



The invisible cat – time budget in lynx in two large Swedish zoos

Den osynliga katten – tidsbudget hos lo i två stora svenska djurparker

Ulrica Ahlrot

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(Photo Ahlrot, 2014)

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ZOOS**

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Studentarbete 564, Skara 2014

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“I would like to dedicate this work to the memory of my mother who was my biggest supporter when I chose to study ethology. I wish you could have been with me to the finish line.”

ABSTRACT

Felids are solitary crepuscular animals, many of them with large home ranges. Due to the expansion of humanity many of them are also endangered and part of conservation programs. To manage felids in captivity with optimal welfare presents several problems. Stereotypic behaviours are frequent and breeding successes falter.

Even though much work already is done to enrich and improve the life of felids in captivity more research is needed to find possible causes to decline in welfare. Coordinated studies of various species of felids in multiple zoos using the same methodology are scarce.

This study is a part of the first such coordinated study of several felids in Sweden and the aim of the study was to research the time budget and activity pattern of the Eurasian lynx in two Swedish zoos. In order to find out if the lynx keeps a natural activity pattern in captivity or has adapted to the zoo's time-line the aim of the study was to address the following questions;

How active or passive are the lynx in captivity? How much are they seen by the visitors? Does stereotypic pacing occur and if so, is the behaviour an indication of decreased animal welfare? Are there any differences between Borås Zoo and Nordens Ark in these aspects? And if there are any differences, in what way are they expressed and why?

During day-time the most common registration of the lynxes in total was out of sight as was also the most common registration of the lynxes in Borås Zoo. At Nordens Ark the lynx were laying or sleeping almost 40% of the time. Research has shown that felids in captivity lower their activity level when visitors are present. Whether the passivity was an expression of natural day-time behaviour or because of decreased welfare could not be determined in this study. The lynx at Nordens Ark are both more active and more visible than the lynx in Borås Zoo. The level of activity varied greatly between the individuals (15, 35, 43, 53 and 80 % respectively) but all animals show a drop in activity during midday.

Stereotypic pacing differed among the animals. It was more common in males and in Borås Zoo but the variation over time is very much alike in the two most frequently pacing animals although they are from different zoos. There is no detectable pattern in the stereotypic pacing by those individuals and further research is needed to find the cause to the behaviour, the best way to counter it and to assure optimal welfare.

INTRODUCTION

We know little about the lynx time budget and level of activity in zoos or if there is a high incidence of different stereotypic behaviours. There are much research done on stereotypic behaviours on the other hand but still we are not sure about all factors that cause stereotypes to develop? How does different environment and management affect the welfare of the animals? Can different environment result in a variance of stereotypic behaviours? This is the first time a systematic study with the same methodology over several species of felids is done in the same time in three different Swedish zoos. It is a foundation to better understanding and knowledge of the factors that impact the welfare of felids in captivity.

LYNX IN THE WILD

STATUS

The Eurasian lynx (*Lynx lynx*) is listed in IUCN Red list (2013.2) as least concern due to being widely spread as a species although some subspecies and local populations, especially in Western Europe, are gravely at risk. The lynx is listed in CITES appendix II (2013) and protected in most countries except Russia and China (IUCN Red list, 2013.2). In Sweden the lynx is listed as near threatened in The Swedish Species Information Centre's red list (ArtDatabanken, 2014) and the population is protected but managed by licensed hunting (Linnell *et al.*, 2001; Naturvårdsverket, 2013).

ECOLOGY

The Eurasian lynx is one of Sweden's four native big predators (Bostedt & Grahn, 2008). It is spread over a wide range of Europe and Asia, from Norway in the west to north-eastern Siberia and down to Himalaya in the south and scattered in small populations in several European countries (IUCN Red list, 2013.2). The size, colour and pattern of the fur as well as the behaviour vary with where the lynx lives (Sunquist & Sunquist, 2002). It inhabits forested and/or mountainous areas but the type of forest and use of habitat differs greatly and it seems to be very adjustable (Sunquist & Sunquist, 2002).

TIME BUDGET AND ETHOLOGY

The lynx is crepuscular, i.e. most active during dusk and dawn, but move around periodically all night (Podolski *et al.*, 2013). They spend most of the day sleeping in cover but can change the activity pattern during periods of scarce food or when they are raising kittens (Schmidt, 1999). Schmidt (1999) found that the activity level dropped when the lynx has killed a large prey and then gradually increases over the next three or four days. Podolski *et al.* (2013) on the other hand did not find any difference in the level of activity depending on whether the lynx had killed or not. The lynx movements are not affected by cold or rainfall but during heavy rain and high temperatures the activity is minimal (Schmidt, 1999; Podolski *et al.*, 2013).

They usually prey on small to medium sized ungulates and hares (Sunquist & Sunquist, 2002) but are able to kill considerable bigger animals, in Sweden their main prey are roe deer and semi-domesticated reindeer (Linnell *et al.*, 2001).

As most felids the lynx are solitary animals. Although their home ranges may overlap they tend to avoid each other and alternate the use of the space (Schmidt *et al.*, 1997). Home range sizes vary from 20 square kilometres up to 2000 (Sunquist & Sunquist, 2002). In Scandinavia the home range sizes are far more larger than those found in continental Europe or for the similar species Canadian lynx and are in fact among the largest home range sizes reported for any felid (Linnell *et al.*, 2001). The density of lynx is usually low and most typically males occupy larger areas with one or more female home ranges within or overlapping his area (Breitenmoser-Würsten *et al.*, 2007). The habitat preferred has high complexity and low visibility with trees, bushes, fallen logs and rocks used for stalking prey and safe cover during the day (Podgórski *et al.*, 2008).

LYNX IN ZOOS

Today there are 12 zoos in Sweden, Norway and Finland that are holding Eurasian lynx and are part of the SDF conservation program (Svenska djurparksföreningen, 2014). In the European Endangered species Programmes of EAZA (European Association of Zoos and Aquaria) there were a total of 277 Eurasian lynxes reported in December 2008 (Versteegen, 2010). As a comparison there were 115 Amur leopards (*Panthera pardus orientalis*), 277 Amur tigers (*Panthera tigris altaica*), 303 cheetahs (*Acinonyx jubatus jubatus*) and 116 Pallas' cats (*Otocolobus manul*) listed in the same report (Versteegen, 2010). This study of the Eurasian lynx is together with these other four felid species part of an overall research project.

PROBLEMS HOLDING FELIDS IN CAPTURE

With rapid decline of species and loss of habitats all over the world conservation in captivity is important. But with many species, among them the felids, it is often hard to maintain a good animal welfare and reproduction success (Clubb & Mason, 2007). Being kept in a safe environment with no hazards and no obligation to hunt for food or protect territory also increases the risk of losing important natural behaviours needed if these animals sometime in the future are going to be released in to the wild again (Mason *et al.*, 2007).

An altered pattern of activity can make a captive animal more vulnerable when released in the wild (Resende *et al.*, 2014). A reduced level of activity during day-time is normal to most felids (Sunquist & Sunquist, 2002) but inactivity or excessive sleep can also be expressions of stress and indicate a reduced welfare (McPhee & Carlstead, 2010).

Space and enclosure complexity are important issues for maintaining welfare in captive felids. For many species the ability to hide and retreat from both humans and conspecifics is highly important for their well-being and ability to cope with different stressors (Morgan & Tromborg, 2007). They also often prefer resting places that are easily defended (Morgan & Tromborg, 2007) and common in many species of cats is that they often prefer an elevated resting place with an overview (Wooster, 1997).

Most felids are solitary animals with a crepuscular activity pattern and large home ranges where they patrol and hunt for long distances every night. Poorly adapted holdings and social structures can make the animals passive, bored or frustrated and stressed with repetitive abnormal behaviours or stereotypic behaviours as a result (Clubb & Mason, 2007; Morgan & Tromborg, 2007).

The term stereotype is used to describe a repeated unvarying behaviour with no obvious function induced by frustration, attempts to cope with a situation or dysfunction in the central nerve system (Mason *et al.*, 2007). If the cause to the behaviour is unknown or the behavioural pattern vary in some degree the wider term abnormal repetitive behaviour (ARB) can be used instead (Mason *et al.*, 2007).

The exact reasons why some animals perform stereotypes or ARBs are not altogether known but believed to be caused by either frustration or stress over not being able to control the current situation, unable to perform natural behaviours or being kept in to small space and barren environment among others or by changes in the central nerve system induced by said causes in an early stage of the animals life (Mason *et al.*, 2007; Morgan & Tromborg, 2007). Stereotypic behaviours are common in zoos but to estimate an overall amount is hard since few studies are done in a broad perspective with the same methodology (Mason *et al.*, 2007). Clubb & Mason (2007) compiled data from about 100 behavioural studies of 33 species of carnivores. They found that from a total of 940 animals 426 were registered performing stereotypic behaviours.

