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Comparative Behavioural Analysis of Asiatic Lions, *Panthera leo persica*, at Fota Wildlife Park.

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FOTA
WILDLIFE PARK

Contents

Abstract

This study examines the behaviour of six Asiatic lions, *Panthera leo persica*, housed at Fota Wildlife Park, Cork, Ireland. Behavioural data were collected using focal, scan and ad libitum sampling. It has been shown that understanding the behaviour of captive animals is one of the easiest ways of analysing their welfare in a non-invasive way. This means improvements to the care of captive animals can help to improve their behaviours and increase the chances of breeding programmes in captivity in the long run. Considering the importance of breeding programmes to the status of populations in the wild this area of research plays an important part in conservation projects worldwide. Data collected showed that the pride as a whole spent a vast majority of their time on inactive behaviours such as lying down and sleeping as expected of lions. Apart from inactive behaviours some other frequently witnessed behaviours included walking, allogrooming and autogrooming and eating. The six individuals were compared to each other using a variety of statistical techniques, including Mann Whitney U tests, Chi Square tests and Spread of Participation Indexes, to determine similarities and differences in behaviour. Results showed that between the adult and juvenile males the behaviours of cheek rubbing, climbing and playing had significant differences. Between adult and juvenile females no difference in behaviour was statistically significant. When examining how visitor numbers affected grouped behaviours there were ten associations seen, five positive and five negative. The test performed on data examining how time of day affects grouped behaviours found six associations, two positive and four negative. When examining how the lions made use of their enclosure it was found that each individual used their enclosure in a very uneven way and the pride as a whole used the enclosure unevenly. The study showed a wide variety of behaviours present and a very low percentage of abnormal or stereotypic behaviour indicating good welfare amongst the six lions. While the pride of lions seems to be very healthy there are ways in which to ensure no decline in welfare. Increasing the use and variety of enrichment in the enclosure is a proven method for engaging animals and keeping them healthy. Future work with the pride could look at the changing relationships as the cubs grow older. Should new cubs be born a study could look at the changing dynamics in the pride as Loki, Arya and Amira lose their status as the youngest.

(WC: 404)

Introduction

Current Status of Wildlife Populations

Due to the actions of humans worldwide there are decreasing population numbers seen across taxa. Numerous factors have caused the observed decline in populations. Some of the most damaging of these influences are climate change, habitat loss, alien invasive species, introduction of foreign disease and direct conflict between animals and humans (MacDonald, 2016). Human impact on the Earth's environment has caused the decline and extinction across many large carnivore species. The decline in populations has been, and still is, continuing to accelerate as each year as global populations of wild carnivores become more threatened (Rosenblatt et al., 2014). With many of these predators requiring large home ranges to be able to sustain themselves and any young, habitat fragmentation plays a large role in causing decreasing populations. This can be due to increased conflict with humans or possibly because of a lack of viable prey options in decreasing territories (Meena et al., 2014, MacDonald, 2016).

With the continuing increase of human populations conservation research is becoming an area requiring more dedicated study from a variety of scientific fields. It has been shown that human impacts can cause changes in the personalities of wild predators over time. These changes in behaviour can occur due to plasticity in an individual or due to micro evolutionary changes to a species (Greenberg & Holekamp, 2017). While the integration of various fields of study have been slow it is becoming more acknowledged that understanding the behaviour of target species is crucial to the success of conservation projects whether *in situ* or *ex situ* (MacDonald, 2016). Knowledge of how human activity shifts the behaviour of wild carnivores is key in being able to understand how best to manage and conserve wild populations in conflict with humans (Greenberg & Holekamp, 2017).

Importance of Ex Situ Conservation

Ex situ conservation consists of breeding a captive population of a species which has been deemed to be in danger in their native habitat. The aim is to keep a viable population that may be re-introduced to the wild should a wild population need bolstering of numbers or in case of local extinction (McPhee, 2003). Re-establishment of captive animals to wild populations has in recent decades become more recognised as an extremely difficult but

possible conservation technique (Jule et al., 2008). The IUCN define re-introductions as “an attempt to re-establish a species in an area which was once a part of its previous historical range” (Jule et al., 2008).

Using large charismatic species as figureheads of conservation has become a popular and effective strategy worldwide. Large carnivores play an important role in this strategy as members of the public find them stimulating. This is especially true for large felid species such as Asiatic lions, *Panthera leo persica* (Banerjee et al., 2010). To be able to properly raise animals in captivity for any research or conservation project an initial population of suitable genetic diversity must be used. If genetic variation is lacking the individuals may not be able to produce viable offspring to provide a stable captive population (Atkinson et al., 2018).

Studies have shown that projects using wild caught individuals can have greater success rates than those raised in captivity (Jule et al., 2008). Over time, researchers have come to realise populations kept in captivity lose and modify elements of behaviour which may make it difficult to re-introduce captive bred animals back into their original range. With a regular routine and lack of unpredictability in captivity, animals may lose the required behavioural plasticity needed to adapt to changes in a wild setting (McPhee, 2003).

To consider a reintroduced population a success four criteria have been proposed that are indicators of establishment. If there is breeding amongst the first generation of wild born animals, three years of successful breeding with birth rate higher than mortality of adults, an independent population of five hundred individuals and a self-sustaining population in the wild then a reintroduction programme is considered a success. These signs must not be taken as a final indication of whether a project has worked however as extended monitoring and management is required to ensure continuous growth (Jule et al., 2008). With regards, to Asiatic lions, for example, the current wild population is only slightly higher five hundred individuals. Having that as a factor of success could vary from species to species depending on the circumstances in which a species recovery has occurred. Factors influencing a failed introduction attempt can include an over-friendliness to humans due to the close proximity in captive conditions. Lack of an ability to find resources and development or loss of suitable behaviours can also play a role (Jule et al., 2008).

When reviewing the success of programmes, where captive animals are introduced to their original habitat, many programmes fail due to inadequacies in the behaviours of those animals. In a famous case of golden lion tamarins, *Leontopithecus rosalia,* some members of the introduced population were unable to survive due to a lack of climbing ability. Individuals died as they were unable to efficiently travel through the canopy, find food and resources and avoid predators (McPhee, 2003). There have been several other reintroduction projects carried out that have gained the backing and understanding of the public due to their successes. These include introductions of Californian condors, *Gymnogyps californianus*, and Arabian oryx, *Oryx leucoryx*. The animals in these studies were mostly captive born or brought into captivity from the wild to increase their numbers before being reintroduced to the wild (Jule et al., 2008).

The Asiatic Lion, Panthera leo persica

There are two species of lion recognised by the International Union for the Conservation of Nature (IUCN), the African lion, *Panthera leo*, and the Asiatic lion, *Panthera leo persica* (Bertola et al., 2011). Both species of lion have seen decreases in population numbers and habitat ranges due to the increase in human activities such as poaching, trophy hunting, increases in agriculture and direct conflict between animals and humans caused mainly because of habitat loss (Rosenblatt et al., 2014). During the 20th century the Asiatic lion almost went extinct. By the late 20th century the wild population of Asiatic lions is thought to have dropped to about twenty individuals (Atkinson et al., 2018). It was through the conservation efforts such as the establishment of the Gir National Park in 1965 that allowed populations to increase once more and begin expanding outwards to form satellite populations (Singh & Gibson, 2011, Singh, 2017).

The remaining population of Asiatic lions, *Panthera leo persica*, is found in the Gir forest of the Saurashtra region which lies in the state of Gujarat, India (Banerjee et al., 2010, Singh & Gibson, 2011). With increasing populations animals naturally started spreading outwards to form satellite populations (Meena et al., 2014). These satellite populations now house approximately one quarter of the lion population (Singh, 2017). Today five protected areas exist for Asiatic lions. The Gir Sanctuary, Gir National Park and Pania Sanctuary protect the main populations of lions while the Mitiyala Sanctuary and Girnar Sanctuary protect the

satellite populations (Singh & Gibson, 2011). These five protected areas cover an approximate area of 1621km^2 (Singh, 2017).

