have not been studied as thoroughly during the course of the night compared to studies during the day. Therefore the purpose of this study was to obtain information on the elephant's nocturnal behaviour, allowing for understanding of the elephant's activities and sleeping patterns which would aid to the improvement of the standards of husbandry, animal management, and most importantly, the welfare of animals. The study was completed over a 28 day period with a total of eight live observation nights and thirteen camera reviewed nights over the study period. The live observations consisted of a 12-hour time period which started at 19:00 and ended at 07:00. The elephants were situated in a night camp, where additional browse was supplied, while consisting of three different locations the elephants could chose to rest, namely the shelter, boma or outside. The study population consisted of four female and two male African elephants (*Loxodonta africana*). Negative binomial regression models were fitted with generalized estimating equations to determine sleeping patterns and activity budget through the duration of the night. Throughout the duration of the night, feeding was seen to be the most prolific activity (44%), followed by sleeping (31%). The elephants slept on average for 03:30 hours per night, while showing preference to sleep in the shelter (SE= 0.08552, z=3.10, p=0.001958). Overacast and rainy conditions were seen to signifcantly decrease sleeping standing and increase recumbent sleep. The study aims to understand and increase the welfare of captive elephants through understanding elephant preferences in captive environments, while aiming to protect elephant populations which are at jeopardy through anthropogenic factors. Future studies on captive elephants will need to consist of a wider range of ages, increased sample sizes and obtain various sleeping locations to identify elephant preferences, allowing for accurate management protocols to increase their sense of welfare in captive environments.

Key words: nocturnal; African elephants; animal welfare; *Loxodonta africana*; activity budget; sleeping patterns; recumbent sleep

2. Introduction

2.1 Background

African elephants (*Loxidonta africana*) are an iconic species that interest individuals around the world with their sheer size, intelligence and presence (Kangwana, 1996). The elephant's contribution to habitat structure and function is second to none and cannot be overlooked. These magnificent mega-herbivores are the main contributor to the creation and maintenance of habitat heterogeneity in the wild. The importance of elephants within their natural environment is often misunderstood. Elephants are perceived as destructive mega-herbivores which have minimal benefits to the environment and ecosystem. However, elephants are pivotal for the formation, functioning and balancing of an array of natural ecosystems. Elephants form several symbiotic relationships with numerous species that co-exist with each other to form cohesiveness and rich ecosystems (Dean and MacDonald, 1981). These symbiotic relationships include both mutualism and commensalism. Elephants play a vital role in the creation of microenvironments which allow for species of all sizes to co-exist and thrive. Elephants are classified as a keystone species as they define the characteristics of ecosystems (Bond, 1994).

Seed dispersal is critical for the survival of many vegetation types and elephants play an active role in the spreading of vegetation as they travel vast distances and disperse numerous seeds via their faeces. Despite all the benefits that elephants bring to the environment, there are several negative aspects related to the species as well. Due to the radical increase in elephant populations in certain sectors in Southern Africa, and reduction of their natural environment, more trees are being pushed over which has resulted in a domino effect on the environment; large tree disappearance, changes in habitat structure, impacts on biodiversity, and a transition from woody vegetation to open grasslands occurs. For instance, Drizo et al., (2014) showed that by removing large herbivores of greater than15kg (including elephants, being a major contributor to the process of defaunation), the process of defaunation is reduced showing a change in species, abundance and diversity of other consumers. This process is seen to be reduced by the absence of larger herbivores for the most part. Therefore, large herbivores such as elephant are partially responsible for changes in the ecosystem, fire regimes, photosynthetic and transpiration rates.

2.2 Poaching history

Throughout history, elephants' lives have been put in jeopardy due to the vast amount of poaching in certain countries. Over the last five decades the elephant populations have decreased in certain countries primarily due to poaching for the ivory trade. As a result of the high poaching statistics, the Convention on International Trade in Endangered Species (CITES) introduced a ban in 1989 on the trade of ivory (Stiles, 2004). Ivory is seen as a status symbol in the East and is in high demand. Despite the ban, elephant populations in certain African countries continue to decline as a result of poor wildlife management and law enforcement (Smith et al., 2015). At the other extreme, in countries with good wildlife management and law enforcement, elephant populations are either steady or are growing out of control. Therefore sustainable solutions are vital to balance the threat of elephant extinction with that of over population and habitat destruction. Through institutes such as the Knysna Elephant Park (KEP), elephants at risk to anthropogenic factors are able to be housed within the park, thereby protecting the species.

2.3 Conservation of elephants

Elephants have been under constant threat from anthropogenic factors such as human expansion, hunting, poaching, deforestation, degradation of wild lands, land transformation for agriculture, and destruction of essential elephant habitats. These factors cause a disruption of ancient migratory corridors which result in elephants and wildlife being confined to protected areas thereby reducing natural ranges and consequently resulting in numerous wildlife populations being fragmented and isolated. (Barnes, 1999; Hanks, 2003) These factors have impeded the traditional migration pathways over time (Hoare and Du Toit, 1999). The isolation of species has resulted in major concerns about the adverse outcomes and effects of fragmentation for conservationists. Possible solutions to reduce the threat on elephant populations for conservation is to manage the issue through creating distributions for elephant population , rather than managing and controlling single population numbers (Young and Van Aarde, 2011). This can be accomplished through connecting reserves to expand the range and create larger regions the elephants can traverse, while implementing effective networks for elephant conservation. The historical cause of landscape fragmentation issues will be resolved as elephants will be able to migrate using their previous routes through seasonal movements, which will create an opportunity for the rejuvenation of vegetation of varying intensities, as elephants will be absent from regions during certain times of the year (van Aarde and Jackson, 2007).

2.4 Wildlife institutes

The rapid increase of the human population, poaching, hunting, and deforestation are some of the major factors which have contributed to the need for institutes such as KEP. Since the opening 27 years ago in 1994, over 40 elephants have been through the park. Many have been reintroduced into private game reserves while others remain within the park boundaries. Those elephants that have left have moved to specific reserves which best facilitate their needs, personalities and welfare. Associated with the KEP is the African Elephant Research Unit (AERU). AERU was created in 2009 to study elephant behaviour and physiology within the premises so as to improve the welfare of captive elephants. Institutions such as KEP are therefore part of a collective effort to increase the African elephant's welfare through rehabilitation programs, while aiming to protect elephant populations which are at jeopardy through anthropogenic factors (Fischer and Sach, 2019). The Knysna Elephant Park aims to rehabilitate elephants that have previously been at threat due to anthropogenic factors, while also creating a learning environment for guests and tourists. The importance of institutes such as KEP (as well as other wildlife institutes) is to protect threatened species. Institutes protecting a species in captivity provide a reservoir population against a population crash or extinction in the wild. Other reasons include the loss of suitable habitat for the species, species that are threatened from anthropogenic factors (poaching and human wildlife conflict), and species that have been a menace to the region they once occupied (Cuarón, 2005). The additional research benefits conservation institutions and organisations provide, are through promoting awareness and conservation values for future conservation initiatives (Young and Van Aarde, 2011). It is essential for captive and wild elephants to share the same sense of welfare, as captive elephants have the additional stress amongst others, of being translocated and reintroduced to new and unfamiliar locations (Williams, et al., 2020). Difficulties in captive facilities around an elephant's welfare are generally due to their sheer size, intelligence and complex social lifestyle (Veasey, 2006). Therefore, KEP ensures that the semi-captive elephants receive similar amounts of welfare that a wild elephant would, through having adequate social and foraging opportunities (Williams et. al, 2018). Wilson et al., (2006) showed that elephants which access all sectors of the area provided are regarded as having a greater sense of welfare through affiliated social behaviour. These findings display evidence that appropriate elephant management strategies are very successful.

2.5 Elephant activities

Previous studies on elephants have primarily been based on their interaction, behaviour and movements during the day. Elephants have not been studied as thoroughly during the course of the night compared to studies during the day. Wilson et al., (2006) showed a significant relationship between specific hours of the night and elephants' activity budgets. The activities which were mostly influenced were the time the elephants spent feeding, sleeping standing and sleeping lying down. This showed that at certain periods of the night, elephants' activity budgets are more productive through increased feeding and walking further distances earlier in the night, while being more lethargic and stationary in the early mornings.

