

MSc Thesis
Behavioural Ecology

STEREOTYPIC BEHAVIOUR IN POLAR BEARS (*Ursus maritimus*) IN DUTCH ZOOS

*The influence of age and sex on stereotypic behaviour in ten captive
polar bears housed in four different Dutch zoos*



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**Influences of age and sex on stereotypic behaviour in polar bears
(*Ursus maritimus*) in Dutch zoos**

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Abstract Stereotypic behaviour is a currently well-known welfare issue in zoo-housed animals, especially in wide-range carnivores. For zoo professionals it is important to improve the well-being of captive animals and to do so, variables influencing stereotypic behaviour need to be investigated. Very little is explored about the variables influencing stereotypic behaviour of zoo-housed animals and especially polar bears. Two important factors influencing this behaviour in captive animals are age and sex. Therefore, in current study I explored if age and sex influenced the performance of stereotypic behaviour by observing polar bears and using ZooMonitor. I analysed the performance of stereotypic behaviour of ten zoo-housed polar bears (*Ursus maritimus*) in four zoos in the Netherlands. Overall, my results indicated that all behaviours performed were independent and that age and the behaviour category did not influence the time spent on any of the behaviours analysed (i.e. Eliminating, Foraging, Locomotion, Lying down, Manipulation, Pacing on land, Self-directory behaviour, Sitting, Social interaction, Standing and Swimming). My findings also indicated that sex influenced the time spent on a behaviour, females spent on average more time on inactive behaviours than males whereas males spent more time on active behaviours. Moreover, three males of the ten polar bears showed stereotypic behaviour during the observation period, and for this group, younger bears were more likely to display stereotypic behaviour. Lastly, I found that being housed together or alone did not have an influence on the performance of stereotypic behaviour. The influences of age and sex on the performance of stereotypic behaviour were explored and these results may function as a great starting point for further investigation on the variables influencing stereotypic behaviour in zoo-housed animals and improving the well-being of captive animals.

Key words Abnormal behaviour, Age, Polar bear, Sex, Stereotypic behaviour

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Introduction

One of the most prominent and well-spoken welfare issues of zoo-housed animals is the performance of abnormal or stereotypic behaviour. Stereotypies are known as invariant, repetitive behaviour patterns lacking a goal or function (Mason, 1991). Some studies indicated that stereotypic behaviour is performed as a calming, coping mechanism for stress (Bacon, 2018; Mason, 1991; Rose et al., 2017), while otherwise indicated that stereotypic behaviour arises when there is a lack of ability to perform species-specific behaviours (Browning, 2020; Clubb & Mason, 2007) or when there is the inability of controlling the environment (Hosey, 2005). Even though it is currently inconclusive whether stereotypic behaviour has a significant relation with welfare (Mason, 1991; Mason & Latham, 2004), a study by Mason et al., (2007) suggested that stereotypic behaviour could implicate impaired brain function or a form of motivational frustration, therefore they plead for a “zero tolerance” policy for these behaviours in zoos.

Carnivores are most prone to performance of stereotypic behaviour while in captivity. This is true especially for wide-range carnivores and in particular captive ursids as compared to other families (Clubb, 2002). A reason for this could be the constrained range and foraging area in the enclosure of the animal. Especially polar bears (*Ursus maritimus*) who inhabit the Arctic sea ice, a widespread territory, where they often roam large range sizes from 185 km² to 370 km² annually (Mauritzen et al., 2001), are prone to show stereotypic behaviour in captivity. In the studies of Mason et al., (2007) and Shepherdson et al., (2013), the percentage of zoo-housed polar bears showing stereotypic behaviour is on average 57% and 85%, respectively.