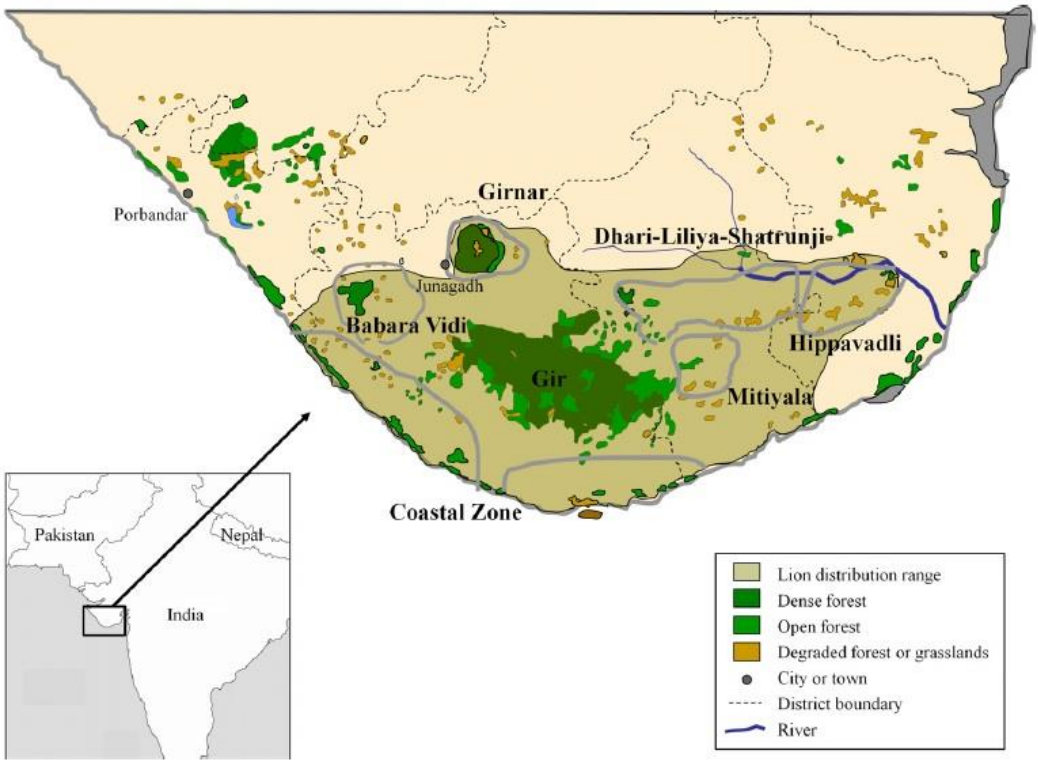

Figure 1: Map of the Saurashtra region of India displaying the range of the Asiatic Lion. (Sourced from Singh & Gibson, 2011).

Increasing populations of lions have led to the IUCN changing the categorisation of *Panthera leo persica* from critically endangered to endangered (Singh & Gibson, 2011, Meena et al., 2014). As of 2015 it was recorded that there are at least 523 individuals located within the protected areas of Gujarat (Atkinson et al., 2018). The success in the re-establishment of Asiatic lions in Gujarat has been due to several factors but key amongst them is the view that the local people have of the lions. The locals take great pride in having the only wild population of Asiatic lions and see them as a valuable asset. The lions control numbers of wild blue bull and boar which are considered nuisances to the farms of the local people. The presence of lions also discourages leopards from the area reducing the risk of leopard attacks (Singh, 2017). An overwhelming majority of the locals near the Gir forest are in favour of the conservation efforts for the lion populations. With only twenty percent of people in the area feeling negatively towards the presence of lions the continuation of conservation projects has a promising future (Meena et al., 2014). To continue effective conservation of the species in the wild understanding the human-animal relationships becomes more important as conflicts

between lions and locals becomes more possible (Meena et al., 2014). Understanding the behaviour of wild individuals can be better achieved through study of their captive counterparts.

The history of Asiatic lions in captivity had a questionable origin. In the early 1990s a project was undertaken to create a captive population of Asiatic lions, *Panthera leo persica,* within Europe. A European Endangered Species Programme (EEP) was set up using eight lions taken from Indian collections and a single individual from the wild (Atkinson et al., 2018).

Due to the lack of ability at the time to analyse the genetics of the animals the initial nine animals would under today's consideration be unsuitable for establishing a population. This is due to the lack of variation in their genetics that was caused by an inbreeding depression driven by inappropriate pairings within the original Indian mating programme (Atkinson et al., 2018). This led to all females and one male of the European founding population having the same grandfather. With the limited genetics available this led to a bottleneck in genetic variation and the establishment of a founder's effect within the European population. This founder's effect led to extremely high mortality rates within Asiatic lion cubs and made it very difficult to establish a healthy population (Atkinson et al., 2018).

While improvements have been made to the mating programmes within the European population and steps have been taken to diversify the gene pool of the European population, careful management is still required to ensure the best possible management of the EEP (Atkinson et al., 2018). By understanding the behaviour of these animals, plans and contingencies can be developed for controlling and properly managing captive populations.

Understanding Captive Behaviour

Understanding a species behaviour can allow collections to design and prepare enclosures and routines to best prevent abnormalities before they develop. In carnivores improving enclosure design may lead to improvements in the success of breeding programmes worldwide (Clubb & Mason, 2007). Understanding the behaviour of captive animals relies on dedicated research looking at what triggers abnormal behaviour and what can be done to pre-empt and prevent abnormalities.

Some species are better able to adapt to captive conditions; being able to display normal behaviours and produce offspring without any noticeable difficulty. Other species however suffer from reduced welfare, displaying abnormal behaviours and struggling to reproduce (Clubb & Mason, 2007). Abnormal behaviours can also be a problem for studies being conducted on captive animals. While studies on captive animals cannot be considered to provide detailed answers about wild individuals of the same species, they can give indicators of behaviour and help improve the understanding of the species and designs for study of the wild counterparts. The presence of stereotypes can skew the results of these studies and cause problems within the research (Mason et al., 2007).

Stereotypes are generally defined to be behaviours that are repetitive, unchanging and seem to serve no visible purpose or benefit to an animal (Mason et al., 2007). Animals are thought to perform stereotypies for reasons that include indicating poor welfare. Some reasons are thought to include a lack of variation in captive habitats leading to an excess in energy causing stress to an animal that is then released through the performance of stereotypic behaviour. Another suggestion is that trauma during the developmental stages of an animal's life can cause damage to the central nervous system leading to physiological or psychological scarring that can lead to the performance of stereotypes (Mason et al., 2007).

To reduce abnormal behaviours enriching the enclosures and routines of captive animals plays an important role in encouraging natural behaviours and discouraging stereotypes. Enrichment starts from enclosure design. By creating diverse and complicated enclosures it gives animals more opportunity to explore and make use of their enclosure while also giving important hiding areas where animals may avoid the attention of the public (Mason et al., 2007). Other enrichment practices include creating toys and interactive items to trigger the curiosity of the individuals. This normally will include an element of food to engage an animals senses to create a response and interaction with the enrichment tools. While enrichment is used frequently and often shows promising results, rarely does it ever seem to truly eliminate abnormal behaviours (Mason et al., 2007).

Studies have showed the likelihood of a carnivore species to display abnormal behaviours is more likely to be related to the size of the species' natural territories rather than being related to a species' hunting behaviour. The larger a natural territory in the wild the more likely a captive species is to show abnormal behaviours and the higher mortality seen in cub numbers

(Clubb & Mason, 2007, Kroshko et al., 2016). It has been well documented that pacing in captive felids is one of the most prevalent modes of stereotypy. The continuous pacing back and forth on the same trail may be due to an animal's natural instinct to travel over larger territories. With this not being fulfilled within a limited enclosure the excess energy may be displaced in the form of pacing (Mason et al., 2007, Kroshko et al., 2016).

Only a single previous study (O'Sullivan, 2016) has been conducted to observe and understand the behaviours of the Asiatic lions kept in Fota Wildlife Park. That study looked at the behaviour of the females Gita and Gira when they first arrived at Fota over a period of four months; examining how the females' behaviour changed over time as they adjusted to their new location. When Shanto, the male, was introduced on the 12th July 2016 the behaviour of the females was analysed through the adjustment period where the individuals began integrating themselves into a pride (O'Sullivan, 2016). The final element of that study looked at the behaviour of the group once Gira was seen to come into oestrus from the 5th September 2016 until an unspecified date (O'Sullivan, 2016).

Objectives

Following on from the 2016 research project this study was developed to look at five different questions regarding the Asiatic lion's behaviour.

(a) Does Shanto's (adult male) behaviour differ from Loki's (juvenile male)?
(b) Does Gita and Gira's (adult females) behaviour differ from Arya and Amira's (juvenile females)?
(c) Do visitor numbers affect the behaviour of the lions?
(d) Does time of day affect the behaviour of the lions?
(e) How do the lions use their enclosure?

(WC: 2480)

Materials and Methods

Study Location

The study took place at Fota Wildlife Park, Carrigtohill, Cork. GPS coordinates 51.8914° N, 8.3074° W. The study focused on the pride of six Asiatic lions (see table 1 for details), *Panthera leo persica*, located in the Asian sanctuary area of the park.

Table 1: Individual lions showing gender, age, original collection or zoo and date of arrival or birth of each animal at Fota Wildlife Park.