Feeding issues have been found to be the most important cause to stereotypes in herbivores (Bergeron *et al.*, 2006) and accordingly deprivation of the ability to stalk and hunt has been the most researched and probable cause to stereotypes in carnivores (Mason *et al.*, 2007; Morgan & Tromborg, 2007). The most common stereotype in carnivores is pacing (Clubb & Mason, 2003). Today much effort is done to increase welfare and reduce stereotypic behaviours with different types of enrichment and increased environmental complexity. Most of these efforts have been on food enrichment (Clubb & Mason, 2007).

PURPOSE

This study is part of an overall research project with coordinated studies of five felid species. The purpose with this research is to study time budget and behaviours in lynx in two Swedish zoos, Borås Zoo and Nordens Ark, as an initial study about felines in zoos and how to improve their welfare.

The questions this study will address are:

- ❖ How active or passive are the lynx in captivity?
- ❖ How much are they seen by the visitors?
- ❖ Does stereotypic pacing occur and if so, is the behaviour an indication of decreased animal welfare?
- ❖ Are there any differences between Borås Zoo and Nordens Ark in these aspects? If there are any differences, in what way are they expressed and why?

MATERIAL AND METHOD

As part of a systematic study of different felids in three large Swedish zoos this study was conducted over two weeks in April in two Swedish zoos, Borås Zoo and Nordens Ark, and included a total of five lynxes.

BORÅS ZOO

In Borås Zoo there were three animals studied. A female, Blanka, one adult male, Gustaf, and one sub-adult male, Spot. Blanka and Gustaf are both born in 2005 and have been at Borås Zoo from that year. Blanka was born in another Swedish zoo, Järvzoo, and Gustaf was found as an abandoned kitten in the wild. They are a part of EAZA and SDF conservation programs. Spot is born in Borås Zoo and is the only surviving kitten from 2013.

The female is held in two connected enclosures, in the map marked as 1 and 2 (Figure 1). The males are held together in enclosure 3. The enclosures are constituted by natural forest with trees, fallen logs and rocks. All enclosures have a manmade hutch or platform for resting. The back of the enclosures faces the outer fence of the zoo with forest and a small road a few meters away. The front end is the public area, marked with P. Enclosure 1 is withdrawn from the public a few meters. In the adjacent corners fronting the public of enclosure 2 and 3 is a public building with glass walls facing both enclosures, marked with P.

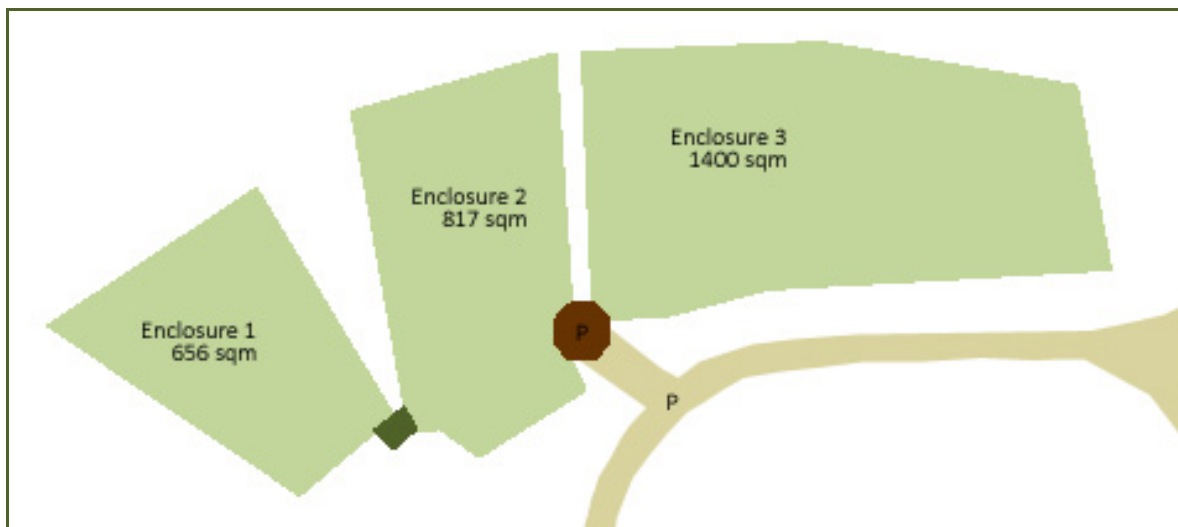


Figure 1. Outline of the lynx enclosures in Borås Zoo.

The lynx were fed in the afternoon every second day. In order to do a daily check the lynx were also offered small pieces of meat in the morning if they showed themselves and approached the keeper. Enrichment were presented on the non-feeding days in the form of prey (i.e. a piece of zebra hide) hanging in a tree, odour (i.e. faecal from ungulates) or forage enrichment (i.e. fish) thrown in the front end of the enclosures.

Visitors were present only the last of the six observation days as it was off-season and the zoo was open to public only during weekends.

NORDENS ARK

At Nordens Ark there were two lynxes, a female Dicksi and a male Synulox, both born in 2009. Dicksi is born wild, found as a kitten and has been at Nordens Ark since then. Synulox is born in the Swedish zoo Kolmården and came to Nordens Ark in 2011. They are listed in both EAZA's and SDF's lynx conservation programs and have been held together since the male's arrival at the zoo.

They were held together in two connected adjacent enclosures. The enclosures consist of natural forest and high cliffs with ledges and a small cave where they like to rest. They also have a manmade hutch. The back of the enclosures are facing forest and in the front is a road for the public and for the zoo keepers' vehicles.

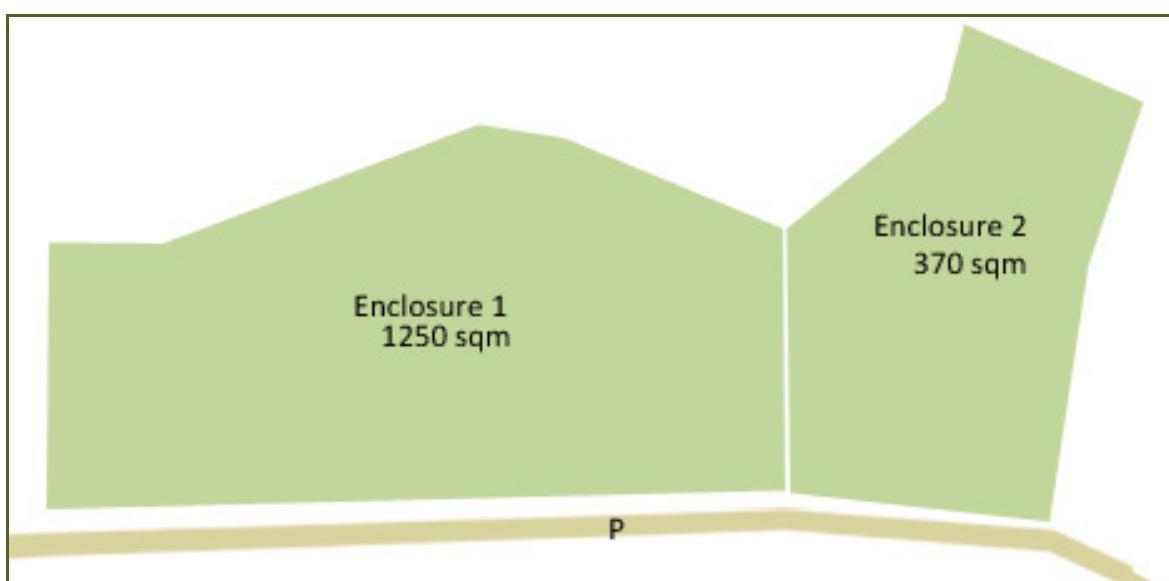


Figure 2. Outline of the lynx enclosures at Nordens Ark.

The lynx were feed every second day but the times varied. Food was presented in different ways each day (i.e. hidden in a box or tube of paperboard, hanged in a tree, spread out). Enrichment was presented on the non-feeding days in the form of odour, popsicles, minced meat, blood-trail, a piece of hide or some kind of new object. The only enrichment observed in the study was odour enrichment with cinnamon at one occasion.

As the zoo is open year round visitors were present all days during the study.

BEHAVIOURAL OBSERVATIONS

The method used was continuous registration with focal animal sampling with one individual per observation.

The observations were carried out between the times 8-9, 10-11, 12-13 and 14-15 each day for six days. Each observation lasted 60 minutes and the protocol was divided into 10-minute intervals. The observations were balanced between days and periods so each individual were observed three times in each time-period.

There were two different observers during this study, one in each zoo. All behaviours were recorded according to a previously determined ethogram defined by the research-team of the overall study of several felids (Table 1).

All the enclosures were exhibition enclosures and the animals were studied exclusively from the visitor areas but the observation spot varied with the lynx's location in the enclosure because it was not possible to overlook the whole enclosures from one spot.

Table 1. Ethogram over behaviours to register.