Several studies have investigated stereotypical behaviour of bears in captivities and the findings are diverse. The moment of the day (Grandia et al., 2001) and period of the year (Carlstead & Seidensticker, 1991) can influence the display of such behaviours. Also the frequency of social interaction (Fischbacher & Schmid, 1999), and the inability to perform migratory behaviours (Clubb & Mason, 2003) were found to have an influence. Age and sex were also shown to influence the performance of stereotypic behaviour in bears (Ames, 2000; Montaudouin & Le Pape, 2004). Polar bears in the wild are solitary most of the time; forming social groups is rare and engaging with their conspecific to mate, occurs only once per year (Amstrup, 2003). However, in captivity, both sexes are often housed together which could evolve into a stressful situation (Amstrup, 2003), males may get frustrated by not being able to reach the female to mate (Ames, 1993). Those frustration episodes often result in the displaying of stereotypic behaviour. Furthermore, male and female polar bears have different ages of reproductive maturation, on average a female matures at the age of five years and a male one or two years later (Lønø, 1970; Rosing-Asvid et al., 2002; Sonne et al., 2007). The age of reproductive maturation could be correlated to the age when a polar bear starts performing stereotypic behaviour when in captivity. In addition to this, age is suggested to play a role in the performance of active stereotypic behaviour like pacing, since physical abilities may decrease with an older age (Gottlieb et al., 2013, 2015).

Even though stereotypic behaviour in zoo-housed animals is currently an important topic and many studies are conducted on this subject, very little is known regarding the influence age and sex have on the performance of stereotypic behaviour in zoo-housed animals and especially wide-ranging carnivores like polar bears. The aim of my study is to identify the

influences of intrinsic factors, like age and sex, on the performance of stereotypic behaviour. Here I explore this idea in ten polar bears in four zoos in the Netherlands, the influences of age and sex on the performance of stereotypic behaviour will be investigated by observing their behaviour for eight weeks using ZooMonitor-

Overall, the goal of my study was to first give an overview of the performance of stereotypic behaviour in zoo-housed polar bears in the Netherlands. And secondly, to gain and provide zoo professionals with valuable insights on potential correlations between factors like age and sex and performing such behaviour which can be used for future decisions regarding the housing conditions of zoo animals.

Materials and methods

Study species and study areas

I collected behavioural data for eight weeks from the beginning of November 2022 until the end of December 2022, on ten polar bears (five males and five females), housed in four different zoos (Fig. 1). During the data collection, the age of the polar bears ranged from 4 years old to 22 years old, with an average of 12.3 years. The polar bears in AquaZoo and Wildlands Zoo were continuously housed together, the polar bears from Blijdorp Zoo were housed separately most of the time, except for one day and in Dierenrijk Zoo, the females were housed together, separate from the male, who was housed alone.

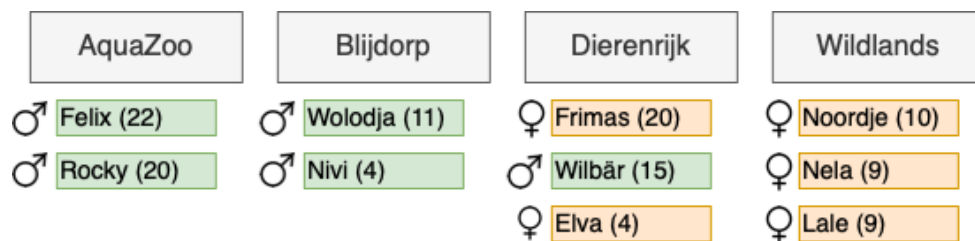


Fig. 1 Overview of zoos and polar bears (N = 10) used in this study. Male (green) polar bears (N = 5) and female (orange) polar bears (N = 5) with corresponding age between brackets

Behavioural observations and data collection

For this study, I used the application ZooMonitor (Lincoln Park Zoo, 2022) to score data of behaviour of polar bears. Continuous focal sampling was used to measure the time spent on behaviours performed by different individuals. I collected the data over a period of eight weeks, for three times a week, for four hours a day, totaling for 96 observation hours. I visited the four zoos three days a week for two non-consecutive weeks, totaling for six days per zoo. Every polar bear was observed in sessions of one hour, totaling for six hours (Blijdorp Zoo and AquaZoo) or four hours (Dierenrijk Zoo and Wildlands Zoo) per week divided over three days. In Blijdorp Zoo and AquaZoo, the zoos with two polar bears, I observed both polar bears twice a day. In Dierenrijk and Wildlands, the zoos with three bears, I observed all polar bears for one hour per day, but solely one bear was observed for two hours, this individual rotated over the three days.