Individual	Sex	Age (Years)	Original Collection/Zoo	Date of arrival/birth at Fota
Shanto	M	7.5	Santillana del Mar, Spain	07-Jul-16
Gira	F	4.5	Helsinki Zoo, Finland	24-May-16
Gita	F	4.5	Helsinki Zoo, Finland	24-May-16
Loki	M	1.5	Fota Wildlife Park, Ireland	13-Aug-17
Arya	F	1.5	Fota Wildlife Park, Ireland	13-Aug-17
Amira	F	1.5	Fota Wildlife Park, Ireland	13-Aug-17

Table one shows that the adult male Shanto is the dominant male of the group being the oldest male. Gita and Gira are from the same litter and arrived together at Fota on the same day. Gira and Shanto mated in the months following his arrival and Gira gave birth to Loki, Arya and Amira. As seen from Appendix 1 (fig. A1) and images 1, 2 and 3, the enclosure, approximately 4893.21m^2, consists of the house which is divided into four indoor and two outdoor areas as well as one large outdoor enclosure and a smaller outdoor enclosure. The enclosure has a raised rock in the centre of the enclosure, which contains a cave that the animals may shelter in. The rock is heated both within the shelter and on top. Large tree trunks are laid against the rock to allow the lions to climb onto the roof of the cave. An artificial stream runs down off the rock through the enclosure and out through a drain into the artificial lake nearby. Various foliage throughout the enclosure provides cover for the animals. The enclosure contains two public viewing platforms which allowed for clear views of most of the enclosure.

Image 1: External view of Viewing Bay 2 (left) and indoor lion house (right). Refer to Appendix A1

Image 2: External view of Viewing Bay 1. Refer to Appendix A1.

Image 3: Raised heated rock in lion's enclosure with den area visible and trees laid against it for climbing.

Data Collection

The behavioural sampling methods to be used to collect data include instantaneous scan sampling, focal sampling and ad libitum sampling (Altmann, 1974). These methods were chosen to be able to capture the most varied range of behaviours of the animals for a variety of settings in both the group and individuals. For capturing states of behaviour focal sampling provides a better understanding whereas scan sampling is more appropriate for capturing states of behaviour. Instantaneous scan sampling provides accurate data on the overall behaviours displayed within a group and can be used to calculate times and frequencies of behavioural states. Focal samples are used to gain a better understanding of individuals' behaviours and can be used to compare and contrast between individuals within the group. When ad libitum sampling is used on its own the data can be difficult to quantify and can contain a variety of biases. The samples are useful however when backing up the data collected from the other sampling methods (Altmann, 1974). Preliminary sampling was

conducted on the 25th October 2018. The samples done on this day were not included in the overall calculations as they were simply to gain an understanding of the animals' habits, prepare for samples that would be used and decide on the length of focals and on the intervals to use for scan sampling.

Focal sampling

For answering questions (a) and (b) focal sampling was used. On the test date five test focal samples were conducted starting at a duration of five minutes. The duration then increased by five minutes each new sample so samples of five, ten, fifteen, twenty and twenty-five minutes were taken respectively. It was decided to use focal samples of twenty minutes as this was deemed to be the most representative time of the behaviour. This time was chosen for several reasons. It was deemed to be representative of the observed behaviours without collecting data that was considered repeated. As well as that the twenty minute samples allowed for a reasonable number of samples to be collected every day of sampling. Finally when considering observer fatigue twenty minute samples allow the observer to continue working for longer periods while still having enough time to rest in between samples. This reduces the degree of human error when collecting data (Altmann, 1974). To conduct the focal samples an animal was chosen at random using a random number generator application called developed by UX apps and downloaded from the google play store. Each animal was assigned a number from one to six (One = Shanto, Two = Loki, Three = Gira, Four = Arya, Five = Amira, Six = Gita) and the number generator was used to pick which animal was sampled. It must be noted that the application comes with a no repeat function. This was disabled for the sampling to provide true random sampling.

Scan Sampling

Scan samples and visitor numbers were used to answer questions (c) and (d). For scan samples four test samples were conducted on the 25th October 2018. The first test scan was ten minutes long with scans done every thirty seconds starting at zero seconds. The second test lasted ten minutes with scans every sixty seconds. The third test scan was of twenty minutes duration with scans every thirty seconds and finally the fourth test was twenty minutes long with scans every sixty seconds. After conducting these tests it was decided that a scan length

of twenty minutes was appropriate if scans were taken every two minutes. To simplify the process of taking scan samples a data collection sheet was made out. See Appendix 2.

Ad libitum sampling was taken throughout the day when observing the animals. Any behaviours witnessed considered to be valuable (see Table 2) for answering the objectives and providing evidence of behaviour not captured during the restricted focal and scan samples were noted.

As well as the behaviour of the lions, numbers of visitors to the enclosure were also noted. This was done during both focal and scan sampling. Initially during the test day each group of visitors was noted individually with their arrival time and departure time. However there were soon too many to be able to keep track of while completing the behaviour samples so, instead, a head count system was adopted. During focal and scan samples a head count of all visible visitors was done and noted every two minutes starting at the one minute mark. The observer was discounted from the head count and considered a constant.

Enclosure Usage

Question (e) was answered using data collected on enclosure maps. The final samples taken were observations of enclosure usage by the animals. This was noted using an overhead view map of the enclosure, see Appendix 3. The data were collected by marking the position of all visible animals within the enclosure just before starting each scan sample and just after each scan sample.

Other Details

In total eleven days of sampling were conducted excluding the test day. Three days of samples were conducted in November 2018, four days in December 2018 and four days in January 2019. An effort was made to ensure the weather conditions did not act as a variable by only sampling on days of mild weather conditions.

The sampling was done between the hours of 10am and 4pm each day. Each day was divided up into blocks of two hours within each of which two focal samples and two scan samples were taken along with the accompanying side data of visitor numbers and enclosure usage. These blocks lasted from 10am – 11.59am, 12pm – 1.59pm and 2pm – 3.59pm. Over the duration of the study two focal samples were not taken for the second time block due to

keepers locking the animals indoors so as to clean the enclosure. When this occurred it resulted in pacing from all six animals. Two scan samples were missed from the third time block. For one all animals had moved out of sight and did not re-appear. The second was not taken as the animals were locked inside by keepers.

Ethogram

Table 2 shows the ethogram used when collecting data on the pride of Asiatic lions. The ethogram includes both grouped and detailed behaviours. Individual behaviours are assigned to appropriate groups of behaviours including inactive, active, social, feeding and other behaviours. Both grouped and detailed behaviours were used when conducting data analysis.

Table 2: Ethogram of lion's behaviour. Behaviours are divided up into groups of appropriate categories including inactive, active, social, feeding and other.

Behaviour	Code	Description
Inactive Behaviours	**IAB**	
Lying down	LY	The animal is lying on the ground with their head raised and eyes open.
Sleeping	SL	The animal is lying on the ground with their head on the ground and eyes open.
Standing	ST	The animal is standing with all four legs supporting it and no movement in any direction
Sitting	SI	The animal is in a sitting position with the forelegs supporting it and the hind legs folded underneath it.
Stretching	STR	The animal stretches out its body. Usual position entails the animal bending its chest down to the ground while simultaneously pushing their hips and back legs upwards towards the sky.
Autogrooming	AU	The animal grooms itself using it's tongue and paws to clean their pelt.

Table 2 continued: Ethogram of lion's behaviour. Behaviours are divided up into groups of appropriate categories including inactive, active, social, feeding and other.

Behaviour	Code	Description
Active Behaviours	**AB**	
Walking	WA	The animal is moving forward at a sedate pace and no sign of haste.
Running	RU	The animal is moving forward at a rapid pace with indications of haste.
Climbing	CL	The animal climbs on a tree or rock by moving in a vertical and not a horizontal direction. The action results in a change of elevation.
Scratching	SCR	The animal uses some surface in the enclosure to rake their claws against it and sharpen their claws.
Rolling	RO	The animal rolls around on the floor with it's back on the ground and all four limbs in the air.
Sniffing	SN	The animal sniffs at a scent. This involves an animal bringing their head close to the source, flaring the nostrils and taking short, sharp breaths.
Stalking	STA	The animal chooses a target to approach in a quiet manner in order to surprise them. When stalking the animal keeps it's body crouched low to the ground, keeps their focus on their target and moves slowly and cautiously.
Yawning	YA	The animal leans its head back and opens its jaws wide to yawn.
Headshake	HE	The animal shakes its head vigourously.
Social Behaviours	**SB**	
Allogrooming	AL	The animal grooms another individual using its tongue and paws to clean their pelt
Sexual Inspection	SX	The animal inspects another individual by sniffing oor searching for reproductive organs.
Cheek Rubbing	CR	The animal interacts with anoother individual to greet them by rubbing their heads together and cheek rubbing.
Mounting	MO	A male attempts to stimulate copulation with a female by mounting her from behind. The female supports the front half of the male's body while the male attempts copulation.
Mating	MA	A successful act of copulation where the male is accepted by the female and allows him to mate and inseminate her.
Aggression	AG	The animal shows signs of aggression towards another individual ranging from hissing or growling to actual physical contact of pushing, scratching or biting.
Playing	PL	The animal plays with another individual by playfighting. This may include soft biting, pawing with the claws sheathed and general pushing and nudging.
Suckling	SU	An animal gets into the suckling position with an adult female. The juvenile moves muzzle in to the females abdomen and latches onto the females teat to suckle milk.