2.6 Budget activities

Throughout the day and night elephants perform a large variation of activities. They are seen to be active for at least 18 hours a day without hindering environmental conditions (Hanks, 1973 & Wyatt & Eltringham, 1974). Over a 24-hour period, elephants are seen to spend most of their time foraging, followed by resting and sleeping, although self-maintenance such as dust baths and wallowing occur

intermittently, (Brockett et al., 1999 and Horback et al., 2014). During these hours, elephants predominantly feed and have social interactions amongst the herd (Eltringham, 1982). Brockett et al., (1999) showed a corresponding similarity between the activity budgets of captive elephants and wild elephants during the day and night. Previous studies showed that wild elephants spend the majority of their time feeding. For instance, Wyatt and Eltringham, (1974) found elephants feed for 75% of the day while Moss (1982) found elephants feed for 67% of the day. Similarly, Wilson et al., (2001) found captive elephants feed for 75% of the day and do similar activities as wild elephant during the other 25% of their time. While not feeding, elephant activities consisted of resting, social interaction within the herd, drinking and sleeping, among various other possible behavioural and social activities. Elephants have been recorded to have three major feeding peaks, the first two major feeding peaks being in the day, and the third peak is around midnight. The time period after the third peak eating period is observed as the 'principal sleeping period', with shorter intermittent sleep periods in the early hours of the morning (Gravett et al., 2017).

2.7 Sleeping data

Elephants have two major sleeping styles, 1) sleeping standing, or 2) sleeping lying down (recumbent sleeping). Sleeping patterns have been seen to differ between wild and captive elephants, while differences are also seen between the young and old. Gravett et al., (2017) shows that two wild African elephants recorded had an average sleep period of 2 hours a day. These times were recorded mostly between 02:00 am and 06:00 am, thus displaying the shortest daily sleep period of all mammals documented to date (Tobler, 1992).

Older elephants have been shown to sleep for shorter periods than younger elephants, and have a larger average of sleeping standing as opposed to younger elephants which prefer to lie down while sleeping (du Toit and Yetman, 2004, Schwammer et al., 2000). This is due to the difference in the increased requirement of rapid eye movement (REM) sleep, which helps the development and growth of the brain, which is thought to happen during recumbent rest (Schiffmann et al., 2018).

Elephants do sleep intermittently during the day but predominantly sleep during the night. Sleep periods vary, however, elephants tend to sleep for longer while lying down, compared to sleeping standing. Elephants' sleep patterns and periods can be influenced heavily by weather conditions, other herd members, predators (for wild elephants), poachers and anthropogenic noise. In semi-captive and captive institutes, during wet weather conditions elephants tend to find shelter and often sleep the duration of the night. Environmental conditions such as the ambient air temperature and relative humidity are reliably predictable of the onset and offset of elephant sleeping times (Gravett et al., 2017). Sleeping patterns of elephants are often dependent on specific elephant preferences. These sleeping patterns and periods of sleep vary from elephant to elephant. The locality of where captive elephants can sleep impacts their decision to sleep lying down or standing. Locations with sufficient comforting support such as hay and sawdust enhance the possibilities of elephants sleeping lying down (Holdgate et al., 2016 and Schiffmann et al., 2018). This may be as a result of captive elephants being more accustomed to recumbent sleep as there is less threat from poaching, predators and other herd interactions, while not having to travel vast distances for resources such as food and water over a spatial and temporal scale. Elephants do not sleep for one episode a night but have multiple episodes. These episodes do not have to follow right after each other and could differ between sleeping standing and sleeping lying down (Gravett et al., 2017 & Garai, 1992).

2.8 Significance of the study

There is seen to minimal research on semi-captive rehabilitated elephants that have originated from various localities. Previous studies have often been on captive elephants that are constrained through the method of using leg chains at night; therefore, the existing behavioural literature may not be accurate as the chains alter typical behaviour of elephants. Other studies of captive elephants have seen the elephants being housed in pens, resulting in them expressing less stereotypic behaviour than free roaming captive elephants (Schmid, 1995). Therefore, additional studies are needed to understand the behaviour of unchained and unrestricted captive elephants at night.

The significance of this study is to discover what semi-captive elephants at the KEP do at night in terms of their activity budget and sleep without human interactions. Many studies on elephants have taken place during the daytime but insufficient research has been recorded on elephants at night. This will ensure management strategies can be adapted to benefit captive elephants as there will be an understanding on what the elephants prefer to do, where they prefer to sleep and how. Therefore, infrastructure can be built to best suit and accommodate captive elephant populations around the world. Elephants are known to be active during the night but we are still uncertain as to what actions are taking place.

2.9 Aim

The project aim was to investigate what the elephants in the night camp do at night with no interference from guests, guides and researchers, whilst also investigating whether factors such as sex, age and temperature affect their sleeping patterns and budget activity. This would allow KEP to obtain more detailed information on the local elephant population which will in turn create a platform to increase the welfare and insight of what the elephants do at night.

Specific objectives

i. To establish how the elephants spend their time during the study period (Activity Budget), and how long the elephants sleep on average every night.
ii. To determine if the elephants have a preference for the location in which they sleep and their sleeping position (sleeping standing vs sleeping lying).
iii. To investigate whether factors such as age, sex or weather conditions affect their budget activity and/or sleeping patterns.

2.10 Hypothesis

Through previous detailed literature on wild elephants and the lack of literature on captive elephants, the null hypothesis H0, is that age, sex and temperature has no influence on the elephants, while there is no differential between elephant's predominantly spending time grazing and feeding on branches over interactions between individuals. The alternative hypothesis H1 is that older elephants sleep less than younger elephants, while temperature and weather conditions impact the sleeping patterns and the location of where the elephants sleep.

3. Methodology

3.1 Study area and population

The study was conducted at the Knysna Elephant Park (KEP). KEP is a unique stretch of land which is a new home to previously threatened elephants. KEP is located at the precise coordinates of 34°02'17.2"S 23°16'03.0"E, between Knysna and Plettenberg Bay. Established in 1994, KEP housed orphaned elephants and elephants that were threatened by culling, human wild-life conflict, human expansion, poaching, and hunting. The elephant park has been responsible for the relocation of over 40 elephants back into a natural environment which best suits each individual elephant, based on their bonds, welfare and personalities. For the past 27 years KEP has strived to rehabilitate elephants and create a learning environment whilst always prioritising the elephant's welfare.

The current elephant population at KEP is ten semi-captive elephants. These elephants have been brought in from various locations throughout the country where their lives were at risk. The herd contains eight females and two young males which all vary in age and have distinct characteristics. The elephants are identified through these distinct characteristics which are presented in Table 1. Identification training of the elephants was completed prior to the start of the study. During the day, the herd graze on the lush grasslands, feed on the natural bush vegetation and receive fruit buckets from guests. Guests are present throughout the day and have the opportunity to feed, touch and walk with the elephants. At night the elephants are separated into two holding camps, respectively named the Night Camp and the Orchard Camp. For this study, testing was focused on the Night Camp only. By focusing on one camp, it allowed for replication, accuracy and precision within the data recorded. Reasons for selecting the Night Camp as a focus area include the presence of both male and female elephants within the camp. Between these males and females there was a distinct age variation throughout. The Night Camp has both a boma and a shelter. The elephants allocated to the Night Camp were, Keisha, Amari, Madiwa, Shanti, Mashudu and Shungu.

Table 1 Detailed information on the 6 elephants within the Night Camp

Name	Place of origin	Distinct Characteristics	Sex	Age
Keisha	Kruger National Park	Long tail with few hairs. Small tusks that point downwards. Large tear in the right ear and hole in the left ear.	Female	17y
Amari	Game farm near Hoedspruit	Long tail with minimal tail hair. Big bodied. Tusks point down and out, shaped as an "A".	Female	20y
Madiwa	Relocated from Sandhurt in Mpumalanga.	Long tail with thin hair. Small bodied elephant. Tusks are unevenly curved, thin and pointed upwards.	Female	15y

Shanti	Game farm near Hoedspruit	Very short tail that looks like a stump. Tusks point inwards and down.	Female	18y
Mashudu	Relocated from Sandhurt in Mpumalanga.	Long tail with lots of hair. Bigger body and tusks than Shungu. Tusks point down and inwards.	Male	13y
Shungu	Born in the Knysna Elephant park.	Kink in tail. Thinner build than Mashudu. Bump/cone on top of forehead. Tusks are average size that point outwards and upwards.	Male	14y

3.2 Night Camp and boma dynamics

The Night Camp was where the elephants were housed at night. This camp is a secure patch of land surrounded by a reinforced electrified fence, ensuring safety for the local habituated elephants. The fence also ensures that the elephant population do not venture into the surrounding lands and farmlands during the night. Situated within the Night Camp is a large wooden shelter that provides the elephants with cover and protection during the night and during extreme weather conditions. The shelter is a rectangular wooden structure with a length of 10 meters, a height and width of 5 meters (Image 2). Another addition to the Night Camp is the presence of a boma. The boma is situated within a large industrial-like shelter which facilitates a lodge for visiting guests and acts as a secure area for the elephants. The boma has a surface area of 100 m^2 (Image 1). Sawdust is used within the shelter and the boma to ensure comfort for better sleep. Holdgate et al., (2016) showed that substrate such as sawdust had the strongest association with recumbence sleep, while recumbence sleep is known to be more restful and regarded as a deeper sleep than sleeping standing. A section of the farm's largest dam is situated at the bottom of the Night Camp, providing the camp with a marsh area, allowing for lush green vegetation and a marsh vegetation complexity. Green grass lays lush over the bulk of the Night Camp, however some bare ground patches are scattered throughout the camp. Additional vegetation is strewn over the bare patches of land every night. The blocks labelled A-I (image 1) and 1-2 (image 2) allow for research to be formulated if elephants had preference to an exact area within a location

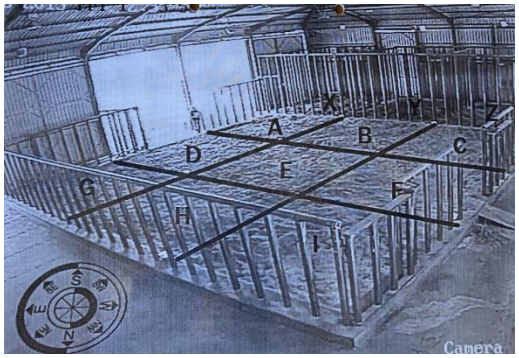

Image 1 Detailed description of the boma and the blocks situated within.