For scoring data, I used an ethogram (Table 1), which was based on other polar bear studies and one master's thesis currently in process in Diergaard Blijdorp regarding polar bears (Nieuwenhoven, 2022). The behaviours are divided in active behaviours (Locomotion, Manipulation, Climbing, Self-directory behaviour, Eliminating, Foraging, Drinking, Social interaction, Swimming and Sitting), inactive behaviours (Sitting and Lying down), stereotypic behaviours (Pacing on land and Pacing in water) and out of sight.

Table 1 | Behavioural ethogram

Behaviour	Description
Locomotion	A minimum of two steps on a terrestrial surface, that is not pacing. For a difference between the two, please consult Cless et al., (2015)
Manipulation	Includes pulling, pushing, nosing, batting, mouthing, rubbing, shaking, holding or biting a movable object, and also paving or permanent surfaces (Ross, 2006)
Climbing	Climbing on top of rocks, or out/into the pool
Self-directory behavior	Scratching, sniffing fur, biting fur, shaking
Eliminating	Defecating
Foraging	Searching for food throughout the environment, includes eating (Maher et al., 2021)
Drinking	Uptake of water
Social interaction	This includes aggression, play; the bears have physical contact (Maher et al., 2021)
Swimming	Movement within the water, including surface and underwater activities (Ross, 2006)
Standing	Touching the ground with all four paws, while staying in one location
Sitting	Touching the ground with butt and front paws, while staying in one location
Lying down	Touching the ground with more than paws, while staying in one location.
Pacing on land	Repetitive locomotion over the same terrestrial path. Must be part of a repetitive pattern that has been completed two times prior (Ross, 2006)
Pacing in water	Repetitive locomotion following a certain path in the water. Must be part of a repetitive pattern that has been completed two times prior (Ross, 2006)
Out of sight	Animal not visible for observer

Statistics

The statistical analyses were performed in RStudio version 2021.09.0. I used generalized linear models (glm) using the function ‘*glm*’ to investigate if the behaviour performed by the polar bears were influencing the duration and if these behaviours were independent. Also, a glm model was used to explore if the time spent on any behaviour (in seconds) was influenced by sex or age. For this model, the behaviour category, the performance of either stereotypic or normal behaviour, was used as a covariate. To explore more of the stereotypical behaviour, a glm was also run to test if age and the number of bears in an enclosure influenced the performance of stereotypic behaviour. In addition, a glm was run to test if the time spent on stereotypical behaviour was different from the time spent on normal behaviour for all polar bears, and for only the polar bears who showed stereotypic behaviour.

No statistical analysis was possible regarding the influence of sex on the performance of stereotypic behaviour since there were no females who showed stereotypic behaviour.

Results

From the ten observed polar bears, only three polar bears (Nivi, Wolodja and Wilbär) showed stereotypic behaviour during observation period. The time spent on stereotypic behaviour expressed as a percentage of the total observed time is for Nivi 48.7%, Wolodja 0.2% and for Wilbär 10,7%.

Looking at the individual behaviours performed, each of the 12 observed behaviours was independent and none of the behaviours influenced the time spent on any behaviour; Foraging ($\beta = -0.055$, $SE = 0.055$, $P = 0.327$), Locomotion ($\beta = -0.053$, $SE = 0.055$, $P = 0.345$), Lying down ($\beta = -0.055$, $SE = 0.055$, $P = 0.321$), Manipulation ($\beta = -0.028$, $SE = 0.059$, $P = 0.637$), Pacing on land ($\beta = -0.055$, $SE = 0.05547$, $P = 0.323$), Self-directory behaviour ($\beta = -0.052$, $SE = 0.055$, $P = 0.351$), Sitting ($\beta = -0.054$, $SE = 0.055$, $P = 0.332$), Social interaction ($\beta = -0.054$, $SE = 0.055$, $P = 0.337$), Standing ($\beta = -0.052$, $SE = 0.055$, $P = 0.351$), and Swimming ($\beta = -0.054$, $SE = 0.055$, $P = 0.330$). The behaviours Drinking, Climbing and