Table 2 continued: Ethogram of lion's behaviour. Behaviours are divided up into groups of appropriate categories including inactive, active, social, feeding and other.

Behaviour	Code	Description
Feeding Behaviours	**FB**	
Feeding	FE	The animal feeds on whatever food is provided.
Drinking	DR	The animal drinks from a water source.
Other Behaviours	**OB**	
Pacing	PA	The animal walks over the same route in a repetitive fashion. Considered pacing if the animal follows the exact same route, retracing their steps for more than three repetitions.
Use of Enrichment	UE	The animal interacts and uses any object of enrichment placed in the enclosures by the keepers.
Out Of Sight	OS	The animal can not be seen in your line of sight.
Vocalisation	VO	The animal makes any type of vocalisation. May be a roar or growl etc.
Scent Marking	SM	The animal leaves its scent on an area of it's enclosure by cheek rubbing against a surface or by spraying from its anal glands against a surface of it's enclosure.
Vigilance	VI	The animal becomes alert and focuses on a stimulus. Signs include the animal suddenly freezing, flicking of the ears and intense gaze staring at the stimulus.

Identification of Individual Animals

To be able to conduct the focal and ad libitum samples it was necessary to be able to identify each animal. This however may not always be possible and can be difficult when in the field (Altmann, 1974). For Shanto and Loki this was comparatively easy as Shanto, being the only fully developed adult male, had a developed mane. Loki was distinguishable from his sisters as he was old enough to have begun growing a mane. It was however still golden brown and very short compared to a fully grown male's dark brown or black mane which covers the neck and chest areas.

Image 4: The adult male, Shanto, with his full adult mane visible.

Image 5: The juvenile male, Loki, with the start of his mane growing.

The females were more difficult to discern from each other. The older sisters, Gita and Gira, and younger sisters, Arya and Amira, were distinguishable as Gita and Gira were fully grown while Arya and Amira were still sub adults and were noticeably smaller than their mother and aunt. The younger pair also still had some of their cub markings remaining on the back of their hind legs.

It was possible to tell Gita and Gira apart by some physical signs. Gira's muzzle was more scarred than Gita's and Gira also had a scar on her right shoulder just below the scapula. While this made it possible to tell them apart, it was sometimes difficult to tell who an animal was from a distance even when using binoculars.

Image 6: Gita.

Image 7: Gira.

Telling Arya and Amira apart from each other was the most difficult comparison. Arya has a very small notch on one of her ears however it is very difficult to see and is only useful when one of them is very close. At any distance it becomes almost impossible to tell the two sisters apart. This makes sampling the behaviour of the two younger females more difficult as identification is based more off a knowledge of their habits and behaviours and the understanding of the animals gained from spending time watching them.

Image 8: Arya.

Image 9: Amira.

Issues with Data Collection

Some problems which occurred during the duration of the study include missing out on data due to keeper's interacting and locking animals away. This was unavoidable as there was no strict schedule that the keepers were able to stick to. The jobs which needed to be done were carried out whenever they had a chance and so days could not be chosen to avoid keeper husbandry.

Other issues included the private tours which are carried out in the wildlife park. These tours consist of small groups being driven around by a staff member and being shown the exhibits from a keeper's point of view. When these tours came along the staff member would attract the animals by calling and throwing in small pieces of meat. This would disturb the animals and sometimes occurred during sampling times.

When collecting data for visitor numbers there is a limited view around the edge of the enclosure and depending where the sample is taken from a full head count may not be possible. For this study all visitors that were visible were used when taking samples of visitor numbers.

Data Analysis

To analyse the collected data several methods were used. IBM SPSS Statistics 25 was used to test for normality of the data. All Shapiro-Wilk normality tests and histograms showed that the data was non-normal and so non-parametric tests were chosen to analyse the data.

To analyse question (a) and (b) the computer programme IBM SPSS Statistics 25 was used to produce Mann Whitney U Tests to examine and compare the relationships of behaviours of the adults against the juveniles. For question (b) the adult female's behaviour was averaged before being run through Mann Whitney U tests and run against the juvenile female's behaviour which was also averaged before being run through a Mann Whitney U test. Microsoft excel was used to produce pie charts looking at the percentages of behaviour displayed in focal samples. Behaviours were run both individually and as grouped behaviours. For both Mann Whitney U tests the standard deviation was used to describe variability.

Questions (c) and (d) were analysed using chi-square tests in IBM SPSS Statistics 25. The frequencies of each group of behaviours were run against the visitor levels and time of day

individually. Visitor levels were split into three categories, low, moderate and high. These were defined through the average number of visitors observed during a scan sample. If the average numbers were equal or less than two they were ranked as low. If they were greater than two but equal to or less than six they were ranked as moderate and any averages greater than six were ranked as high. Time of day was divided into morning, afternoon and evening. These were based on the three time blocks samples were taken within. All p-values for determining significance were taken from Field et al (2012) where different levels of significance are determined depending on the level of association found in a chi-square tests residuals. For residuals outside ±1.96 then the p-value < 0.05. Outside ±2.58 the p-value < 0.01 and outside of ±3.29 p-value < 0.001.

To analyse question (e) enclosure usage maps were made for each animal using Microsoft paint. As well as the maps an index of enclosure usage was calculated for each individual and overall using the Spread of Participation Index (SPI) (Plowman, 2003). The index has been used successfully in several studies on different species including Rothschild's giraffe, *Giraffa camelopardalis rothschildi,* and greater flamingo, *Phoenicopterus roseus,* to demonstrate the usage of animal's enclosures (Rose et al., 2018, Garry, 2012).

The equation is:

$$\mathrm{SPI} = \frac{\sum |f_{\mathrm{o}} - f_{\mathrm{e}}|}{2(N - f_{\mathrm{e\,min}})}$$

Where *f*o are the observed number of times an animal has been in a zone, *f*e is the expected number of times an animal is present in a zone which is calculated by assuming the total number of observations is evenly spread across all zones of the enclosure and therefore taking the expected value of each zone as a fraction of the total observations equal to the ratio of the zone area to total enclosure area. N refers to the total number of observations across all zones and *f*e min is the expected frequency of the smallest zone (Plowman, 2003). This produces a value between 0 and 1. The closer to one the value produced the more even the usage of the zones within the enclosure (Plowman, 2003).

To use the SPI formula the enclosure had to be divided up into several uneven zones (Plowman, 2003). See appendix item three. Zone six was never used during calculations as the animals never had access to this area of the enclosure during the duration of the study.

(WC: 2590)

Results

Before analysing results we can see from figures 2 and 3 that 83.587% of focal behaviour recorded was inactive behaviour. It can also be seen from figures 2 and 3 that of the time spent on all other behaviours walking seems to have the most time spent (5.461%) on it after the inactive behaviours. Other common behaviours witnessed were grooming, both allogrooming (1.142%) and autogrooming (1.979%). From ad libitum data grooming was seen during every day of observations and seemed to form an integral part of the pride's social behaviours.

Some behaviours may be under-represented in the data as event style behaviours may have been carried out during periods where observations on other animals were taking place. For example, Shanto was seen to regularly scent mark and vocalise during the afternoon and evenings. This was recorded as ad libitum data.

With regards to abnormal behaviour very little was witnessed. The only stereotypic behaviour recorded was pacing. From ad libitum observations the younger females and Amira in particular was the most prone to pacing with Shanto being the least prone.

Other behaviours of note during ad libitum observations were aggressive behaviours. For the most part aggressiveness revolved around the acquisition of food. Whenever the pride was fed Shanto would monopolise the food given, chasing away any of the other lion's that tried to take food. After settling and starting to eat only then would Shanto allow the others to feed. Other instances of aggressiveness were witnessed when one individual tried gaining the attention of another who wasn't interested. This was seen when Shanto tried mounting the adult females on several occasions and was rejected. Aggression was displayed through vocalisations and physical swipes towards each other. Shanto also occasionally told off Loki or the juvenile females for trying to initiate play. This would come in the form of a swipe or a

yowl that told them to stop. Once when Loki refused to give up Shanto cornered him and swiped at him while vocalising loudly. Loki displayed submission immediately by rolling onto his back and showing his belly. While doing this though he still pushed at Shanto using his forelegs showing a lack of complete submission

Play was not always ignored however, the three juveniles remained close to each other and were almost always willing to play together. The females were also willing to get involved in play behaviour including mock fighting and stalking and pouncing on one another. Shanto didn't always avoid playing and occasionally show submission to the cubs. Loki once stalked and pounced on Shanto, who immediately collapsed to the ground and rolled to play with Loki. On other occasions Arya and Amira showed hunting technique in play by going for Shanto's haunches. Shanto didn't tell of the females and instead allowed them to practice taking down prey on him.