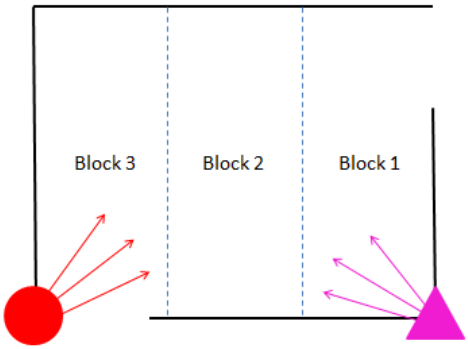

Image 2 Illustration of the shelter setting, as well as the entrances, blocks and cameras (Red= Camera 4, Pink = Camera 3)

3.3 Data gathering & data sheets

Observations of the elephants took place from the 15th of February to the 12th of March 2021, ensuring accurate recordings through observation. This four-week testing period included two live night observations per week, four night camera observations and one rest day every week. A total of eight live observation nights and thirteen camera reviewed nights were completed over the study period. The live observations consisted of a 12-hour time period which started at 19:00 and ended at 07:00. Live observations were recorded every Monday and Thursday night regardless of weather conditions. Rest days occurred on different days every week to ensure each night was recorded several times. Three different data sheets were used to record the elephants' sleep patterns, budget activities, and the night time weather conditions. The sleep pattern data sheet recorded the time that the elephants went to sleep, which elephants were sleeping, where they were sleeping, how they were sleeping and the time that the elephants woke up. Sleeping standing of the elephants was identified by the lack of movement throughout the entire body, the lower quarter of the trunk resting on the floor, the trunk or tusks leaning against a fixed standing object or another elephant. The timing of sleep, regardless of recumbent sleep or standing sleeping was recorded only if the elephant had been sleeping for a period of more than 15 seconds. Recumbent sleeping was observed in all the elephants, however the side the elephant slept on was not recorded. Recumbent sleeping was recorded once the elephant was situated on the floor in a sitting or lying flat on their side.

The activity budget data sheet recorded the elephant's actions every five minutes, including their location based on the recordings from the live observations (refer to Ethogram, Table 2 for descriptions and codes for the activity budget), CCTV and night cameras. The temperature inside the shelter, boma and outside was recorded hourly on the weather conditions data sheet based on the detailed recordings the camera traps recorded. While historical weather data was used to differentiate between overcast and clear conditions (more than 50% of cloud cover through the night was regarded as overcast conditions) (Hoekwil Historical Weather, 2021). Within the live observation hours, there were six shifts of two hours each for members of the AERU team, allowing for concise elephant observation accuracy. All team members had also completed training for the identification and recordings of the elephant specific behaviours. Two spotlights and a night vision scope were used to help identify the elephants and their activity budgets over the live observation period. Ethical clearance was granted by the research ethics committee of Stellenbosch University (Reference: ACU-2021-18893).

Table 2: Ethogram depicting the feeding and activity behaviour of elephants

Behaviour	Code	Description
Feeding		
Feeding - Grazing	FG	Eating grass or shrubs
Feeding - Branches	FB	Eating tree branches, leaves or bark
Feeding - Straw/Lucerne	FS	Eating straw or lucerne
Feeding - Pellets	FP	Eating pellets
Feeding - Fruit	FF	Eating fruit and/or vegetables
Feeding - Oats	FO	Eating oat hay meal mix
Feeding - Miscellaneous	FM	Eating something else
Activity		
Walking	W	Walking with all four legs moving in a steady pace
Walking - Grazing	WG	Walking and grazing simultaneously
Walking - Branches	WB	Walking and eating branches simultaneously
Walking - Guide	WGU	Walking due to commands given or action taken by a guide
Standing	S	Standing stationary for at least 2 seconds, not performing any other general behaviour
Standing - Barrier	SB	Standing at the feeding barrier for tourists, not eating fruit
Standing - Tourist	ST	Standing in response to guest, due to commands given by a guide
Sleeping - Standing	SS	Standing motionless with trunk relaxed, tip flopped on ground or draped over an object
Sleeping - Lying down	SL	Lying down on either side sleeping, eyes closed
Interacting	I	Deliberately interacting, sparring or playing with another elephant
Interacting - Guide	IG	Deliberately interacting with a guide, not for training purposes or in response to commands
Interacting - Volunteer	IV	Deliberately interacting with a volunteer or other member of staff
Playing enrichment	PE	Using any part of the body to play or interact with an enrichment device
Feeding enrichment	FE	Eating food rewards from an enrichment device
Walking enrichment	WEN	Walking while carrying an enrichment device
Trunk to enrichment	TE	Investigating an enrichment device: trunk extended within 10cm or touching the enrichment
Other - Dust throw	OD	Picking up dust with the trunk and throwing it over own body
Other - Mud throw	OM	Picking up wet mud with the trunk and throwing it over own body
Other - Play	OP	Playing with an object, or chasing animals or birds
Other - Water Play	OWP	Playing in large quantities of water, swimming, splashing etc; not merely spraying water
Other - Drink	ODr	Sucking water into the trunk, then ejecting the water into own mouth
Other	O	General behaviour not defined in this list
Data not available	**Codes indicating why behaviour was not recorded at this time**	
Out of sight	OOS	
Not in sight	NIS	
Not recorded	NR	

3.4 Camera traps

Allowing for accurate digital recordings, five camera traps were set up in unique locations throughout the Night Camp. Four Victure HC300 portable camera traps and one Apeman H45 trail camera were the essential items needed to record the elephants' budget activities and sleep data throughout a variety of spots in the Night Camp. All five cameras are equipped with ultra-high photo and video resolution, infrared lights, which ensured clear night time images and videos, fast trigger speeds of between 0.3 and 0.4 seconds, whilst both machines were easy to operate and understand (Smit et al., 2017). The camera traps were marked cameras 1 to 5 (refer to Figure 1 for visual representations of the cameras). Camera 1 was located at the entrance of the boma. The purpose of camera 1 was to record the elephant entering and leaving the boma, thus helping with clarity and avoiding confusing between the elephants during the night. Camera 2 was located at the water trough, allowing a view of which elephants drink water and the time period each elephant takes to drink water. Cameras 3 and 4 were both located in the upper corners of the shelter. The purpose of these two cameras were to record when, where, how and for how long the elephants slept in the protected environment. Each camera faced adjacent entrances to cover all the real estate in the shelter. All cameras had been placed at the top of the shelter to avoid the elephants playing with and displacing the cameras. Camera 5 was also located at the top of the shelter but faced outwards towards the vegetation at the back of the shelter where elephants were often not visible during the live observation nights.

Figure 1: Detailed graphics of the entire Night Camp while illustrating the cameras, shelter and boma. Yellow Circle= Camera 1; Blue Circle= Camera 2; Pink Triangle= Camera 3; Red Circle= Camera 4; Green Star= Camera 5 White Circle= Outside CCTV

3.5 CCTV

CCTV cameras provided live footage and remote play-back of the elephants' movements in the boma. Two CCTV cameras were situated in two adjacent corners within the boma. These cameras were equipped with night vision, allowing for clear footage throughout the night (Smit et al., 2017). A third CCTV camera recorded the region outside the boma, facing the extra food provided daily (Figure 1). This camera identified the time of night that the elephants preferred to feed on the

provided additional vegetation. The CCTV camera also recorded the majority of the camp when there was sufficient natural lighting, thus being able to see what and where the elephants were doing at dusk and dawn.