Behaviour	Definition
Running	Movement where in sequence no paw touches the ground, there is no obvious prey the individual is hunting. Trotting/galloping.
Walking	Movement where at least one paw touches the ground. Easy pace.
Jumping up or down	Movement in height.
Climbing	Movement where the cat distinctly uses paws/claws to move upward/downward.
Scent marking	Scratching, spraying, rolling or rubbing the cheek.
Stereotypic pacing	Walking/running the same track over and over again (more than two turns). If the individual stops and begins another behaviour for at least three seconds it will count as a new behaviour.
Eating	Intake of food with the mouth or using teeth to handle meat or tongue to lick e.g. egg.
Sniffing	Contact with nose against object or surface, not other individual.
Drinking	Intake of water with tongue.
Hunting	Persecution of individual of other species in/outside the enclosure, or persecution of other object.
Foraging	Sniffing at or on food enrichment.
Social interaction	Touching other individual with any part of the body.
Aggressive interaction	Threat, hissing, stroke with paw. Within two meters from other individual.
Sleeping	Laying with closed eyes.
Standing/sitting	No movement in any direction, standing still or sitting.
Laying	No movement in any direction, laying with open eyes. On back or stomach with legs supporting the weight.
Grooming	Body care with mouth or paws.
Out of sight	Individual cannot be seen.
Other behaviour	

ANALYSIS

The results were compiled and reviewed in MS Excel. The continuous registration method provided frequencies of behaviours but in order of creating a more balanced view of behaviours appearing over time the collected data was transformed to a 1/0-score registration for the compilation of behavioural overview and levels of activity and visibility. Data will be presented as percentage of recordings.

The yearling in Borås Zoo is represented in all individual values but when sex or zoos are compared he is excluded and only the mature animals are registered to get the results balanced.

RESULTS

BEHAVIOURAL OVERVIEW

In daytime, during the period 8 am to 3 pm, the observed behaviours the animals performed were in mean values running (3.83 %), walking (7.16 %), jumping up or down (1.99 %), climbing (0.29 %), scent marking (1.19 %), stereotypic pacing (3.09 %), eating (0.76 %), sniffing (0.20 %), drinking (0.20 %), hunting (0.32 %), foraging (0.56 %), social interaction (1.58 %), aggressive interaction (0.03 %), sleeping (8.68 %), standing or sitting (11.25 %), laying (11.75 %), grooming (3.14 %) and other behaviours (1.53 %). 41.15 % of the registrations were “out of sight”.

The most common behaviours were laying or sleeping, standing or sitting and movements of some kind (Figure 3).

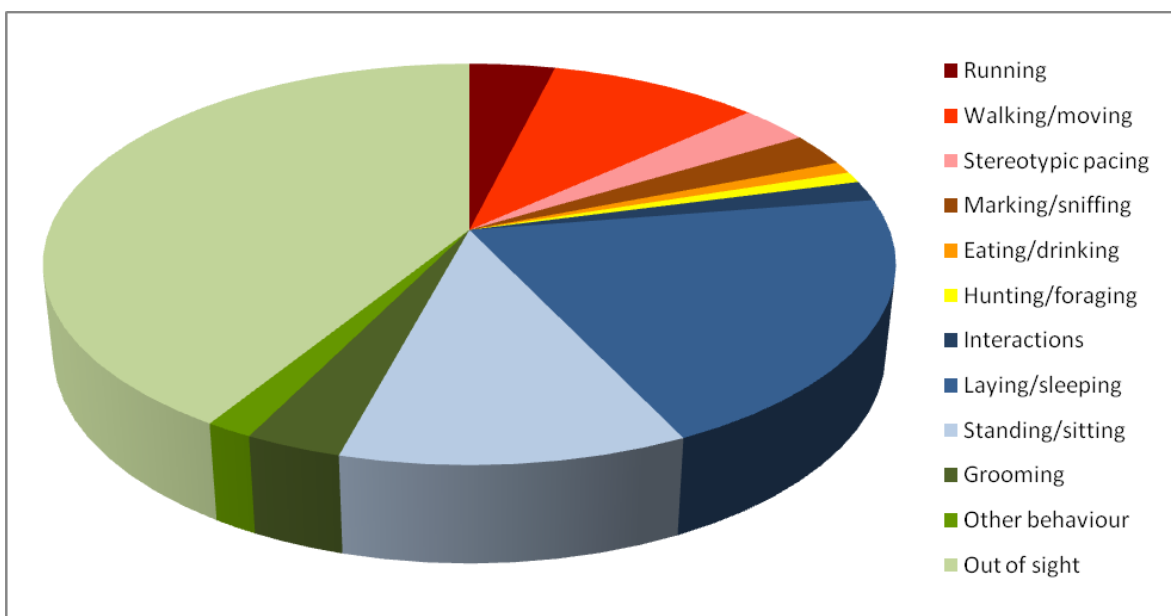


Figure 3. Percentage of recordings in mean values of all 5 observed lynx in Borås Zoo and Nordens Ark over six days. Nineteen different behaviours were observed but for a better overview some of the more similar behaviours have been merged.

Separated into individuals all three animals in Borås Zoo were mostly observed standing or sitting, followed by walking by the two males and laying by the female. The male lynx at Nordens Ark was most active with high scores in several behaviours but most common was standing/sitting and walking while the female was mostly observed laying or sleeping.

When comparing the two zoos the behaviours that stand out as different are a much higher score of laying or sleeping behaviour, more of grooming behaviour and of marking or sniffing at Nordens Ark (Figure 4). The numbers of observed behaviours are less in all categories in Borås Zoo but instead the animals were mostly out of sight there (Figure 4).

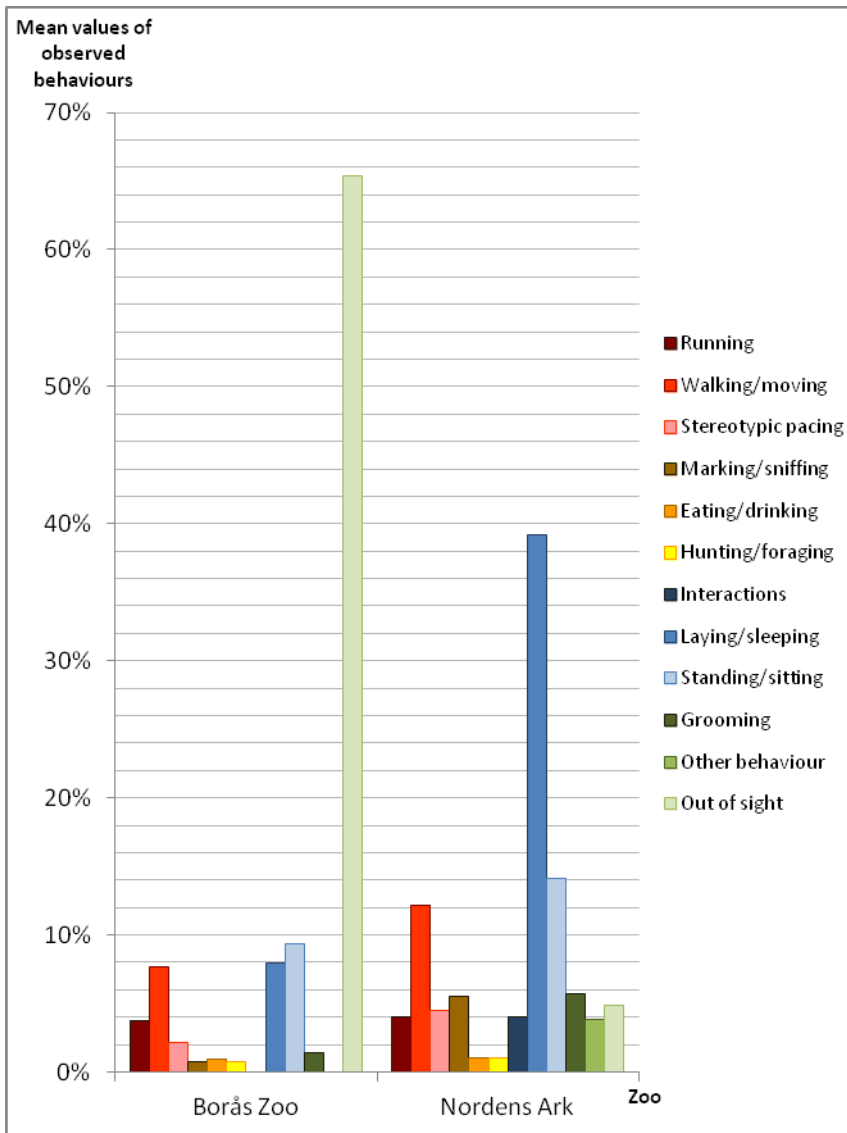


Figure 4. Percentage of recordings over six days in mean values of registered behaviours of the animals in each zoo. Nineteen different behaviours were observed but for a better overview some of the more similar behaviours have been merged.