(a) <u>Does Shanto's (adult male) behaviour differ from Loki's (juvenile male)?</u>

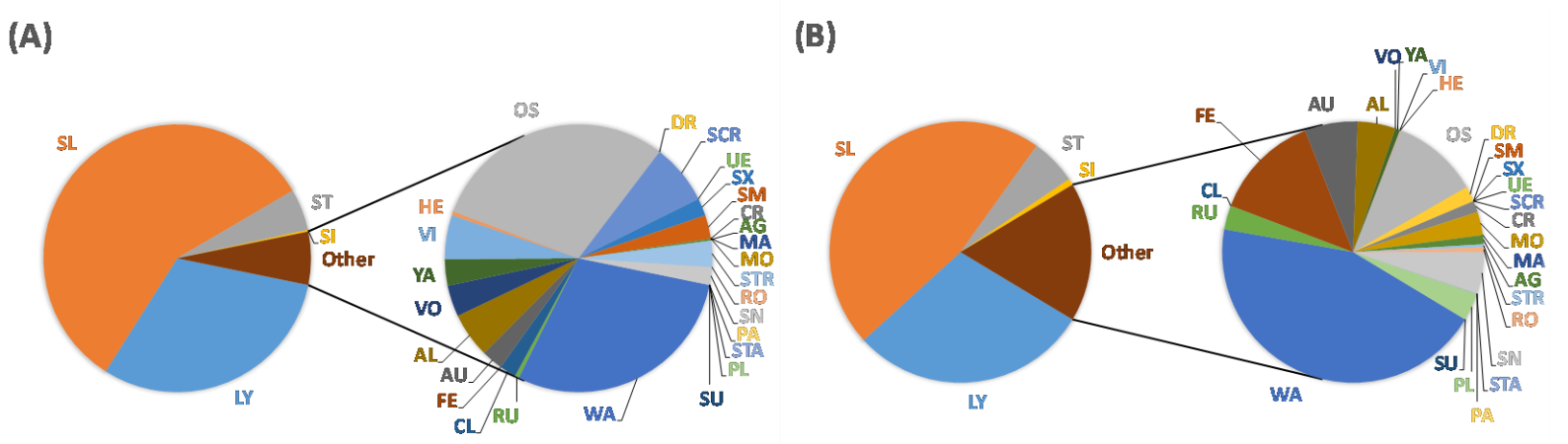

Figure 2: The averaged percentages of overall time spent on behaviours for the adult and juvenile male lions for all focal samples taken of the two lions. Chart (A) displays the average time spent on behaviours by Shanto. Chart (B) displays the average time spent on behaviours by Loki. In each chart the pie on the left displays the percentage of inactive behaviours. The pie chart on the right displays the percentages of active, social, feeding and other behaviours without inactive behaviours.

From figure 2 it can be seen that both Shanto and Loki spent a high amount of time on inactive behaviours with 93.962% and 83.936% of their time respectively. From the rest of their behaviours the most seen trends are walking (1.871%) and being out of sight (1.901%) for Shanto. Loki's other most common behaviours are walking (7.622%) and feeding (2.289%).

When running the Mann Whitney U tests of the focal scans some significant results were found. The data that were run were for all times of day together. Changes in behaviour over

time were not considered when comparing individuals to each other. For the Mann Whitney of individual behaviours three behaviours were found to have significant p-values. Cheek rubbing (U=44.00, p=0.025, median=0.0000, ±SD=0.26466), climbing (U=52.00, p=0.049, median=0.000, ±SD=0.31724) and playing (U=44.00, p=.0.25, median=0.0000, ±SD=0.68094) all showed significant results. This shows us that Loki (mean=14.62) spent more time cheek rubbing than Shanto (mean=10.00), Shanto (mean=14.27) spends more time climbing than Loki (mean=11.00) and Loki (mean=14.62) spends more time playing than Shanto (mean=10.00). Running the grouped behaviours through Mann Whitney U test revealed no significant differences.

(b) <u>Do Gita and Gira's (adult females) behaviour differ from Arya and Amira's (juvenile females)?</u>

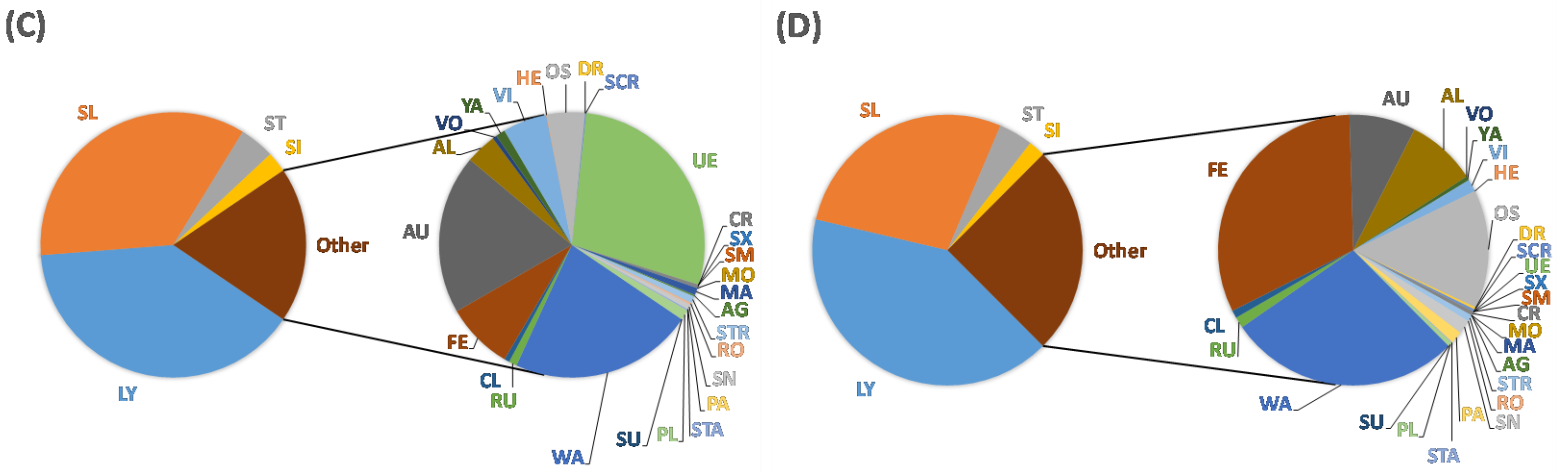

Figure 3: The averaged percentages of overall time spent on behaviours for the adult and juvenile female lions for all focal samples taken of the four lions. Chart (A) displays the average time spent on behaviours by Gita and Gira. Chart (B) displays the average time spent on behaviours by Arya and Amira. In each chart the pie on the left displays the percentage of inactive behaviours. The pie chart on the right displays the percentages of active, social, feeding and other behaviours without inactive behaviours.

From figure 3 both adult females and juvenile females show that the most seen behaviours are inactive with adult females spending 84.870% of time on inactive behaviours and juvenile females spending 77.144% of time on inactive behaviours. Other than inactive behaviours the adult females also spent much of their time on using enrichment (5.333%), walking (4.245%) and autogrooming (3.685%). The juvenile females were seen spending the most time on feeding (8.000%), walking (6.974%) and being out of sight (3.542%).

The Mann Whitney U tests performed on the data for the adult females against the juvenile females revealed no significant figures. Neither the individual behaviour tests nor grouped behaviour tests revealed any significant p-values.

(c) Do visitor numbers affect the behaviour of the animals?

In general from ad libitum observations it could be considered that apart from some specific events visitors may not have any effect on the behaviour of the lions. For the most part the animals seemed to ignore or be oblivious of the noise and stimulus from visitors. It was only under very specific circumstances where responses were witnessed. Upon one occasion Shanto became very aggressive towards two visitors taunting him and banging on the glass of the viewing platform. He reared onto his hind legs pawing at the glass bared his teeth while audibly growling. This was an extreme case of an interaction as most visitors did not display such behaviours.

Table 3: Contingency table displaying results from a chi-square test running animal behaviour collected from scan sampling against visitor number showing frequencies and residuals for grouped behaviours. Significant results are highlighted in bold and marked by an asterisk.