3.6 Data analysis

All data was computed in Microsoft Excel, and analysed using R and Rstudio version 3.5.3 (RCore Team, 2019). Data was tested for normality through the use of plotting a histogram of the number of observations for each response variable, namely FB, FG, O, ODr, S, SL, SS, W, WG (Table 2) for the activity budget data, and time for the sleeping data; while quantile-quantile plots and the shapiro-wilk were also used for normality tests. Due to all the data being non-normally distributed, a General Linear Mixed Model (GLMM) was used with variables of the elephants' activity budgets and sleeping patterns (time, sleep position and location) entered as response variables (dependant variables), while sex, age and temperature was entered as explanatory variables (fixed factors), and ID of the elephants as a random factor (McCulloch, 1996). Due to the distribution of the data, Negative binomial (nbion1) was selected through the selection process by plotting the residuals of candidate models. Test for collinearity was run, temperature in the shelter and temperature outside correlated with one another, thus meaning the variable of temperature outside was not within the statistical tests as one temperature increased or decreased, so did the other. A summary of the data was run, followed by either a boxplot (for categorical data) or a scatterplot followed by a trendline (for continuous data). An ANOVA (Analysis of Variance) was run to determine if there was significance between the locations the elephants slept. Due to significance, a postHoc Tukey test was run to see where the significance was within the three locations. Frequency graphs, boxplots and tables have been constructed, allowing for comparisons between individuals, age groups and sexes. The explanatory variables within the budget activity, Feeding Miscellaneous (FM), Interacting (I), Dust throw (OD), Mud throw (OM), Water Play (OWP), Walking Branches (WB) and Weaving (WE) were not included as there was not enough data on these variables (refer to Table 2 for abbreviations and explanations).

4. Results

The study recorded the elephants for a total of 252 hours, where there were 18270 possible observations within the possible time frame, of which 14327 observations were recorded. This in turn resulted in a 78.42% observation rate. The elephants were out of sight (OOS) for the remaining 21.58% observations.

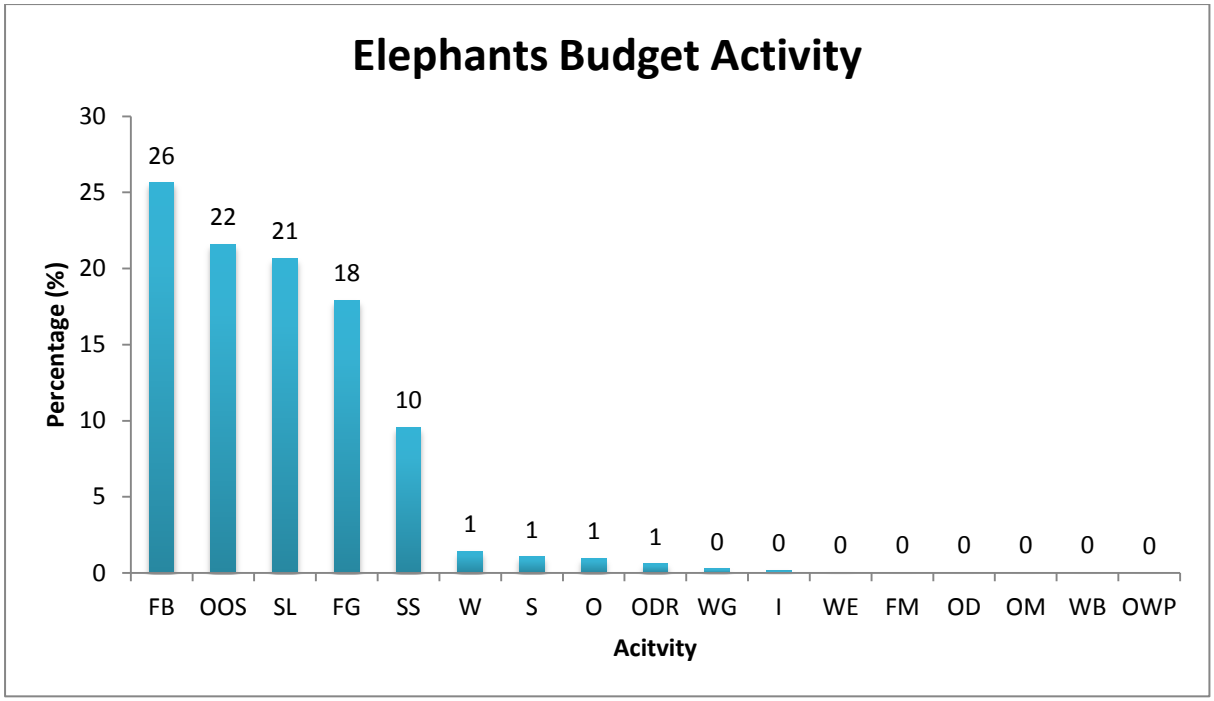

Figure 2: Activity budget of all the elephants, showing the percentages for the 18270 observations, including Out Of Site (OOS) as a variable

With the inclusions of Out Of Site (OOS) the variable ensures all observations are accounted for, while there is uncertainty of what the elephants were doing during the 22% of being OOS, there is significant amount of data to continue with the other response variables. The data shown in Figure 2 represents the amount of time the elephant population spent engaging in various general behaviours. It is important to note that the elephants were observed every 5 minutes and are most likely to continue these actions that have been observed.

Figure 2 represents all the data of the elephants' general behaviour that was physically recorded from the camera traps, CCTV and live observation nights. Elephants spent 26% of their time feeding browsing and 18% of their time feeding grazing, which is 44% of the time observed at night feeding. This shows that elephants most likely spend more than half the night feeding as the possibility of the elephants feeding while OOS is high due to the cameras not covering the entire range of where the elephants could feed. The elephants were recorded SS for 10% and 21% SL of the time, giving a total of 31% of the evening sleeping. Other activities such as Other, Standing, Drinking and Walking ranged from 0-1%, while the other activities contributed minimally to the percentages ranged between 0-0.4%.

The results recorded on the combined sleeping data focussed on the entire elephant population as a whole. This allowed for the total average of the herd rather than individual variations of the sleeping patterns. The recording of the individual differences was also documented, thus the data for all six elephants was analysed, collectively and individually. The following results show the averages amongst the entire herd. The total sleep average for all elephants was 74h 41min 42s. The average for SS was 23:48:58, although 00:21:50 average per bout. SL showed an average of 50:52:44 for the herd and an average of 01:26:30 per bout. The elephants averaged SS 66 times a night and SL 36.16 times for the 21-day period, resulting in an average of 4.86 bouts per night.

The elephants' sleeping data varied from location preference, sleeping style (SS or SL), and the average amount of sleep recorded each night (Figure 3). The elephants' sleep per night was seen to vary from 0-7 hours per night, thus some nights the elephants slept longer than others.

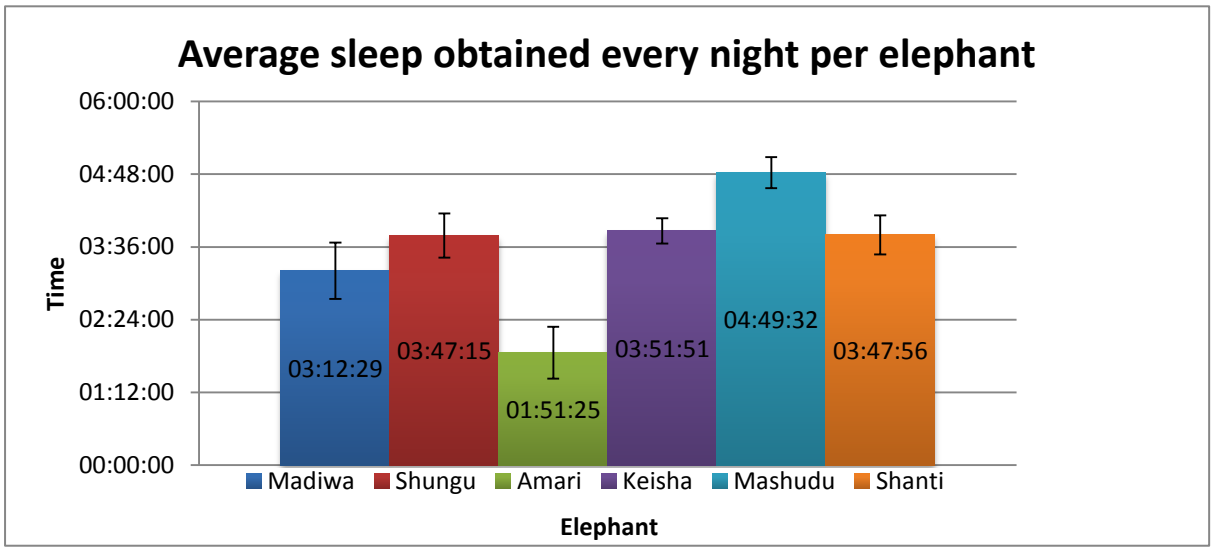

Figure 3: The length each elephant slept on average every night over the 21 day study period (this includes all localities of sleep documented: SH, O and B)

Madiwa was observed to sleep an average of 4.90 bouts per night, ranging from 00:00:44 to a maximum of 02:40:07. While her total sleeping time for the study was 67:22:19, she had a mean of 03:12:29 per night and SE=00:27:55.