ACTIVITY

All the lynxes except the female at Nordens Ark were more active than inactive but the two males in Borås Zoo are well under mean value (Table 2).

The males combined are more active than the females and that result corresponds with the individual results at Nordens Ark. In Borås Zoo it is instead the female that is most active (Table 2).

The male at Nordens Ark has a very high score of activity and stands out from the rest of the animals. The female at Nordens Ark is also active almost half of the time. Therefore when comparing the two zoos, the animals at Nordens Ark have a significantly higher level of activity than the animals in Borås Zoo (Table 2).

All lynxes except the adult male in Borås Zoo have a drop in activity level around midday and most of them have the highest score of activity in the morning (Figure 5).

Table 2. Comparison of activity level and visibility between individuals, sex and zoos using 1/0-registration. Activity is defined as all behaviours except sleeping, laying and out of sight, inactivity as sleeping and laying merged. Visible is defined as all observations except out of sight. Borås Zoo (BZ), Nordens Ark (NA).

Individuals	Number of times observed			Percentage of all behaviours			
	Active	Inactive	Non-visible	Active (%)	Inactive (%)	Visible (%)	Non-visible (%)
Male BZ	11	1	61	15.07	1.37	16.44	83.56
Female BZ	122	45	65	52.59	19.40	71.98	28.02
Yearling BZ	33	2	60	34.74	2.11	36.84	63.16
Male NA	352	46	33	81.67	10.67	92.34	7.66
Female NA	70	93	0	42.94	57.06	100.00	0.00
			Mean value	45.40	18.12	63.52	36.48
			Median value	42.94	10.67	71.98	28.02
Sex							
Males	363	47	94	72.02	9.33	81.35	18.65
Females	192	138	65	48.61	34.94	83.54	16.46
Zoo							
Borås Zoo	133	46	126	43.61	15.08	58.69	41.31
Nordens Ark	422	139	33	71.04	23.40	94.44	5.56

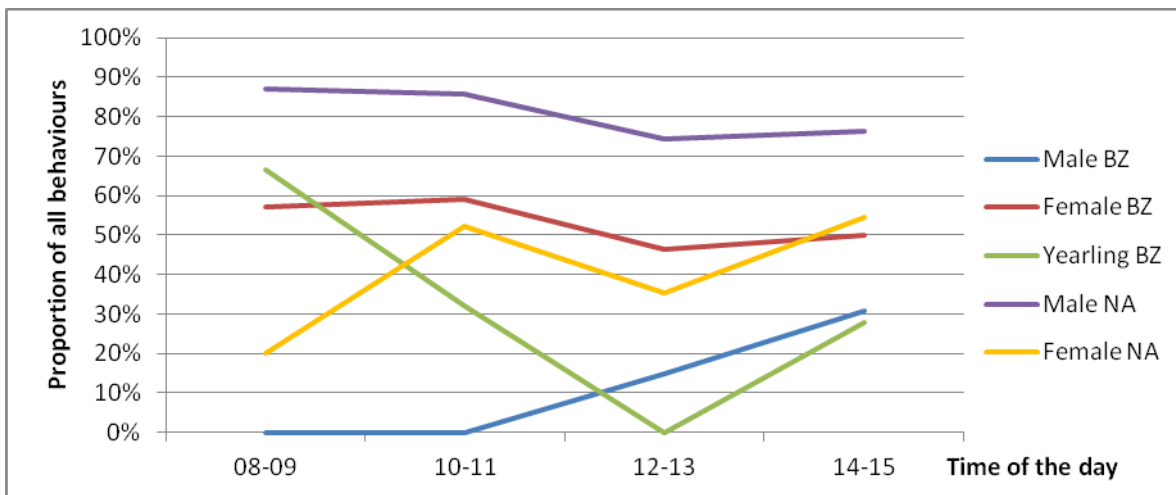


Figure 5. Variation of activity level over time. Activity is defined as all behaviours except sleeping, laying and out of sight. Borås Zoo (BZ), Nordens Ark (NA).

VISIBILITY

In total the lynxes are visible more than half of the time but it differ widely between individuals (Table 2). Both the lynxes at Nordens Ark are almost never out of sight while the males in Borås Zoo are quite the opposite (Table 2).

Both the females are more seen than their counterparts and these results correspond with the comparison between sexes. The lynxes at Nordens Ark are much more visible than the lynxes in Borås Zoo (Table 2).

There is no uniformity in the variation of visibility over time between the individual lynxes (Figure 6).

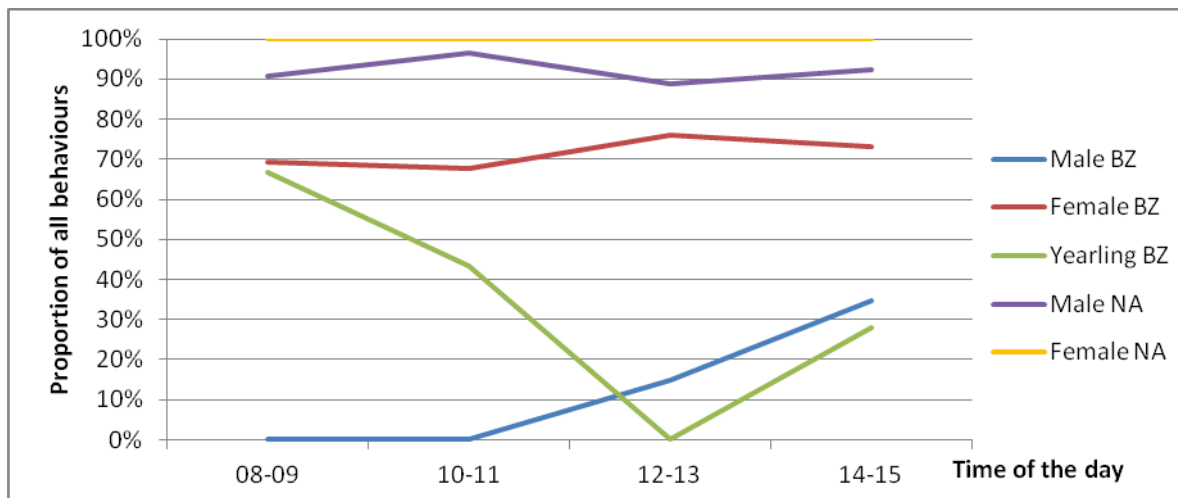


Figure 6. Variation of level of visibility over time. Visibility is defined as all behaviours except out of sight. Borås Zoo (BZ), Nordens Ark (NA).

STEREOTYPIC PACING

Stereotypic pacing was defined in the ethogram as walking or running the same track over and over again, for more than two turns per occurrence and was registered in all five animals but with great differences in number of times. Most common was stereotypic pacing by the female in Borås Zoo (7.98 % of all behaviours) and the male at Nordens Ark (6.57 %), followed by the male in Borås Zoo (3.41 %), the female at Nordens Ark (2.31 %) and the sub-adult male in Borås Zoo (0.37 %).

Males combined (6.40 %), and the lynx in Borås Zoo (7.33 %) are more often pacing than females combined (5.57 %) and the lynx in Nordens Ark (5.71 %).

Compared to the female in Borås Zoo and the male at Nordens Ark the other three animals were seen pacing just a few times each.

During the study all animals were observed three times in each time-period, 8-9, 10-11, 12-13 and 14-15. To see if there was a pattern to when the stereotypic pacing occurred the observations in each time-period were compared in the two most pacing animals. There is a large variation in when the pacing occurred in both the female in Borås Zoo (Figure 7) and the male at Nordens Ark (Figure 8).

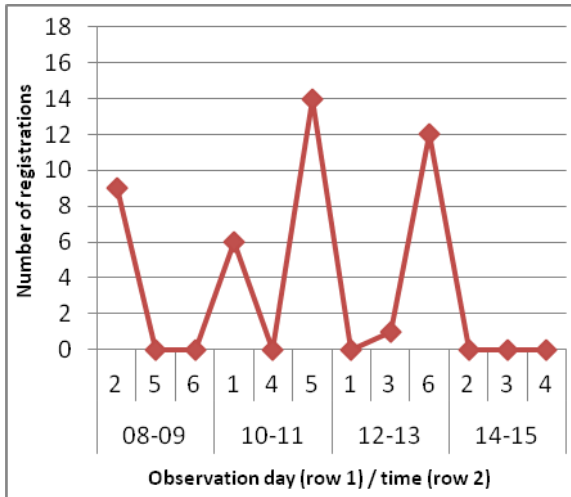


Figure 7. Variation of stereotypic pacing over time in the female in Borås Zoo. Observations have been done three times each time-period. Visibility is defined as all behaviours except out of sight.