	Behaviour					
Visitor Number	Inactive	Active	Social	Feeding	Other	Total Frequency
Low	1322	66	69	52	471	1980
	***-2.4**	***-4.8**	***2.9**	-0.8	***7**	
Moderate	1067	93	18	21	121	1320
	***4.1**	1.6	***-2.5**	***-2.9**	***-7.1**	
High	626	93	17	51	137	924
	-1.3	***5.1**	-1.2	***4.6**	-1.8	

The chi square test run comparing behaviour to visitor numbers shows ten significant results. The test ran with a degree of freedom equal to 8, a Pearson Chi-Square ratio of 224.018 and an overall p-value < 0.001. The positive results indicate positive associations between visitor numbers and behaviours that were seen when that level of visitor numbers were present. Negative values indicate a negative association of behaviour to visitor numbers when that level of visitor numbers were present. That is to say low visitor numbers decreased the level of inactive behaviours ($z=-2.4$; $p<0.05$) and the level of active behaviours ($z=-4.8$; $p<0.001$). Low visitor numbers also increased the prevalence of social behaviour ($z=2.9$; $p<0.01$) and other behaviours ($z=7$; $p<0.001$).

In comparison moderate visitor levels increased the levels of inactive ($z=4.1$; $p<0.001$) while decreasing the visible levels of social behaviours ($z=-2.5$; $p<0.05$), feeding behaviours ($z=-2.9$; $p<0.01$) and other behaviours ($z=-7.1$; $p<0.001$).

High visitor levels only affected two groups of behaviour. High visitor numbers increased the prevalence of both active behaviours ($z=5.1$; $p<0.001$) and feeding behaviours ($z=4.6$; $p<0.001$).

(d) Does time of day affect the behaviour of the animals?

From ad libitum observations the time of day did seem to play a part in the level of activity displayed by the lions. All six lions seemed to spend the majority of their time in the morning lying down or sleeping. In the afternoon and evening the pride seemed to display more movement and a wider variety of behaviours.

Table 4: Contingency table displaying results from a chi-square test running animal behaviour from scan sampling against time of day showing frequencies and residuals for grouped behaviours. Significant results are highlighted in bold and marked by an asterisk.

	Behaviour					
Time Of Day	Inactive	Active	Social	Feeding	Other	Total Frequency
Morning	1090	51	39	0	272	1452
	1.7	***-3.8**	0.5	***-6.5**	1.4	
Afternoon	973	107	26	85	261	1452
	***-2**	***2.2**	-1.6	***6.5**	0.7	
Evening	952	94	39	39	196	1320
	0.3	1.7	1.1	0	***-2.1**	

When comparing the time of day against behaviour a chi-square test produced six significant results. The test ran with a degree of freedom equal to 8, a Pearson Chi-Square ratio of 124.860 and an overall p-value < 0.001. Positive values in table 4 indicate positive associations between the time of day and behaviours while negative values show negative associations between time of day and behaviours.

We can see from table 4 that active behaviours ($z=-3.8$; $p<0.001$) were seen less during the morning.

In the afternoon inactive behaviours ($z=-2$; $p<0.05$) decreased while active ($z=2.2$; $p<0.05$) and feeding behaviours ($z=6.5$; $p<0.001$) were seen more.

In the evening other behaviours ($z=-2.1$; $p<0.05$) were witnessed less frequently.

(e) How do the animals use their enclosure?

Table 5: Spread of Participation Indexes for each individual lion and for the enclosure usage as a pride.

	Shanto	Loki	Gira	Gita	Arya	Amira	Totals
SPI values	0.3287546	0.3050739	0.355063	0.3360071	0.3070937	0.288323	0.2990988

Table 5 displays the calculated SPI values of each individual animal and the pride as a whole. The closer the value is to one the more even the animal's usage of the enclosure. The values show all of the lions use their enclosure in a very uneven way. The index results (see Table 5) show Amira uses the enclosure in the most uneven way while Gira has the most even spread of enclosure usage.

This is backed up by the enclosure usage maps in figure 4. The maps show the spread of observations to be very uneven across the zones assigned. Zones one, three and five are used significantly more than zones two and four. There are no obvious differences between enclosure uses when looking at use across different times of day.

Comparing figure 4(A) to 4(B), (C), (D), (E) and (F) shows us that Shanto makes considerably less use of zone 1 of the enclosure compared to the other five lions. All six lions spend a large proportion of their time within zone 1 where the heated raised rock is. All individuals also spent a large amount of time indoors within zone 5.

From figure 4(A) Shanto spends the majority of the time on the raised rock in zone three. He seems to spend more time there in the morning and evening than in the afternoon. For zone one most of the observations where Shanto was witnessed within the zone were during the afternoon and evening. Shanto's time indoors, zone five, was all during the morning and afternoon. One recorded instance of him being in the indoor yard during the evening is shown on figure 4(A).

Similarly to the others in the pride Loki spent the majority of his time in zones one, three and five as can be seen from figure 4(B). The majority of his time seems to have been spent in zone one and there are no obvious differences for time of day spent there. For zones three

and five the majority of the time spent in them was during the morning while the time spent in each zone during afternoon and evening seems to be very even.

From figure 4(C) Gira is seen to spend most of her time in zone three on the raised rock. It seems most of her time here is in the morning, second most in the evening and third in the afternoon. Next most used zone is zone one with seemingly even usage across the three times of day. Zone five is used approximately twice as much in the morning than either the afternoon or evening.

For Gita usage between zones one and three looks to be close to equal, see figure 4(D). In zone one, usage across the day seems equal while usage in zone three is more imbalanced with more time spent in zone three during the morning than afternoon or evening. Time spent indoors in zone five is equal during morning and afternoon with less time spent indoors in the evening.

As we see from figure 4(E) Arya seems to spend most of her time in zone one. There seems to be a slightly higher number of samples taken of her in zone one during the afternoon than morning or evening. Usage for zones three and five look equal with both zones having her present predominantly in the morning and less so in the afternoon and evening.

Amira's zone usage is very similar to that of Arya, see figure 4(F). Zone one is the most used zone with zone three and five having equal usage. For Amira her usage of zone one is equal across time periods. In zone three usage during the morning and evening are equal but both times have higher usage than the afternoon. Zone five has very high usage in the afternoon compared to the morning or evening where the usage is equal.

(WC: 2223)

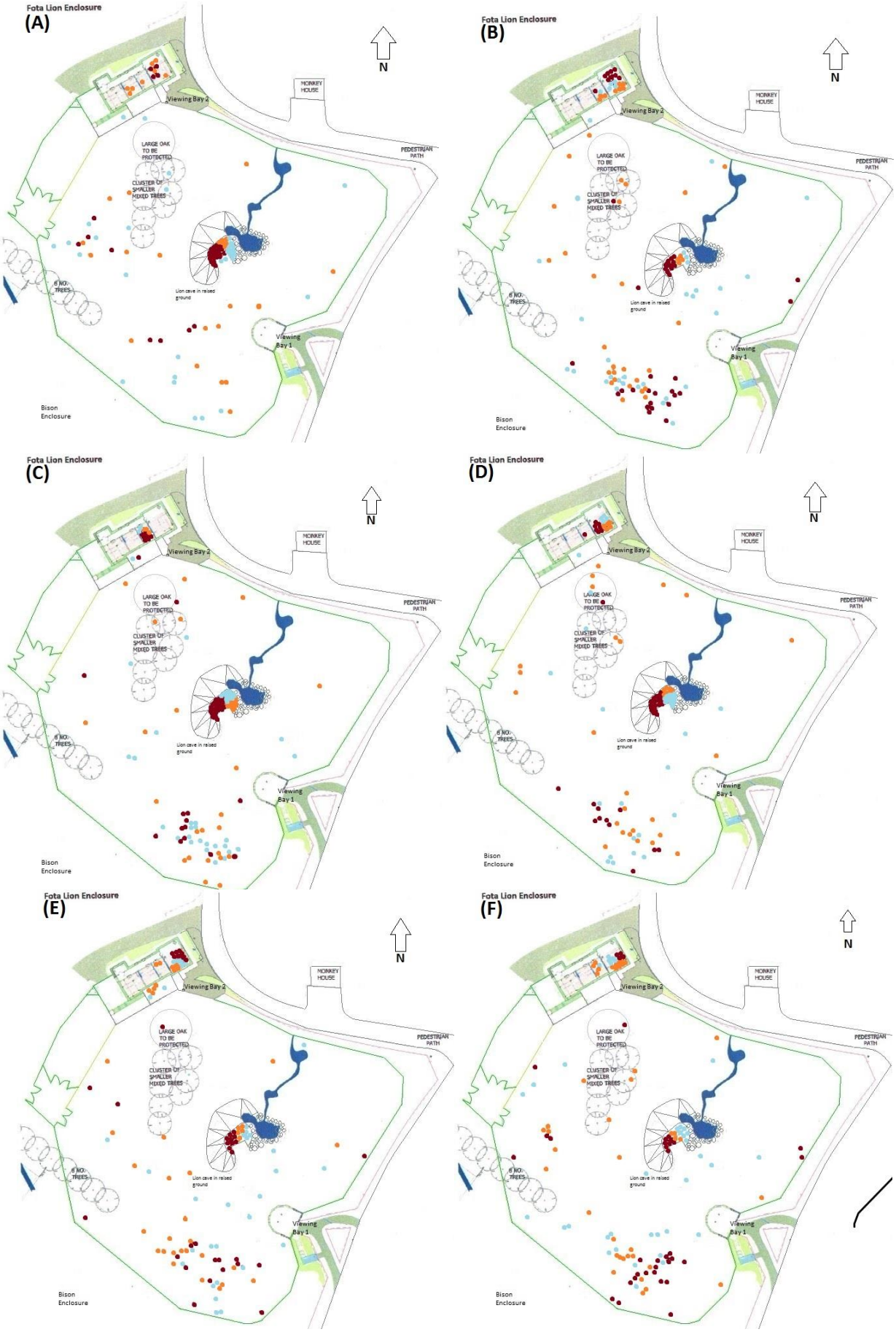

Figure 4: Enclosure usage maps for each individual animal. (A) Shanto. (B) Loki. (C) Gira. (D) Gita. (E) Arya. (F) Amira. Legend: Scarlet: Morning. Orange: Afternoon. Light blue: Evening.