Shungu, tslept an average of 03:47:15 (SE=00:21:46) per night, while sleeping a total of 79:32:15 overall, with an average of 3.95 bouts per night. His minimum was 00:00:41, however he had the longest singular sleeping period of all the elephants, being 03:44:07.

Amari was the elephant who slept the least,sleeping an average of 01:51:25 (SE= 00:25:39) a night. She slept the least amount of times with an average of 2.43 bouts per night, where her minimum sleep period was 00:00:59, maximum 01:40:13 and total of 38:59:52.

Keisha was recorded as sleeping the second most on average per night out of the six elephants, mean=03:51:51 (SE=00:12:31). Her minimum time slept was 00:00:54 and maximum was 03:01:43. Her total sleep was 81:08:47 and had an average of 5.76 bouts per night.

Mashudu, was seen to sleep the longest on average every night, mean = 04:49:32 (SE= 00:15:20). Mashudu averaged 7.57 bouts per night. The minimum time slept was 00:00:32 and the maximum was 02:39:38, with a total of 101:20:14 hours over the 21-day study period

Shanti's shortest sleep was 00:01:00 and the longest 03:04:09. She slept an average of 4.57 bouts per night, at an average of 03:47:56 (SE=00:19:24) each night, and a total of 79:46:43 over the duration of the study.

Table 3 Sleeping preferences for individual elephants, as well as averages and number of times observed sleeping in the different locations

	Locations		
	Shelter	Boma	Outside
Amari	20	11	20
Keisha	84	35	2
Madiwa	58	36	9
Mashudu	132	27	0
Shanti	67	29	0
Shungu	1	80	2
Combined Ave's	60.33	36.33	5.5
Total	**362**	**218**	**33**

Elephants' preferences varied between locations, either being the shelter, boma or outside. The preferences of location choice can be seen in Table 3.There was significance between the locations (p= 0.0231) for sleep location preference, however the significance within the locations was only seen between the shelter and outside (p= 0.0181197), while there was no significance between the shelter and the boma (p= 0.3826968) and no significance between the boma and outside (p= 0.2181708).Thus, showing the shelter was the preferred sleeping location for the elephants herd.

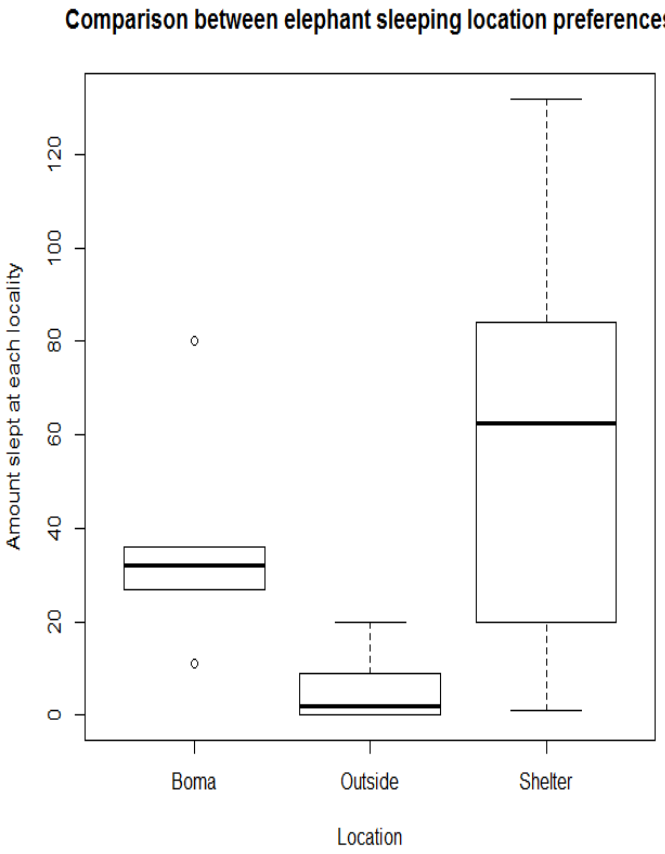

Figure 4 Boxplot showing the visual representation of the preferences where the elephants chose the location of where to sleep

The elephants preferred to sleep in the shelter, followed by the boma and lastly outside. Figure 4 shows where the elephants preferred to sleep. This data is calculated regardless of SS and SL.

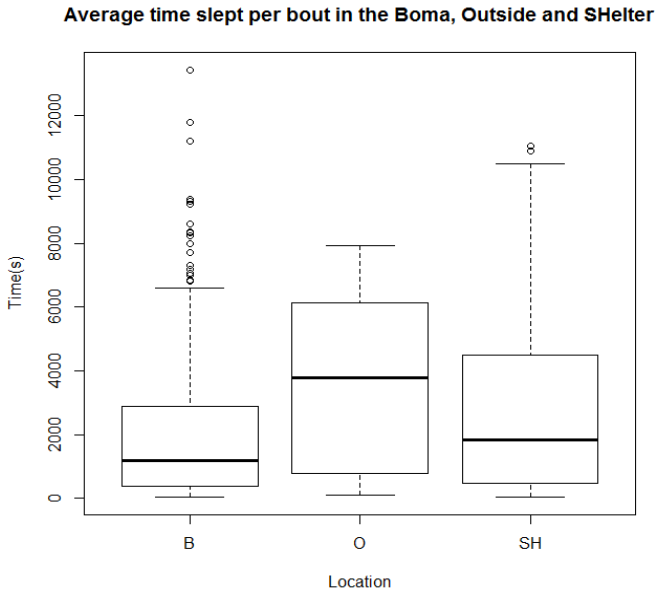

Figure 5 Average time per bout slept in the Shelter and Outside compared to the average of time slept in the Boma

Figure 5 shows that Location O (SE= 0.1576, z=3.57, p=0.000358) and Location SH (SE= 0.08552, z=3.10, p=0.001958) are significantly different to Location B as longer sleeping episodes are seen within the shelter and outside. The elephants had preference for average longer sleep per bout outside and in the shelter (O, estimate= 0.56267 and SH estimate= 0.26482), therefore both showing an increase towards sleeping averages at these two localities compared to that of Location B. The longest time slept was within the boma, however this is classified as an outlier.

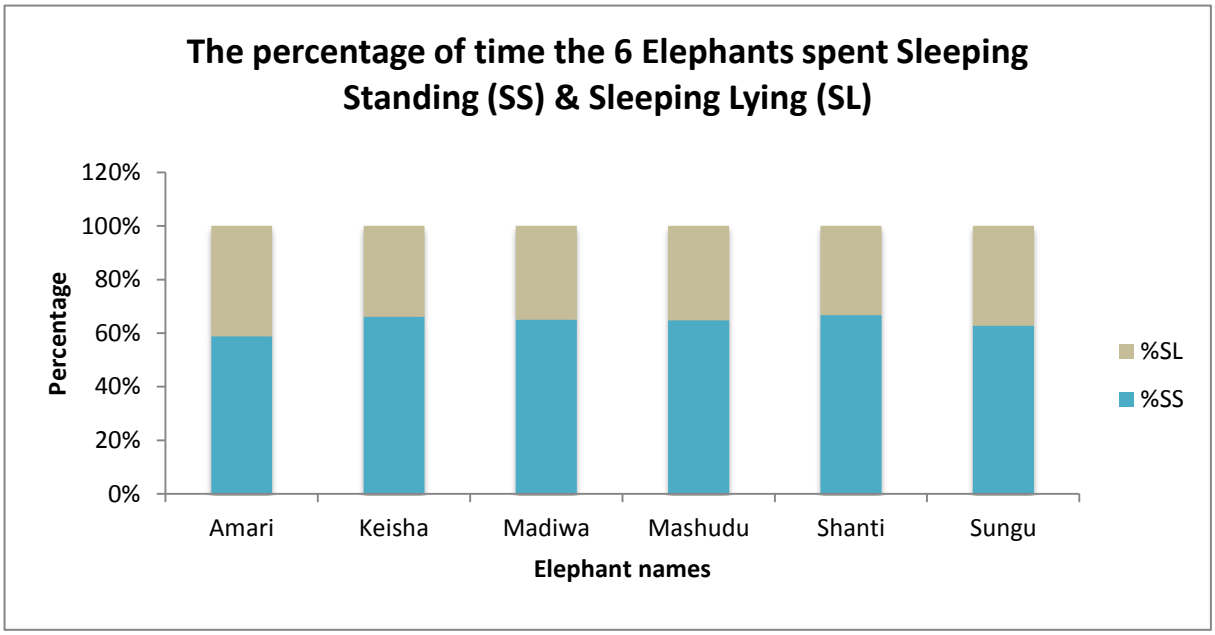

Figure 6: Percentage of different sleeping behaviours amongst the study population of 6 African elephants during the study period (February- March 2021)

The results shown in **Figure 6** reveal that all 6 elephants spent 60% of their time SS and 40% SL. There was negative a correlation between SS (Estimate= -0.1201) and time slept, given P<2e-16). Although SS occurred more, there were longer periods lying down and shorter periods SS.