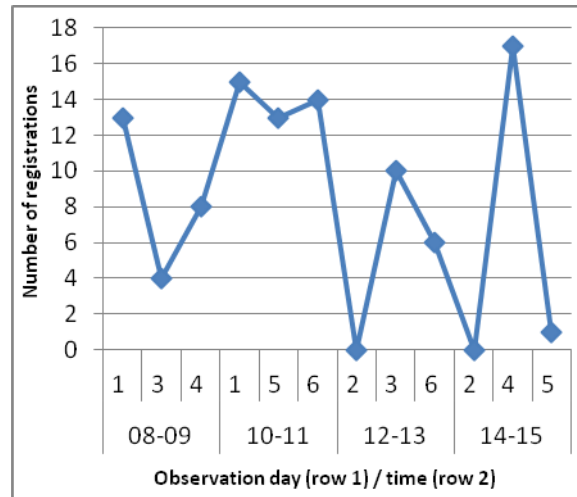


Figure 8. Variation of stereotypic pacing over time in the male at Nordens Ark. Observations has been done three times each time-period. Visibility is defined as all behaviours except out of sight.

DISCUSSION

The most common registration during the whole observation period was out of sight as was also the most common in Borås Zoo. At Nordens Ark the lynx mostly slept. The lynx at Nordens Ark were both more active and more visible than the lynx in Borås Zoo. The level of activity varied greatly between the individuals but all animals showed a drop in activity during midday. There was no uniformity in the variation of visibility over time between the individual lynxes. Stereotypic pacing also differed among the individual animals. It is more common in males and in Borås Zoo but the variation over time was very much alike in the two most frequently pacing animals although they are from different zoos.

ACTIVITY

The first question in this study was to find out how active or passive the lynx in Borås Zoo and at Nordens Ark are.

The study was conducted between eight am and three pm each day, a time that corresponds relatively well with normal opening hours, that is the time when the public wants to see the lynxes. But for the lynx this is the time when they are normally resting after an active night (Schmidt, 1999). Do the lynx keep their natural activity pattern or do they adapt to the time schedule of the zoo?

All lynxes, except the female at Nordens Ark, are more active than not whilst being observed but the lynxes in Borås Zoo are out of sight a major part of the observation period. The adult male in Borås Zoo is only visible 16 % and the yearling 37 % of the time. What they were doing during the non-visible time is impossible to determine but no movement



Figure 9. A complex enclosure might motivate more activity (photo Ahlrot, 2014).

at all could be detected and the enclosure is rather shallow so one can assume

that they were more or less passive during that time. Excessive passivity and hiding has been associated with chronic stress in felids (Wielebnowski *et al.*, 2002). Long-term passivity can also lead to poor physical condition, obesity and lack of specific locomotor skills (reviewed in Meagher, 2011).

The female at Nordens Ark on the other hand is visible all the time and is observed being passive more than half of the observed time. Both females were seen resting for long periods interrupted with short periods where they raised, stretched, sat for a while or moved around and then went back sleeping. The one lynx that stands out from this behaviour is the male at Nordens Ark. The reason why he distinguishes himself from the pattern is

impossible to determine from the result in this present study. Stress can manifest itself in various ways (Morgan & Tromborg, 2007) and his behaviour should be further investigated so that he does not suffer a sub-optimal welfare.

It is hard to find research on time budget and activity patterns in captive felids with nocturnal or crepuscular behaviours. One of the most elaborate in recent time is a study on oncilla cats in Brazil (Resende *et al.*, 2014).

The researchers in the oncilla study found that the cats spent two thirds of the day resting and were most active during dusk and dawn (Resende *et al.*, 2014). With a crepuscular or nocturnal animal it is important to study activity both day and night but most studies are limited to daytime (Mallapur & Chellam, 2002; Dybowska *et al.*, 2008). Fortunately for the study of Resende *et al.* (2014), rather small enclosures made video filming and an all day study possible. The researchers filmed the cats 24 hours a day for three following days and then using a scan sample method every 5 minutes. With a scan sample method there is always the risk of missing short behaviours and since the data is easily accessible the intervals could have been shorter or they could have used a continuous sample method. One could also argue that a sample period of merely three days just gives an instantaneous picture but the researchers made a thorough study and the results correspond with those of wild oncillas and other felids (Resende *et al.*, 2014) so it seems highly plausible.

A study on time budget and stereotypic pacing in Indian leopards showed that the leopards spent a great part of their day resting and levels of resting behaviour varied between 65-90% of all behaviours in the four zoos studied (Mallapur & Chellam, 2002). The leopards' activity level was highest early in the morning and late afternoon with resting during most of the day but with a peak at midday. All observations in this study were restricted to daytime only, between 6 am and 6 pm. The researchers made scan sample observations in 5 minute-intervals for 6-10 hours each day and studied the animals in the exhibit enclosures with and without visitors and also in the off-exhibit enclosures. They speculate that the reason for the higher activity level in the morning is because the leopards were confined in small off-exhibit enclosures during the night and started the day with exploratory behaviours when they were released in the outdoor enclosures. Since there were no correlated behaviours in the lynxes in the present study who were held in the same enclosure all the time it seems to be a plausible theory.

Also in a study of three species of felids at Warsaw Zoological Garden the researchers found that the felids were more active in the morning (Dybowska *et al.*, 2008). In agreement with Mallapur & Chellam (2002) Dybowska *et al.* (2008) think that the high level of activity in the morning is caused by the release in to the exhibition enclosures. Since the aim of the study was to investigate the impact of environmental enrichment on behaviour and not time budget the design of the study might have obscured the presented activity pattern. The felids were observed during three consecutive days each week for 12 weeks. Each observation consisted of three 5-minute intervals during one hour in the morning and one in the afternoon. Although it is a long duration of the total study, each observation is too short and too far apart to really say anything about the whole span of the day.

Feeding, enrichment and other activities in zoos that involve the keepers are done during day-time as well as movement between off-exhibit and exhibit enclosures. Naturally there is impact from and adaption to confinement and management system. But it seems that captive felids keep their natural activity pattern. The lynx in this present study did not alter between off-exhibit and exhibit enclosures which probably make the impact on activity

smaller than in the studies of Mallapur & Chellam (2002) and Dybowska *et al.* (2008) and it might be a factor for increased welfare of the lynx compared to those animals since they avoid the stressor of confinement in a small barren inside-enclosure.

Both Mallapur & Chellam (2002) and Dybowska *et al.* (2008) also found that visitors increased the level of passivity. The present study was conducted during off-season and it is hard to draw any conclusions on visitor impact from it. The female in Borås Zoo was less active the only day with visitors during this study but further research needs to ascertain a pattern.

The level of activity varied between the individual lynxes in the present study but all animals had a reduced level of activity during midday which corresponds with the normal behaviour of a crepuscular animal in the wild during day-time (Podolski *et al.*, 2013). Based on this results and in agreement with the research of Mallapur & Chellam (2002), Dybowska *et al.* (2008) and Resende *et al.* (2014) it seems that the lynx in the present study have kept their natural activity pattern for the most part. There could be some degree of increased passivity due to captivity and the presence of people but with the results in this study it is not possible to determine.

VISIBILITY

The second question was to study how much the lynxes were seen during the day.

For the lynx the normal activity during the zoos opening hours is to sleep. The visitors might think that it is rather boring to look at a sleeping animal but do they even have the chance to do that or do the lynx hide and the visitors just get to see an empty enclosure?

All the lynxes had possibility to hide from the visitors but the amount of time the lynxes were visible varied. The lynxes at Nordens Ark were visible almost all the time even when they were resting. The male lynxes in Borås Zoo were not often seen at all but the female was both more active and also often visible while resting, at least if one knew where to look.

The female at Nordens Ark had a preferred resting place on a ledge of a high cliff. Even though she was clearly visible for the public it was probably a safe enough place with an overview of the whole enclosure.

The female in Borås Zoo also chose a resting place where she could easily control her surroundings, at the highest point in the enclosure where she still could get some cover.

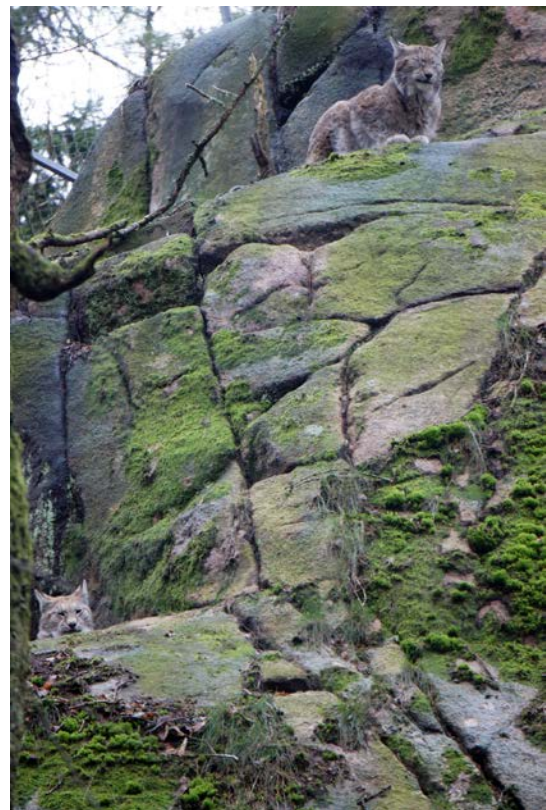


Figure 10. Lynx, as most felids, prefer a resting place with an overview (photo Ström, 2014).