Discussion

From the results it can be concluded that Shanto's pride exhibits strong indications of good welfare. All thirty one behaviours on the ethogram, see Table 2, were recorded during sampling at least once. A wide variety of behaviours has been used as an indicator of good welfare for many years (Broom, 1991). With regards to overall behaviour the pride displays inactive behaviours for a high percentage of their time observed. This can be considered normal as it has been shown that lions both in the wild and in captivity can spend up to twenty hours a day inactive (Young, 2003).

When analysing how the male's behaviour differs from each other only three behaviours showed any significant difference. Cheek rubbing, climbing and playing were the only behaviours to show any significant difference. Many species use social cues as a way of greeting other conspecifics. Different species use different behaviours such as an olfactory inspection in spotted hyenas, *Crocutta crocutta*, or cheek rubbing in lions (Kirk & Wascher, 2018). The result of Loki spending more time cheek rubbing than Shanto may indicate that he spends more time socialising with the other members of the pride than Shanto. It has been shown that adult male lions spend less time cheek rubbing with other individuals of the pride and display more independence from the pride than any other member (Joslin, 1973). With regards to climbing, the difference seen between Shanto and Loki may be due to Shanto having a preference to spending time on top of the raised rock in the enclosure. With the time spent climbing up and down from the rock this may be the reason as to why a significant difference is seen between Loki and Shanto's behaviour. Finally a significant difference is seen in the time the two males spend playing. While Shanto was seen to play with the cubs, Loki spent considerably more time playing as he would also play with his sisters daily. With Loki still being quite young it is expected to see him playing more than an adult male would. Something for future research to focus on would be the changing behaviour as the play fighting between males becomes more serious. Aggression was witnessed between the two males very little but as Loki grows older the play behaviour will gradually become more rough and aggressive as Loki begins challenging Shanto for dominance. This behaviour in the wild leads to sub-adult male lions being forced out of the pride by their fathers as they reach adulthood (Kirk & Wascher, 2018). Although Loki is still young and does not seem to display behaviours challenging Shanto for leadership being a male he will eventually have to be

removed from the pride to prevent conflicts and the best measure for when to do this will be the level of aggression witnessed.

For comparing the female's behaviour between adults and juveniles there is no visible results that show any significant difference. This may be because females mature faster than males or perhaps males and females develop in the same way up until maturity at which point they develop different trends of behaviour. The second hypothesis would make more sense as adult males take on different responsibilities than adult females by defending the pride from external males. To fully understand the possibility of this divergence of behaviour further studies would be required. What can be said about the females is that from ad libitum data they spend a lot of time on allogrooming. Allogrooming plays a key role in social groups of animals to ensure the bonds between individuals stay strong (Kirk & Wascher, 2018). Sociality within lions seems to provide a pride as a unit with a variety of advantages. Improving the levels of defence for both males, females and cubs from invading parties. Improving the chances of hunting success and overall wellbeing of the pride. Females also seem to reproduce more easily in a larger pride where there are more females to spread the load of maintaining the health and structure of the pride. This reduces the stress on individual females and allowing more individuals to have successful pregnancies (Mosser & Packer, 2009). Therefore maintaining the bonds within a group plays a key role in the survival and expansion of the pride.

When looking at how visitor numbers affect the lions there are changes in behaviour witnessed with changing visitor numbers. Visitor's behaviour varied depending on each group. From observing how visitors behaved towards the lions there was a mixture of positive and negative behaviours ranging from individuals banging on the glass and shouting to try and elicit a response from the lions to individuals being quiet and talking in hushed tones to avoid attracting attention. The visitor's had very little visible effects on the lions apart from several incidents including lions being woken up because of visitors banging on the glass and the episode of aggression from Shanto already described. The chi-square test showed a variety of significant results displaying how visitor numbers can cause increases and decreases to the lion's behaviour. From the results it seems social behaviours are more prevalent when visitor numbers are low. The lions spent less time inactive and active and more time on social behaviours. Looking at whether visitor numbers has an effect on the sociality of the pride is a

topic of research for the future and may help understand if being viewed in captivity can have an effect on the strength of the bonds within a captive population; therefore having a detriment on welfare of the group. This may be important in the context of introducing animals to the group. Introductions and the movement of animals is a key part of captive breeding programmes and it is important to have an understanding of the factors that can make introductions a success or failure. What this study does not examine is the impact to the welfare of the animals which visitor levels have. This is an area of research that could be looked at in the future to see if changes in the enclosure design are necessary for preventing negative effects to the lion's welfare.

When looking at the effect the time of day has on the behaviour of the lion's, ad libitum data would suggest there is a difference. This is then backed up by the chi-square test run on the grouped scan samples. From both ad libitum data and the chi-square results active behaviours were witnessed less frequently during the morning. As lions are generally nocturnal or crepuscular animals this is to be expected. However it has been shown that captivity can disrupt and change the natural rhythms of a species circadian system (Gattermann et al., 2008). This may be the case here as the pride gradually seemed to become more active throughout the day, displaying a wider variety of behaviours during the afternoon and early evening before becoming less active again towards the late evening. An example of this was witnessed through the ad libitum observations of Shanto's vocalisations and scent marking in the afternoon and evening. These behaviours are recognised as displays of territoriality in male lions. Displaying dominance through these behaviours is a recognised method of male lions for claiming and maintaining territories (Mosser & Packer, 2009).

From the results, zones one, three and five of the enclosure are the most used. The usage of zone one is most likely due to the proximity of the European bison's, *Bison bonasus*, overnight pen to the South-West of the lion's enclosure. From ad libitum data we see the lions are stimulated by the movements of the bison in and out of their overnight pen. The interest caused by the lion's natural hunting instincts results in them spending significant time within zone one. This interest is the only catalyst which seemed to trigger stereotypical behaviours. The only stereotypic behaviour witnessed was pacing, which is recognised as the most common stereotype amongst felid species (Mason et al., 2007). The inability of the lion's to interact with and hunt the bison seemed to trigger the pacing behaviours that were

witnessed. While it is a minor percentage of the witnessed behaviour and is not significant enough to cause immediate concern it may be worthwhile to try and improve and prevent the pacing behaviour. This may be possible by blocking the view of the bison's enclosure for the lions using screens, thereby removing the catalyst of the pacing. Otherwise it may be possible to make use of the interest triggered by the bison to increase activity levels of the lions. When hunting instincts are triggered by the bison giving them an outlet to use them on within the enclosure may be a new form of enrichment. This could be achieved by using a zip line chase system to provide the lion's with moving prey. A similar system is already being used successfully by Fota Wildlife Park for their captive cheetah, *Acinonyx jubatus*, population. Otherwise introducing enrichment items or food over the fence, as is currently being done, at times when bison are being left in and out may provide a distraction for the lions and prevent pacing.

Zone three contains the heated raised rock which provides an explanation as to why all members of the pride frequent this zone. In cold weather having an area that would provide warmth for such an inactive species would create a draw that would result in large proportion of their time being spent their. This we can see from figure 4. Similarly zone five is the indoor enclosure and provides areas of shelter for the lions. The indoor enclosure also contained straw beds to give the lions somewhere comfortable to rest and from ad libitum data most of the time spent indoors lying down was spent on these beds. Zones two and four may be unused due to a lack of stimulus. Neither zone contains any features that provide something of interest to the lions. Both zones are predominantly large areas of grass with some foliage.

Overall the analysis conducted on the pride is encouraging. The ability of the pride to reproduce is a testament to the hard work conducted by the staff of Fota Wildlife Park to ensure the welfare and proper management of the species. Understanding their behaviour is key to ensure their continued breeding success. This is of great importance as the pride play a key role in the European Endangered Species Programme for Asiatic lions. This programme ensures a captive population of lions survives in captivity in case of extinction of the wild population. The responsibility lies with every collection taking part in the programme to properly manage and understand what it takes to ensure their animals are at the peak of health. By understanding the behaviour of animals we will be able to make concerted conservation efforts to preserve animals both *in situ* and *ex situ*.