Table 4: The influence of explanatory variables on the elephant's activities

Activity	Explanatory variable	Estimate	Std. Error	z value	Pr(>|z|)
FB	Sex	-0.182346	0.128982	-1.414	0.157438
	Age	0.055118	0.024158	2.282	**0.022517**
	Ave Temp SH	0.005040	0.016544	0.305	0.760631
	Weather Overcast	-0.379811	0.099101	-3.833	**0.000127**
	Weather Rain	-0.341729	0.089136	-3.834	**0.000126**
	OOS	-0.008957	0.001188	-7.541	**4.65e-14**
FG	Sex	0.168603	0.141496	1.192	0.233428
	Age	0.020243	0.028327	0.715	0.474837
	Ave Temp SH	0.024487	0.017597	1.392	0.164061
	Weather Overcast	0.371994	0.101811	3.654	**0.000258**
	Weather Rain	0.365663	0.096980	3.770	**0.000163**
	OOS	-0.012863	0.001639	-7.847	**4.24e-15**
O	Sex	-0.907407	0.787723	-1.152	0.24935
	Age	-0.366376	0.178717	-2.050	**0.04036**
	Ave Temp SH	0.054062	0.052878	1.022	0.30660
	Weather Overcast	-0.612156	0.417774	-1.465	0.14284
	Weather Rain	0.411672	0.295173	1.395	0.16311
	OOS	-0.015796	0.005669	-2.786	**0.00533**
ODr	Sex	-0.860775	NA	NA	NA
	Age	0.082306	NA	NA	NA
	Ave Temp SH	0.037526	0.043416	0.864	0.38740
	Weather Overcast	-0.219883	0.222247	-0.989	0.32249
	Weather Rain	-0.950701	0.315585	-3.013	**0.00259**
	OOS	0.002026	0.002818	0.719	0.47207
S	Sex	-0.056808	0.476116	-0.119	0.90503
	Age	0.023522	0.094813	0.248	0.80407
	Ave Temp SH	0.013521	0.044815	0.302	0.76287
	Weather Overcast	0.570931	0.229736	2.485	**0.01295**
	Weather Rain	0.275688	0.234966	1.173	0.24067
	OOS	-0.013741	0.003922	-3.503	**0.00046**
SL	Sex	0.092382	0.192061	0.481	0.630516
	Age	-0.070267	0.040920	-1.717	0.085947
	Ave Temp SH	0.016680	0.026021	0.641	0.521491
	Weather Overcast	0.492341	0.146110	3.370	**0.000753**
	Weather Rain	0.197815	0.140288	1.410	0.158521
	OOS	-0.022364	0.002577	-8.680	**< 2e-16**
SS	Sex	-0.314790	0.423666	-0.743	0.457473
	Age	-0.122528	0.085782	-1.428	0.153188
	Ave Temp SH	0.078846	0.032644	2.415	**0.015722**
	Weather Overcast	-0.600139	0.212768	-2.821	**0.004793**
	Weather Rain	-0.202787	0.172040	-1.179	0.238509
	OOS	-0.010553	0.003048	-3.463	**0.000535**
W	Sex	0.278936	0.225207	1.239	0.216
	Age	0.036088	0.045058	0.801	0.423
	Ave Temp SH	0.019794	0.029447	0.672	0.501
	Weather Overcast	-0.001574	0.175432	-0.009	0.993
	Weather Rain	0.093904	0.151749	0.619	0.536
	OOS	-0.015572	0.002780	-5.602	**2.12e-08**
WG	Sex	-1.121636	0.531525	-2.110	**0.03484**
	Age	-0.083563	0.098868	-0.845	0.39800
	Ave Temp SH	-0.042823	0.078402	-0.546	0.58493
	Weather Overcast	1.087395	0.413935	2.627	**0.00861**

	Weather Rain	0.790683	0.400395	1.975	**0.04830**
	OOS	-0.021502	0.007558	-2.845	**0.00444**

Explanatory variables were seen to have a significant effect on the various budget activities. Age showed that older elephants were seen to spend more time FB than that of younger elephants (Est. = 0.055118, p=0.022517), while weather conditions of overcast and rain resulted in less time FB for all elephants in the Night Camp (overcast, Est. = -0.379811, p=0.000127 & rain, Est. =-0.341729, p=0.000126). FG was significantly positively influenced by overcast and rainy weather, therefore in these weather conditions the elephants tend to graze more and for longer periods than normal (overcast, Est. = 0.371994, p= 0.000258 & rain, Est. = 0.365663, p=0.000163). Age was the sole factor to influence O (other) as Est. = -0.366376 and p=0.04036, meaning the older the elephant, the more times they were observed doing 'other' activities. ODr was significantly impacted by rainy weather conditions as the elephants did not drink water as regularly, Est. = -0.950701, p= 0.00259, thus drinking significantly less water when precipitation occurs. Overcast weather conditions were seen to increase the amount of time the elephants slept sleeping standing and lying down (Standing, Est. =0.570931, p= 0.01295 & Sleeping lying. Est. =0.492341, p=0.000753). An increase of time SS was also influenced by the temperature in the shelter and outside (stated in data analysis heading due to collinearity) Est. = 0.078846 and p=0.015722, and overcast conditions also increase the amount of time spent SS, Est. = -0.600139 and p=0.004793. Walking was not influenced significantly by any explanatory variable, while walking grazing was seen to occur more in overcast and rainy conditions (overcast, Est. =1.087395, p= 0.00861 & rain, Est. = 0.790683, p= 0.04830).

5. Discussion

5.1 Budget activity

As expected, feeding (browsing and grazing) was the most abundant activity within the herd (Wilson et al., 2006). There was a difference in the activity budget compared to wild elephants, with a decrease in time spent feeding, walking and foraging for resources, while an increase in sleeping time. Horback et al., 2012 shows that the wild African elephants fed for 63%, walked for 7%, and slept for 27%. While the study population was seen to feed on average for 44%, walk for 1% and sleep for 31% throughout the night. The feeding and walking differences is due to the differences in browse provisioning (Harris et al., 2008). The elephants at KEP are supplied substantial additional browse over a small spatial range. There is sufficient additional browse as the surrounding area has an abundance of invasive tree species. There is close to unlimited browse for the elephants; however the quantity is regulated by the staff members who set out the additional food., The elephants do not need to travel far distances to find adequate resources, resulting in them being able to consume sufficient amounts of food over a short time scale at one locality, corresponding to lower amounts of walking grazing observations within the study. When foraging, the diet of a wild African elephant generally consists of branches, grass, twigs and roots (Carrington, 1958 & Laws, 1970). This is regarded as low quality vegetation, and the majority of their time is spent foraging, resulting in substantial allocation to walking for resources. Viljoen, (1989) reiterates that wild elephant are prepared to travel far distances to obtain sufficient amounts of food and water.

5.2 Sleeping patterns

Sleeping (recumbent and standing) was the second highest percentage within the activity budget. Elephants are seen to sleep for a substantial period of time, more so in captivity than in the wild. Semi-captive elephants' average sleep is more similar to wild elephants than captive elephants, this could be as a result of the individuals coming from wild regions and not being born in captivity like many captive elephant populations. The KEP herd was seen to sleep an average of 03:33:25 per night (ranging from 1.8h- 4.2h). Research by Tobler (1992) showed that Asian elephant populations that were located in either zoos or captivity had an average sleep of 4-6.5 hours of sleep per night. This is significantly longer than the recording of the two wild African elephants which had an average of 2 hours a night (Gravett et al., (2017) and other captive African elephants which average 3-6 hours per night (Evison et al., 2020). The study by Posta, Huber and Moore III, (2013) is an example of the study population of captive elephants that were all born in the zoo. The elephants are seen to sleep for longer periods than wild elephants as there is a substantial amount of additional food available, resulting in less time spent foraging for sufficient resources (Harris et al., 2008). The fact that these elephants are regarded as being a semi-captive elephant population, explains why their average sleep per night is less then captive populations but more than wild elephant populations.

The percentages seen in this study correlate to natural sleeping patterns of elephants. Interactions amongst the herd was seen less than in other captive states and the wild, possibly due to the recording every five minutes being precise to the second, where several interactions could have happened in between the five minute sampling period. Captive elephants showed an average of 6.6 (Wilson et al., 2006) and 5.47 (Brockett et al., 1999) interactions per hour, while wild elephants were seen to interact 1-3 times per hour (Guy, 1976). The elephants in this study only showed >0.01% of interactions over the study period. Interactions could also have been influenced by the fact that there is a sufficient amount of food, resources and space provided for the animals so they are not in close proximity to one another.