It seems that the male lynxes in Borås Zoo chose to rest in places not seen by the public and are not visible a majority of the time during opening hours in the zoo. Is it a deliberate choice of resting place just to be out of sight or is it merely a preferred spot? If non-visible also means passive the high level of passivity in the males in Borås Zoo could be an effect of an enclosure too close or too much exposed to the public.

When the adult male does come out he does not seem to be shy but the yearling is clearly stressed by people, vehicles and movement around the enclosure. A few times the yearling was seen resting on a man-built platform but hid himself as soon as any keepers or visitors came. So it could be that he is not feeling safe enough there even if the platform gives him some overview.

To be able to hide is important for the lynxes (Morgan & Tromborg, 2007). By measuring levels of faecal glucocorticoid metabolites in Canadian lynx Fanson & Wielebnowski (2013) found the adrenocortical activity strongly correlated with three factors, the size of the enclosure and sex of cage-mate, but also the number of hiding places.

When studying space utilization in Indian leopards Mallapur *et al.* (2002) found that all leopards used the back end of the enclosure to rest except for those that had some form of elevated resting place in the enclosure. These results collaborate with the findings of Lyons *et al.* (1997) when studying felids in Edinburgh Zoo. Often enclosures are built sloping with the back higher than the front (Lyons *et al.*, 1997). Using the back end of the enclosure might be a way to place oneself at the highest point in the absence of elevated objects (Lyons *et al.*, 1997). It might also be a way to increase the distance to the visitors. As well as increasing passivity Mallapur & Chellam (2002) saw that the presence of keepers and large number of visitors also increased stereotypic pacing. There were not many visitors in the zoos in the present study and impact by keepers' presence was not investigated.

There is a considerable difference in the level of visibility between the two zoos in this present study. Even though Borås Zoo does not have natural high cliffs as Nordens Ark there are still possibilities to improve the enclosure design to better suit the lynxes' preference. To ensure that the zoo-visitors can see the lynx and not just an empty enclosure and in the same time assure a good welfare of the lynx it is important to design the enclosure with multiple resting places (Fanson & Wielebnowski, 2013). These resting places should be elevated or high levelled (Lyons *et al.*, 1997; Mallapur *et al.*, 2002), so that the lynxes' need to retreat can be fulfilled and they can feel safe to relax.

STEREOTYPIC PACING

The third question was to see if stereotypic pacing occurs and if it is possible to determine if the behaviour is an indication of decreased welfare.

There were two animals that clearly were pacing stereotypically, the female in Borås Zoo and the male at Nordens Ark. According to the zoo personnel the pacing by the female in Borås Zoo seems to be induced by the keepers' presence and the male at Nordens Ark is pacing before feeding (personal communication Daniel Roth, zoologist Borås Zoo, 5 April 2014; Eva Andersson, Nordens Ark, 5 May 2014).

But those explanations do not match the observations done in the present study. At one occasion the female started pacing immediately after the keepers had been there but she was also seen pacing at other times. It is of course possible that the observer induced the

pacing although she was never in the enclosure. The male was observed pacing often and for long periods but not specifically in connection with feeding-time. Interestingly there is an equally great variation in when the pacing occurred in both lynxes (Figure 7-8) although they are of different sexes, ages and from different zoos. One day there is much pacing in one time-period and the next day none or very little pacing in the same time-period. A possible explanation for this could be that the cause for the pacing is not found or countered.



Figure 11. Stereotypic paces is a common problem in captive felids (photo Ahlrot, 2014).

Both Borås Zoo and Nordens Ark had a schedule for different enrichments but those observed in the present study did not engage the lynx more than a few minutes if at all. Modern zoos work regularly with enrichments to counter stereotypes and ARBs but it rarely abolishes the behaviour and enrichments only positively effects around half of all stereotypes in studies (Clubb & Mason, 2007). Commonly the pacing in carnivores is considered connected with hunting and foraging deprivation (Lyons *et al.*, 1997; Clubb & Mason, 2007; Mason *et al.*, 2007; Morgan & Tromborg, 2007). Clubb & Mason (2007) theorized that maybe there is something else behind the stereotypic pacing and therefore although food enrichments help to a degree it is not targeting the real reasons behind the behaviour.

By collecting data from research in stereotyping carnivores over the latter half of the last century Clubb & Mason (2007) found that pacing in animals with wide normal home ranges correlates more with natural ranging behaviour than hunting abilities and also that infant mortality rates is higher in captive animals with big natural home ranges and ranging behaviours. Different research methods and different aims in the various studies make it hard to compile the results but they did get a lot of data from many different species of carnivores which points in a slightly different direction than previous studies i.e. Lyons *et al.* (1997). Although Lyons *et al.* (1997) did find that larger enclosures make the animals more active it did not affect the amount of pacing in their study.

For an animal with a large home range an enclosure in a zoo is always going to be unnaturally small and confined so one can assume that bigger is always better. But equally or maybe even more important seems to be complexity. Both Lyons *et al.* (1997) and Mallapur *et al.* (2002) saw that the animals were more active in the environmentally enriched enclosures and made much use of elevated elements. According to Fanson & Wielebnowski (2013) stress levels were lower with larger enclosures and more hiding places. Mallapur & Chellam (2002) saw that stereotypic pacing in the Indian leopards were more frequent off-exhibit where they were kept in a small barren environment than in the bigger more complex out-side enclosures. A very interesting development of zoo-design is currently going on in Philadelphia Zoo where they have built elevated walking trails outside the enclosures for several of the species in the zoo including big cats (Philadelphia Zoo, 2014). The trails are a way to encourage exploration and make the environment larger

and more complex for the animals. Hopefully there will be research on the animal's behaviour and welfare following this development.

DIFFERENCES BETWEEN THE TWO ZOOS

The fourth and last question was to detect and explain any possible differences between Borås Zoo and Nordens Ark regarding level of activity, visibility and stereotypic pacing.

There are differences in the behaviour of the lynxes in the two zoos, Borås Zoo and Nordens Ark. The lynx at Nordens Ark are considerably more active than the lynx in Borås Zoo. The lynx at Nordens Ark are visible almost all the time but the lynx in Borås Zoo are out of sight almost 60 % of the observed times.

Regarding stereotypic pacing there are less differences between the zoos and more between the individuals. Pacing occurs in all animals but there are two lynxes that are pacing more frequently. Those two are one from each zoo and of different sex and age.

Except the behaviour of the lynxes there are also other factors that differ between the two zoos. The enclosures are reasonably large. Collectively the lynx at Nordens Ark have the largest habitat and are also the most active in correlation with Lyons *et al.* (1997) findings. Fanson & Wielebnowski (2013) found a variation in whether it is the total area of enclosure or area per lynx that is the most important factor for increased stress. The enclosure of the female in Borås Zoo is 1473 square meters which makes it the largest amount of space per individual, the males in Borås Zoo and the lynx at Nordens Ark has 700 and 810 square meters per lynx respectively. Although not as active as the lynxes at Nordens Ark she was the most active lynx in Borås Zoo which agrees with the result of Lyons *et al.* (1997).

Naturalistic enclosures for lynxes in Sweden are relatively easy to create since the lynx naturally occurs in the country. All enclosures consist of naturally forested and rocky environment. The male enclosure in Borås Zoo is rather dense compared to the other enclosures which can be a reason why the two lynxes are so much non-visible. All enclosures have a high level of complexity with fallen logs, rocks, hedges and other objects to investigate, use as cover or perch upon. The importance of elevated viewing points and resting places was highlighted above (Lyons *et al.*, 1997; Wooster, 1997; Mallapur *et al.*, 2002) and a unique feature for the enclosures at Nordens Ark are high cliffs enabling the lynxes to have a good overview of the enclosure and maintain a distance to people which might give them more security than the lower and shallower enclosures in Borås Zoo.

Both zoos feed the lynxes every second day but at Nordens Ark they change both presentation of the food and feeding-time more. Whether changes in routine are enriching or a source for frustration for the lynxes is not possible to determine in this study. Enrichments are presented on the non-feeding days in both zoos and both have a schedule with varying kinds of enrichment. In neither zoo did the enrichment make any impact on behaviour in the present study. The lynxes in Borås Zoo were fed in the afternoon every time and there were no observed pacing in relation to feeding. At Nordens Ark the feeding-time varied over the day and there was a perception that the male was pacing in anticipation of food but observations did not corroborate this. Studies of the causation of pacing are inconclusive but Clubb & Mason (2007) suggests that it might not be food-related and further research is required.