Preserving the remaining populations of all animal species worldwide is becoming more and more of a priority with the continuing expansion of human influences. The destruction caused by humanity as a whole is being tempered by a small percentage of the worldwide population putting large amounts of effort towards conservation and modification of human understanding and education. To fully understand how to change the current way things are worldwide multiple areas of study must come together to increase our understanding of our planet and how to find an appropriate balance between nature and humanity.

(WC: 1907)

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(WC: 189)

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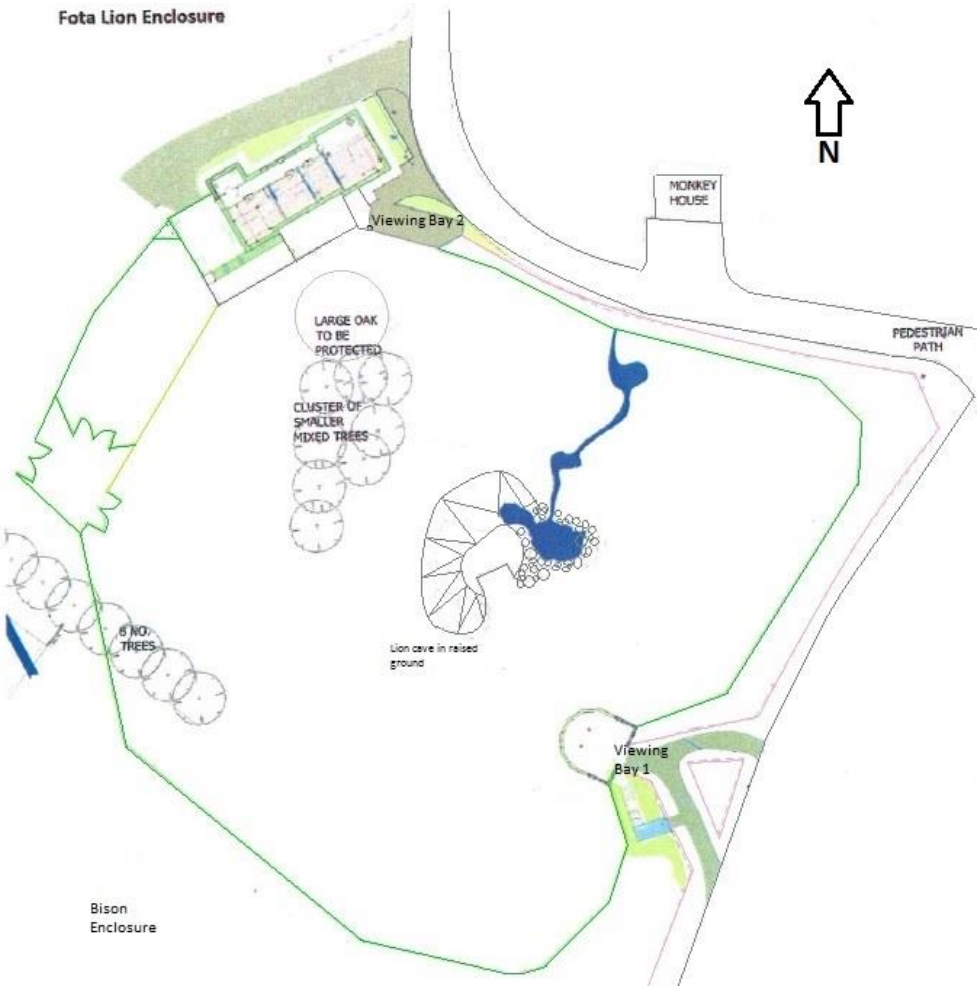
(WC: 713)

Appendix

Appendix 1: A1: An overhead map of the lion's enclosure with an arrow indicating orientation.

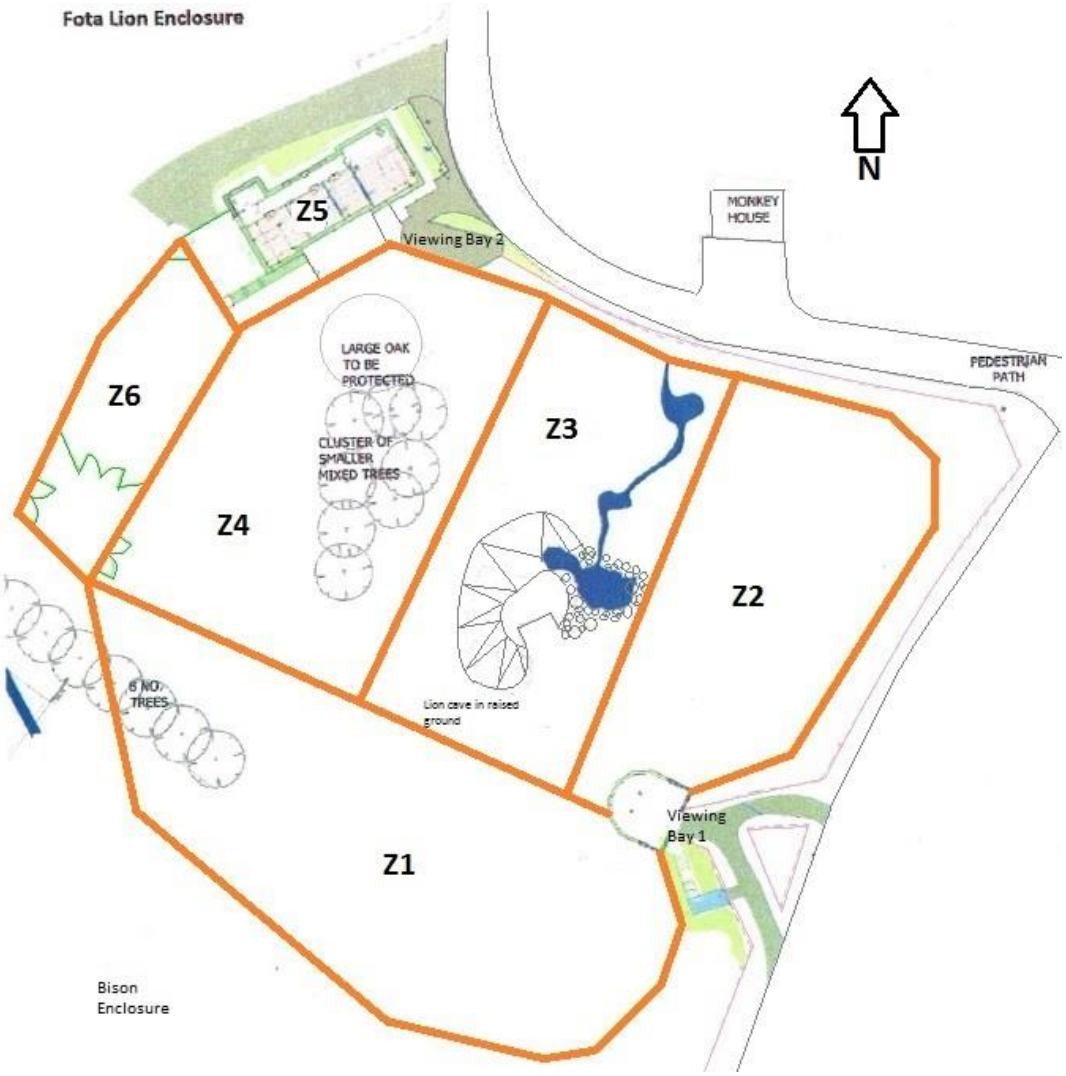


Appendix 2: A2: Sheet used when collecting scan sample data including table for headcount of visitor numbers.

Time:												
Behaviour	Code	00:00	02:00	04:00	06:00	08:00	10:00	12:00	14:00	16:00	18:00	20:00
Lying down	LY											
Sleeping	SL											
Standing	ST											
Sitting	SI											
Walking	WA											
Running	RU											
Climbing	CL											
Feeding	FE											
Autogrooming	AU											
Allogrooming	AL											
Vocalisation	VO											
Yawning	YA											
Vigilance	VI											
Headshake	HE											
Out Of Sight	OS											
Drinking	DR											
Scratching	SC											
Use of Enrichment	UE											
Sexual Inspection	SX											
Scent Marking	SM											
Cheek Rubbing	CR											
Mounting	MO											
Mating	MA											
Aggression	AG											
Stretching	STR											
Rolling	RO											
Sniffing	SN											
Pacing	PA											
Stalking	STA											
Playing	PL											
Suckling	SU											

Minute of scan	Number of Visitors
01:00	
03:00	
05:00	
07:00	
09:00	
11:00	
13:00	
15:00	
17:00	
19:00	

Appendix 3: A3: Overhead map of the lion's enclosure showing zones one to six used for Spread of Participation Index.



(Total WC: 10771)