The general data on the averages of the herd (Total average sleep, average SS and SL, average SS and SL per bout, average number of SS and SL over the study period and average bouts per night) mimics wild and captive elephant populations. Elephants are seen to sleep multiple episodes throughout a night, thus making elephants polyphasic sleepers. Limited research has been documented on the amount of sleeping episodes per night in captive populations. Important resources for captive elephants are readily available, resulting in limited impacts on sleep duration compared to the wild elephants that have to continuously forage for resources (Viljoen, 1989). Study by Gravett et al., (2017) showed an average of 5.0 sleeping episodes per night (not including nights where they did not sleep) between a population of two wild African elephants. This study does not correlate to Gravett et al., (2017) as the averages of bouts per night were 4.86 (including nights where they did not sleep or were possibly OOS). This means that wild African elephants sleep less occasionally than semi-captive elephants. Reasoning is that wild populations are predominantly impacted by various threats within their environment, and have to focus ultimately on survival rather than requirements for physiological maintenance (Tobler, 1992).

5.3 Recumbent sleep

This study showed that two-thirds of sleep was recumbent. This correlates to previous studies on captive African elephants (Hartmann & Wilson 1968). Recumbent sleep within captive African elephants showed an average of 96 minutes per bout (Kuhme, 1963), and recumbent sleeping in wild

African elephants was seen to vary between 40-65 minutes (Gravett et al., 2017), while captive Asian elephants varied from 50-77 minutes per bout (Tobler, 1992). The elephants recorded in this study showed more recumbent sleep per episode than wild African elephants and captive Asian elephants, while showing less recumbent sleep than captive African elephants. Captive elephants tend to sleep the longest in recumbence as resource provisioning is in abundance. Wild elephants are under threat and vulnerable to predation when lying down. This is a satisfactory reason why recumbence occurs less in wild populations. Study by Schiffman et al., (2018) shows that certain elephants, captive and wild, do not lie down due to vigilance, insecurity, or anxiety. Elephants replace recumbent sleep through particular adaptations in their environment to accommodate standing rest. There is thus an inverse correlation between sleeping lying and standing. Braidwood, (2013) reiterates the notion that standing rest has the possibility of being a substitute for lying rest. Therefore, wild elephants tend to use their environmental conditions more considerably to reduce the amount of time having to spend in recumbent sleep through the action of facilitated standing rest, which results in similar rest while standing to recumbent sleep (Schiffman et al., 2018). This may be the sole reason the sleeping standing is a reoccurring pattern and regularly observed within the boma as the boma is the only place in the entire night camp with sufficient standing support.

The elephants in the KEP Night Camp preferred to sleep in the shelter. The shelter was a small area which was often crowed by several members of the elephant herd. Holdgate et al., (2016) show that as one of the elephants woke and stood up, this often triggered one or more of the other elephants in recumbent sleep to also wake and stand up. Elephants within the study population were often disturbed by other elephants while sleeping (possible matriarchy within the herd), which influenced sleeping periods that were shorter than that of others. This was often the case due to the congestion which occurred in the shelter, which in turn reduced the average length in recumbency. However, sleeping patterns may differ due to seasonality, where research would need to be conducted to see elephants sleeping preferences.

5.4 Standing sleep

Sleeping standing per episode was seen to be the same in the study of populations of wild and captive Asian and African elephants. Wyatt & Eltringham (1974) showed that elephants generally have one long resting period per night (more often than not being recumbent sleep), followed by shorter periods of sleeping standing which were often consistent and similar in length. Garai, (1992) shows that sleeping standing bouts were seen to be more prominent as the episodes are shorter than the recumbent sleeping, but occur more often. Elephants in captivity and the wild often rely on structural support while sleeping, being either metal poles, a shelter or trees (Schiffman et al., 2018). The leaning of elephants on an object while sleeping standing ensures successful transmission of weight, allowing for relaxation and relief of the anti-gravity musculatures (Schiffman et al., 2018). Sleeping standing is often documented while the elephant is stationary; therefore the standing episodes are shorter as often elephants move several meters and start sleeping again. This breaks up the length of long sleeping standing periods into shorter sleeping periods.

5.5 Influence of age on sleep

Younger elephants tend to get more sleep as they feed less than the adults (Holdgate et al., 2016; Gravett et al., 2017; Tobler, 1992). Adults spend more time feeding due to their sheer size, resulting in more time dedicated to foraging and feeding than sleeping. Young elephants have been seen to sleep longer than older elephants in captive and wild environments. Evison et al., (2020) shows

significance in average sleeping length per night between younger and older elephants. Younger elephants aged 1-9 were seen to sleep an average of 266.1 minutes per night while aged 10-60 averaged 185.2 minutes per night. This is most likely due to the difference in the increased requirement of rapid eye movement (REM) sleep, which helps the development and growth of the brain, which is thought to happen during recumbent rest (Schiffmann et al., 2018).

5.6 Location preferences

With the variety of sleeping locations within the night camp, the elephants had choices of where they could rest. This study shows that the elephants were seen to prefer the shelter over the boma and outside while sleeping as there was significance for the elephants to continuously sleep in the shelter. Elephants predominantly chose to sleep in the shelter, possibly because it was the furthest protected place from humans, while also having sawdust scattered on the floor (Schiffman et al., 2018). The shelter had two entrances which was more than that of the boma's one entrance. This may give rise to a breeze blowing through the shelter, making it cooler during the summer months, which may have increased the possibility of the elephants sleeping in the shelter. The difference in seaonality may influence the nocturnal activity budgets and sleeping patterns of the herd,however, research will need to be conducted to see if the weather shows significance on sleep location preferences. There was no significance for the elephants having a preference sleeping either in the boma or outside; however the possible reasons have been elaborated on why they tend to sleep in these localities. The boma had poles and a roof which was the only form of support the elephants were able to lean on while standing, resulting in the elephants mostly sleeping standing in the boma. The boma floor was also scattered with saw dust which provides soft interactive flooring for lying down while sleeping, this was seen during the major sleep period while standing sleeping was seen more in the early mornings. Study by Holdgate et al., (2016) showed that substrate had the strongest association with recumbence, and a substrate variable was included during building programs for captive elephant shelters. Soft substrates can be regarded as grass, sand, or rubber (Meller, Croney, & Shepherdson, 2007; Lewis et al., 2010). Soft substrates provided comfort for the elephants' pads (feet) while standing and general comfort while lying down. This shows why the elephants possibly preferred to rest in the two inside locations (shelter and boma), rather than outside as saw dust is more comforting than grass. The outside ground is still regarded as a soft substrate as it is covered by grass (Meller, Croney, & Shepherdson, 2007), although it is not as soft and comforting as saw dust. A possible reason for less sleep outside was due to the fact that the ground was more uneven. Dew also collected over the duration of the night, consequently resulting in wet grass (Janssen and RÖmer, 1991) and making the conditions for the elephant colder than within the boma and shelter. Schiffman et al., (2018) shows that elephants exposed to hard substrates are less likely to lie down as the substrate is uncomfortable for the elephant (Roocroft, 2005). The shelter was a more rustic and natural environment compared to the boma. The shelter was less impacted by noise pollution, whereas at the boma elephants experienced noise from guests in the lodge and the passing security guard on duty. The boma had additional heaters which created a warmer environment for the elephants during extreme weather conditions outside. Wilson et al., (2006) showed that elephants preferred certain locations and had options to sleep inside and outside as the elephants preferred the outside paddock rather than the smaller indoor shelter due to space. Evison et al., 2020 showed that the elephants did not sleep outdoors and only slept indoors, thus correlating to the lack of sleep observed outdoors in this study. The reason for the elephants sleeping outside in this study is that there is less congestion, thus less competition for space and less interruption while sleeping as observed by Holdgate et al., (2016) who showed that elephants often communicate with each other and recumbent sleeping episodes often

finish when one wakes and stands up. Sleeping outdoors at night may be an important factor for the thermoregulation of elephants, allowing for the loss of body heat attained throughout the duration of the day herd (Wilson et al., 2006).