The lynxes in each pair were of the same age but the pair in Borås Zoo was older than the pair at Nordens Ark. In Borås Zoo there was also a third lynx, a sub-adult. According to Fanson & Wielebnowski (2013) lynxes were considerably less stressed when housed single than in pair, either same sex or mixed. Most stressed were lynxes in mixed-sex groups of three or more. Same-sex pairs were less stressed than mixed pairs but with a small difference (Fanson & Wielebnowski, 2013). Sub-adult lynxes have been observed partly sharing home range with adult males in the wild (Breitenmoser-Würsten *et al.*, 2007). Therefore, although none of the lynxes in the present study were housed in a larger group than two, the lynxes in Borås Zoo might be less stressed by social factors than the lynxes in Nordens Ark. Since the female in Borås Zoo was held alone she should be least stressed of all lynxes in the study. But she was also the one that was pacing most of all lynxes which illustrate that stress and decreased welfare most probably has multi-factor causes.

It is not possible to conclude that one zoo is better than the other. There are factors indicating risks for decreased welfare in both zoos and likewise there are elements in favour for a good welfare in both. Which of the factors that is most important most likely varies with the individual lynx and its environment.

PROBLEMS WITH THE STUDY

This study has several limitations. It is proportioned to be a bachelor study and it is part of a coordinated study of several species of felids. Coordinated studies using the same methodology are necessary to get general results of welfare in captive felids but it also means that one has to compromise about the best suitable method or definitions for each species.

The ethogram used is constructed to suit the behaviours in all the observed species of felids and the behaviours stand still and sit are defined as the same because it can be hard to discern which behaviour the cat is performing. The lynx observed was either sitting for a longer period, i.e. a passive behaviour, or often stopped during walking or running to stand still a few seconds and then remain walking or running, i.e. an active behaviour. Since the standing still was performed more often than the sitting the combined behaviour has been identified as an active behaviour here but it is a possible source of error.

The wild lynx is active in the night and rests during the day. Does the captive lynx uphold the same activity pattern or has it adapted to the zoo's hours? Does this clash of time tables affect the welfare of the animal? To measure the activity levels and map out a time budget we need to study the whole 24 hours of the captive lynx not just the few hours when the zoo is open to public. It presents problems because it is hard to observe behaviours in the dark and the largeness of the enclosures makes it difficult to for instance film the lynx with a night vision camera instead. But to fully understand the normal behaviour of the lynx in captivity and be able to more correctly measure their welfare it is necessary to map the whole activity pattern.

Many of the active behaviours are performed during a short period of time while the passive behaviours are few and performed during a long period of time. Therefore the results might be deceptive and picture a higher level of activity than in reality. To counter this error the observation intervals should have been shorter.

The choice of sampling method is disputable. To meet the aim of the study the results were transformed from a continuous registration method to a 1/0-score registration, but when

doing the continuous sampling while observing more data were obtained than if only the 1/0-score sampling would have been used and therefore it was possible to get both occurrence and frequency. The registration method did not provide us with duration of the behaviours which is necessary for a proper time budget.

The research population of only five animals in two zoos is too small to make it possible to draw any general conclusions from the results. Therefore this study can only be reviewed as an initial foundation for further studies or guidance for the management of these two zoos studied.

FURTHER RESEARCH

As most felids the lynx is a solitary crepuscular cryptic animal prone to stereotypic pacing in captivity. Since stereotypic behaviours are founded in some sort of frustration or inability to cope with the situation and are a sign of probable decreased animal welfare. Although enrichment activities are done in most modern zoos the results are not satisfactory and one can assume that they in some way fail to address the root of the problem. Pacing felids are very common and it is imperative that more research efforts are made to find the underlying causes and the best way to counter the problems to not only decline stereotypic behaviours but to abolish them.

Further coordinated studies in a greater scale are needed to map the behaviours and activity pattern of all felids in captivity. To assure a good welfare to the animals it is important that we learn the motivations for the behaviours of our captive felids. We must know the baselines to be able to find the best model of husbandry so that the welfare is not compromised. Although the different species of felids share a great part of their behaviours it is important to not only study the big cats, the most common and the most popular felids but also in greater detail learn the behaviours and needs of the not yet so much studied felids such as the lynx.

Animal welfare is an important topic both in conservation, zoo management and in the public eye. All animals in captivity should have optimal welfare but at present we do not have the knowledge to maintain such an optimal welfare. Impact from further behavioural research may very well be a turning point in management of felids in captivity. If research finds that keeping felids at optimal welfare is not possible it is also important to study which species are most vulnerable in captivity and which species are most at risk in the wild.

The zoos might have to decide if this species really should be in a public zoo or maybe for conservation purposes only should be kept in captivity in non-public breeding centres where the need for space and solitude more easily can be met. And there might be need to see if it is possible to work with more in situ-conservation programs instead.

CONCLUSIONS

From this study one can conclude that the lynx in Borås Zoo and Nordens Ark are mostly out of sight or resting. It is a normal behaviour for a wild lynx to be resting during day-time but passivity and hiding are also behaviours that increase in the presence of humans in captive felids.

The lynx at Nordens Ark are more visible than the lynx in Borås Zoo. It might be a sign that the welfare of the lynx in Borås Zoo is sub-optimal, possibly because the enclosure is too much exposed to the public. The lynx at Nordens Ark have more elevated resting places and more distance to the visitors.

There are stereotypic pacing in both Borås Zoo and Nordens Ark. It might be because of decreased welfare. The correlation between pacing and keepers' presence or feeding is not corroborated in this study and the cause of the pacing is seemingly not countered with the current enrichment efforts. Further investigation in the reasons behind the stereotypes need to be done.

The most pronounced differences between the zoos are a higher level of activity and visibility at Nordens Ark whilst there are more similarities than not regarding stereotypic pacing. The reasons behind the differences needs to be further investigated.

This is a part of the first coordinated study of felid behaviour in captivity in Sweden. It is therefore an important foundation to further research well needed to ensure the welfare of captive felids.

POPULÄRVETENSKAPLIG SAMMANFATTNING

Kattdjur är solitära djur som är mest aktiva i skymning och gryning. Många av dem har stora hemområden och vandrar långa sträckor varje dygn för att jaga och patrullera sina territorier. På grund av att vi människor breder ut oss allt mer är många arter av kattdjur hotade när orörd natur och deras möjliga utbredningsområden krymper. Därför pågår arbete med olika bevarandeprojekt för att skydda ett stort antal olika kattarter.

På grund av kattdjurens naturliga levnadssätt ställs man inför många problem och hinder när man ska försöka hålla kattdjur i fångenskap utan att deras välfärd blir lidande. Begränsade utrymmen, ingen möjlighet att vandra, jaga eller kanske att undvika andra artfränders närhet gör att det är mycket vanligt med stereotypa beteenden. Stereotyper, beteenden utan någon funktion som upprepas i samma mönster gång på gång, är tecken på att djuret är frustrerat eller stressat över sin situation och kan betyda att djuret har en låg välfärd. Det är också ofta svårt att lyckas med uppfödning av hotade kattdjur i fångenskap, även det kan vara ett tecken på bristande välfärd.

Även om mycket jobb redan idag utförs för att berika och förbättra kattdjurens levnadsförhållanden i fångenskap behövs mer forskning för att finna möjliga orsaker till varför kattdjuren inte trivs. Vi håller många olika arter av kattdjur och trots skillnader i utseende, storlek och vart på jorden de lever delar de många egenskaper och beteenden. På grund av att de normalt lever ensamma så finns det sällan mer några enstaka djur av varje art i en djurpark och för att få ett tillräckligt stort forskningsunderlag för tillförlitliga och generella resultat behövs studier över artgränserna. Trots det finns det få koordinerade studier av flera olika arter av kattdjur på ett flertal djurparker där man använder sig av samma forskningsmetodik och kan samköra resultaten för att få en ökad insikt i de gemensamma faktorer som styr kattdjurens välfärd.

Den här studien är en del i det första koordinerade forskningsprojektet av kattdjur i Sverige och syftet med den är att studera tidsbudget och aktivitetsmönster hos europeiskt lodjur i två svenska djurparker, Borås djurpark och Nordens Ark. Studien syftar till att ta reda på om lodjuren bevarar sitt naturliga aktivitetsmönster även i fångenskap eller om de har anpassats till djurparkernas tider. Dels behöver vi veta hur djuren betar sig för att kunna gå vidare i forskning om bättre hållning och berikning men vi behöver också se om en eventuell anpassning till djurparkens rutiner på något sätt påverkade lodjurens välfärd.