5.7 Factors influencing activity budgets

There is no significant difference with age and sex impacting the percentage of different sleeping patterns within the study population. Elephants expressed both recumbent and sleeping standing patterns in all three locations, however the average time slept per bout slept varied. The average time slept in the boma was substantially lower than that of the shelter and outside. Gravett et al., (2017) showed that environmental effects from weather conditions have the possibility of shaping sleep architecture in elephants. Often the elephants were seen to congregate in the boma during extreme conditions, resulting in congestion. Tobler (1992) shows that the weather conditions in winter influenced the number of hours spent outside. The total time slept was different in winter compared to summer. The elephants' sleep onset was seen to be significantly earlier, while more sleep was seen to occur earlier in the night in winter months than in summer. This time period was made up of multiple short sleeping bouts, whereas the deep long periods of sleep in wild elephants is seen to be after the 'peak feeding period' at 00:00 (Wyatt and Eltringham, 1974). Elephants have been seen to have one major long sleep episode and several other shorter sleeping bouts. Wyatt & Eltringham (1974) showed that captive adult elephants had a deep sleep from around 00:00-06:00 in captive elephants and 01:00-04:00 in wild elephants. The longest sleeping period of this study was seen to be outside because of less competition for space and less interruptions while sleeping (personal observation). The shelter also showed a high average sleep period per episode because the structure was often utilised in the hours between 23:00-05:00, when the major singular sleep period occurred. The shelter was seen to be an intermediate between the average lengths slept outside and in the boma because the major periods often took place within, however congestion and interruption often shortened sleeping bouts. After waking from a long period of sleep, the elephants were observed to sleep and rest for shorter periods followed by a gradual increase in feeding and other activity levels from 05:00), as seen in this study and Horback et al., (2014). The one major sleeping period per night was most likely to be the elephant lying down, where the short sleeping periods were seen to be standing up. Therefore, the majority of sleep occurred sleeping standing (60%) and the other 40% being recumbent sleep. The recumbent sleep of the study population is substantially higher than that of wild elephants. Gravett et al., (2017) showed that two wild elephants were seen to spend 12% and 15% of the total sleeping time in recumbent sleep. The substantial differences are that the local herd spend more time sleeping. Recumbent sleep is seen to provide a deeper sleep for the elephants. Wild elephants face the threat of predation, lack of food or water and poaching which limits the elephants' time and amount of sleep spent lying (Grandin & Johnson, 2009). The herd has more comforting support while sleeping lying down due to the saw dust, making sleeping lying down more often.

Wild and captive elephants have been studied with regards to their behavioural (Guy, 1976), social (Harvey et al., 2018; Evison et al., 2020) and physical activities (Greco et al., 2016). Research has found that wild and captive elephants feed, but documentation on the specifics within factors such as sex and weather influencing feeding is limited. During winter months wild elephants are seen to eat less due to lack of food availability (Evison et al., 2020). There was significance that feeding browsing was influenced by age. The reason may possibly be that the older elephants show hierarchical dominance over the younger elephants as the older elephants fed on the supplied browse first (Harvey et al., 2018). Archie et al., (2006) explained how hierarchies within the unrelated captive herd were ordered by age and size, where older, larger females were seen to dominate the smaller,

younger elephants for access to additional resources. The younger elephants therefore most likely got to feed on the provided browse after the older elephants had consumed most of the edible sections on the branches, resulting in them feeding browsing less however are seen to feed graze more during these times.

Various weather conditions had an influence on the elephants throughout the study period. Overcast and rainy conditions were seen to impact both the amount of time spent feeding grazing and feeding browsing. During both these conditions, the time spent feeding grazing increased and feeding browsing decreased. Temperatures are usually warmer when there is cloud cover at night as opposed to when the sky is clear and has no cloud cover. When the heat from the previous day escapes back into the atmosphere, this results in colder nighttime temperatures compared to cloudy overcast nights that retain the heat from the previous day (Geiger, Aron and Todhunter, 2009). Grazing was possibly increased during overcast conditions because the elephants need to be moving to thermoregulate as the weather conditions were possibly warmer from the cloud cover (Wilson et al., 2006). This caused them to walk more and keep moving to thermoregulate during the warmer evenings. Therefore, feeding browsing decreased during overcast conditions as the elephants were noticeably walking around more feeding grazing, and not situated at the stationary browsing points within the night camp. The influence of rain may have influenced an increase in grazing as the grass contained more moisture and held more water from the precipitation. This is in contrast to dryer conditions as the elephants were seen to drink significantly less when rain occurred as warmer conditions tend to be drier and water consumption is mandatory to stay hydrated. The elephants were thus able to receive sufficient amounts of water from the grasses while feeding in rainy conditions, resulting in less time spent drinking from the water trough. Babaasa (2000) showed that only heavy rainfall in wet seasons influenced the feeding of elephants as new shoots develop over a period of time, whereas one isolated shower (as seen in this study) is not sufficient to allow for new grass shoots to develop. There is a contrast as significant results show that overcast and rainy conditions also increase walking grazing. While grazing, the elephants continuously move over a spatial region to continuously find more grass. Therefore, walking grazing is seen to be significantly impacted by overcast and rainy conditions as the elephants are seen to increase their feeding patterns on grazing during these conditions, due to thermoregulation and water moisture on plants. Studies have shown that walking grazing in elephants is due to traveling to find resources such as water while feeding, while being influenced by the quality and quantity of food availability (Mramba et al., 2019). Sex was another explanatory factor that impacted walking grazing significantly. Male elephants were seen to walk and graze more possibly due to the females feeding browsing more because of age and the hierarchal structure in the herd. This correlates to the study by Archie et al., (2006). The study shows that older females show hierarchal capabilities which ensure they acquire the provided resources first, as seen in this study. This means the males spent more time grazing, and were thus observed to be walking grazing more than the females in the herd.

Overcast conditions were seen to significantly increase sleeping lying and decrease sleeping standing. Clouds on an overcast night retain the heat from the day, therefore the weather temperature is generally warmer at night. An increase in sleeping lying is possibly due to the air at night being colder closer to the ground (Geiger, Aron and Todhunter, 2009). At night, hot air rises, resulting in colder conditions lower down, closer to the floor, therefore, the elephant slept lying down in a colder environment enabling them to thermoregulate and cool their body temperatures (Wilson et al., 2006)

The present study on six African elephants located at the Knysna Elephant Park has shown various important observations regarding their activity budget, sleeping preferences and sleeping patterns. The findings correspond to studies previously focussed on the nocturnal behaviour in both captive

(Kühme, 1962), and wild elephants (Wyatt and Eltringham, 1974) where captive and wild elephants have shown differences and similarities with the budget activity, nocturnal sleeping and feeding.

5.8 Limitations

Whilst weather conditions were not favourable, the CCTV camera and Camera 5 visuals were prioritised as visuals were blurred from dust particles and raindrops. However the cameras within the shelter and boma were functioning optimally and were not disturbed in any manner. The results may not be as accurate, possibly due to the vast counts of OOS, although this could be a focus point to improve on for such a study. Solutions of either more camera footage or traps, extending the study period to increase observation counts or increase live observation nights will all increase the accuracy and precision of the results. However, the results documented have been thoroughly processed and managed carefully to provide the most accurate results possible with the recorded data.

There were nights where sleep was not recorded for several of the elephants, being either OOS or actually not having slept. There has been no previous study that has seen captive elephants not sleeping at all throughout the night therefore the elephants were most likely sleeping outside, however this was not recorded.

The age of the elephants may also be a limitation as the age of all elephants was between 13-20 years. There were not enough individuals with a range of ages for creating age categories, to determine if age influences sleeping patterns.

The elephants interact with tourists throughout the day. These interactions often limit the populations' sleep throughout the day, which may influence their sleeping patterns and duration of sleep at night. There are minimal studies on their impacts on the sleep duration at night. The elephants may increase their sleep duration due to exhaustion or decrease their duration of sleep due excessive stress.

6. Conclusion

Many studies have been documented on wild and captive elephants. However, these semi-captive rehabilitated elephants are unique in their own way. Certain findings of this paper correlate to previous findings in several scientific papers, while this study will add to the limited findings on factors such as age, sex and weather impact on the budget activities of the elephant herd have been established.

The nocturnal behaviour of the elephants showed that the herd spent a majority of their time feeding, followed by sleeping. The elephants expressed favouritism with where they preferred to sleep, while also showing a differential in the average time spent sleeping in these preferred locations. A high percentage of recumbent sleep was seen, although sleeping standing was more reoccurring than sleeping lying. The original hypothesis is thus correct as temperature and weather conditions impacted the sleeping patterns, location of where the elephants slept and their budget activities. While the H0 was correct in terms of no significance that older elephants sleep less than the younger elephants.

An African elephant symbolises nature and wildlife throughout the world. Under changing environmental circumstances, elephants are becoming more prominent in captive environments. The importance of scientific research on elephant populations aims to find new endeavours on the functioning of these species. New knowledge through unique research allows for a creation of a captive environment to mimic that of the natural world. Future research should focus on increasing

the sample size through the addition of more individuals of different sexes, ages, relatives and non-relatives, ensuring a more precise depiction of results.

Research allows for the understanding of what elephants prefer, which in turn allows for adequate management of the species. Gathering of research through regular data collection and evidence of elephant nocturnal behaviour would have direct implications for the management of captive animals to maximise their welfare. The research would aid with the improvement of the standards of husbandry, animal management, and most importantly, the welfare of animals, aiming to express the typical behaviour of an elephant.

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