Under dagtid var det vanligaste beteendet som observerades hos alla djur i studien ”ej synlig” och det samma gäller om man bara tittar på lodjuren i Borås djurpark. På Nordens Ark låg lodjuren och vilade eller sov nästan 40 % av tiden. Graden av aktivitet varierade stort mellan individerna men alla djur hade en sänkning av aktivitetsnivå mitt på dagen vilket följer lodjurens naturliga aktivitetsmönster i det vilda. Tidigare forskning har visat att kattdjur i fångenskap får en lägre aktivitetsnivå när människor är närvarande. Om den låga aktivitetsnivån under dygnets ljusa timmar hos dessa lodjur är ett uttryck för deras naturliga beteende eller om de var passiva på grund av sänkt välfärd gick dock inte att avgöra genom de resultat som kom fram i den här studien.

Lodjuren på Nordens Ark var både mer aktiva och mer synliga än lodjuren i Borås djurpark. Varför de är mer aktiva och synliga kan bero på individuella skillnader i deras personligheter. Det är också möjligt att hägnen på Nordens Ark är mer optimala för att lodjuren ska trivas. De flesta kattdjur föredrar att vila på platser med en bra överblick. På Nordens Ark finns fler högt belägna viloplatser och en större möjlighet för lodjuren att dra

sig längre ifrån besökarna, detta skulle kunna bidra till en högre välfärd. Den högre aktivitetsnivån skulle också kunna förklaras med en större förekomst av stereotypiskt vandrande vilket i så fall mer är ett tecken på lägre välfärd hos dessa djur jämfört med lodjuren i Borås djurpark.

Stereotypiskt vandrande förekom hos alla individer men i varierande grad. Det är mer vanligt hos hanar och hos lodjuren i Borås djurpark men vid en granskning av mönstret av stereotypiskt vandrande över tid så var det en liknande variation hos båda de djur där stereotyper var mest förekommande trots att de var från olika djurparker. Det gick inte att urskilja något mönster för när deras vandrande utfördes och det är därför omöjligt att svara på varför stereotyperna förekommer.

Arbete med berikning för att motverka stereotyper förekommer frekvent i de flesta moderna djurparker men med begränsat resultat. En anledning till att berikning inte fungerar tillfredsställande kan vara att man inte bemöter rätt orsaker till frustrationen. För att hitta de orsaker som ligger till grund för det stereotypiska vandrandet behövs det mer forskning.

Vidare forskning behövs för att ge oss bättre insikt i lodjurens naturliga beteende och vad som krävs för att de ska vara kapabla att hantera sin situation utan att frustrationer uppstår. För om vi inte kan försäkra oss om att de har en optimal välfärd bör vi kanske inte ha dem i djurparker över huvud taget.



(Photo Ahlrot, 2014)

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REFERENCES

Ahlrot, U. 2014.

ArtDatabanken, 2014. <http://www.artfakta.se/GetSpecies.aspx?SearchType=Advanced>, downloaded 21 April 2014.

Bergeron, R., Badnell-Waters, A. J., Lambton, S. & Mason, G. 2006. Stereotypic Oral Behaviour in Captive Ungulates: Foraging, Diet and Gastrointestinal Function. In: Stereotypic Animal Behaviour: Fundamentals and Applications to Welfare, 2 ed. (Eds. G. Mason & J. Rushen). Wallingford, CABI.

Bostedt, G., & Grahn, P. 2008. Estimating cost functions for the four large carnivores in Sweden. *Ecological Economics*. 68, 517-524.

Breitenmoser-Würsten, C., Zimmermann, F., Stahl, P., Vandel, J-M., Molinari-Jobin, A., Molinari, P., Capt, S., & Breitenmoser, U. 2007. Spatial and social stability of Eurasian lynx *Lynx lynx* population: an assessment of 10 years of observation in the Jura Mountains. *Wildlife Biology*. 13, 365-380.

CITES, 2013. <http://www.cites.org/eng/app/appendices.php>, downloaded 21 April 2014.

Clubb, R., & Mason, G. 2003. Animal welfare: captivity effects on wide-ranging carnivores. *Nature*. 425, 473-474.

Clubb, R., & Mason, G. J. 2007. Natural behavioural biology as a risk factor in carnivore welfare: How analysing species differences could help zoos improve enclosures. *Applied Animal Behaviour Science*. 102, 303-328.

Dybowska, J., Górecka, J., Grzegorzóka, B., Wieczorek, M., & Złamal, A. 2008. Analysis of the influence of environmental enrichment on the behaviour of wild cats kept in captivity. *Annals of Warsaw University of Life Sciences-SGGW, Animal Science*. 45, 3-17.

Fanson, K. V., & Wielebnowski, N. C. 2013. Effect of housing and husbandry practices on adrenocortical activity in captive Canada lynx (*Lynx canadensis*). *Animal welfare*. 22, 159-165.

IUCN Red list, 2013.2. <http://www.iucnredlist.org/details/12519/0>, downloaded 21 April 2014.

Linnell, J. D., Andersen, R., Kvam, T., Andren, H., Liberg, O., Odden, J., & Moa, P. F. 2001. Home range size and choice of management strategy for lynx in Scandinavia. *Environmental management*. 27, 869-879.

Lyons, J., Young, R. J., & Deag, J. M. 1997. The effects of physical characteristics of the environment and feeding regime on the behavior of captive felids. *Zoo Biology*. 16, 71-83.

Mallapur, A. & Chellam, R. 2002. Environmental influences on stereotypy and the activity budget of Indian leopards (*Panthera pardus*) in four zoos in Southern India. *Zoo biology*. 21, 585-595.

Mallapur, A., Qureshi, Q. & Chellam, R. 2002. Enclosure Design and Space Utilization by Indian Leopards (*Panthera pardus*) in Four Zoos in Southern India. *Journal of Applied Animal Welfare Science*. 5, 111-124.

- Mason, G., Clubb, R., Latham, N., & Vickery, S. 2007. Why and how should we use environmental enrichment to tackle stereotypic behaviour? *Applied Animal Behaviour Science*. 102, 163-188.
- McPhee, M. E. & Carlstead, K. 2010. The Importance of Maintaining Natural Behaviours in Captive Mammals. In: *Wild mammals in captivity: principles and techniques for zoo management*. 2nd ed. (Eds. D. G. Kleiman, K. V. Thompson & C. K. Baer). Chicago, University of Chicago Press.
- Meagher, R. K. 2011. The welfare significance of inactivity in captive animals, using mink as a model. Doctoral dissertation. University of Guelph.
- Morgan, K. N., & Tromborg, C. T. 2007. Sources of stress in captivity. *Applied Animal Behaviour Science*. 102, 262-302.
- Naturvårdsverket, 2013. Nationell förvaltningsplan för lodjur 2013-2017. Stockholm.
- Philadelphia Zoo, 2014. <http://philadelphiazoo.org/Explore/Animal-Trails.htm>, downloaded 13 May 2014.
- Podgórski, T., Schmidt, K., Kowalczyk, R., & Gulczyńska, A. 2008. Microhabitat selection by Eurasian lynx and its implications for species conservation. *Acta theriologica*. 53, 97-110.
- Podolski, I., Belotti, E., Bufka, L., Reulen, H., & Heurich, M. 2013. Seasonal and daily activity patterns of free-living Eurasian lynx *Lynx lynx* in relation to availability of kills. *Wildlife Biology*. 19, 69-77.
- Resende, L. D. S., Lima e Neto, G., Gonçalves Duarte Carvalho, P., Landau-Remy, G., de Almeida Ramos-Júnior, V., Andriolo, A. & Genaro, G. 2014. Time Budget and Activity Patterns of *Oncilla* Cats (*Leopardus tigrinus*) in Captivity. *Journal of Applied Animal Welfare Science*. 17, 73-81.
- Schmidt, K. 1999. Variation in daily activity of the free-living Eurasian lynx (*Lynx lynx*) in Białowieża Primeval Forest, Poland. *Journal of Zoology*. 249, 417-425.
- Schmidt, K., Jędrezejewski, W. & Okarma, H. 1997. Spatial organisation and social relations in the Eurasian lynx population in Białowieża Primeval Forest, Poland. *Acta Theriologica*. 42, 289-312.
- Ström, J, 2014.
- Sunquist, M. E. & Sunquist, F. 2002. Eurasian Lynx. In: *Wild cats of the world*. Chicago, University of Chicago Press.
- Svenska djurparksföreningen, 2014. <http://svenska-djurparksforeningen.nu/bevarandearbete/sdf-projekt/lodjur/> downloaded 16 May 2014.
- Versteeg, L. 2010. Eurasian lynx ESB Annual Report 2007 - 2008. In: *EAZA Yearbook 2007-2008*. (Eds. D. de Man, W. van Lint, A. Garn & C. Henke). EAZA Executive Office, Amsterdam.
- Wielebnowski, N. C., Fletchall, N., Carlstead, K., Busso, J. M. & Brown, J. L. 2002. Noninvasive Assessment of Adrenal Activity Associated with Husbandry and Behavioral Factors in the North American Clouded Leopard Population. *Zoo Biology*. 21, 77-98.
- Wooster, D. S. 1997. Enrichment techniques for small felids at Woodland Park Zoo, Seattle. *International Zoo Yearbook*. 35, 208-212.

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