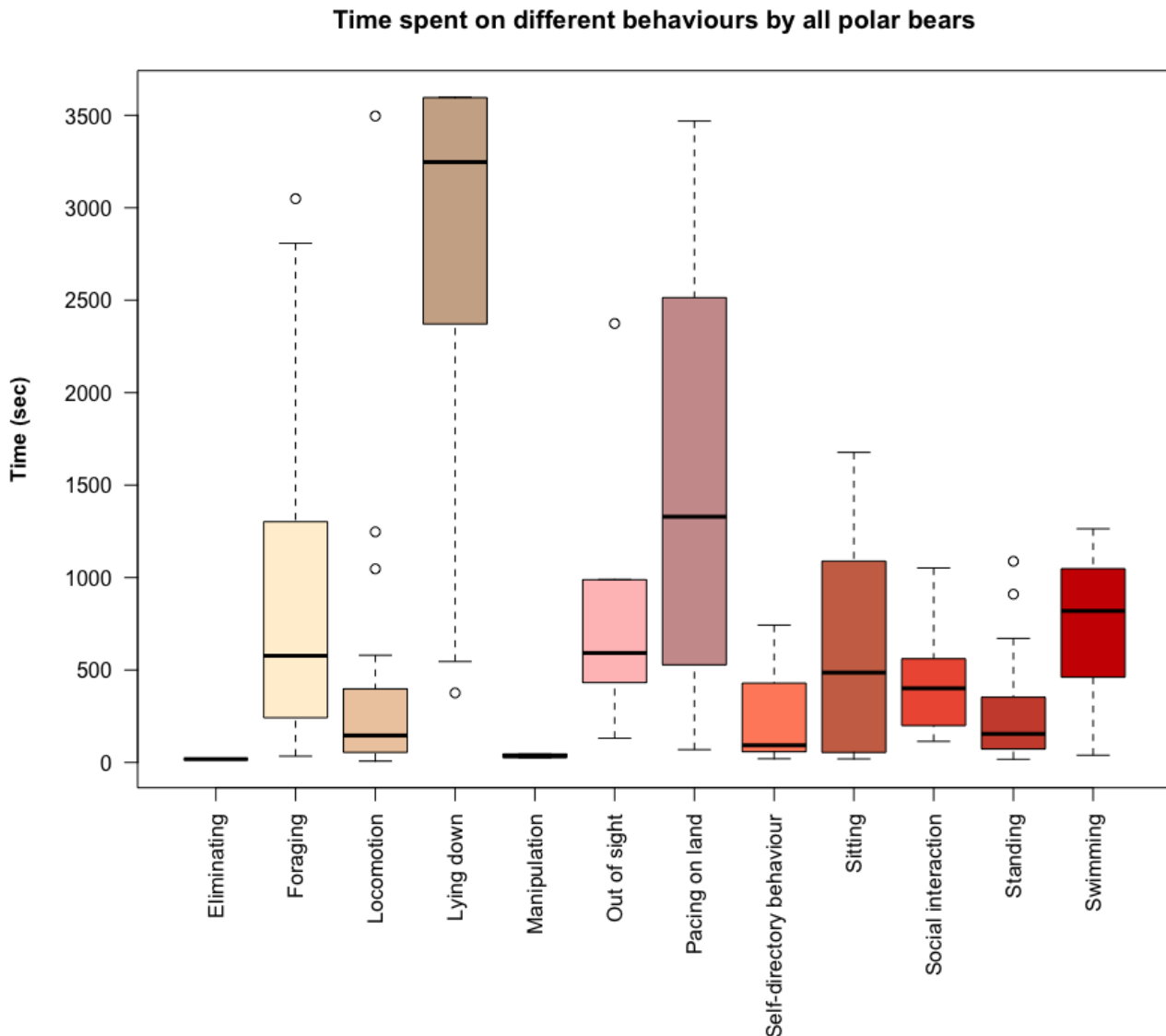


Fig. 2 Boxplot illustrating the maximum, minimum, and median time in seconds spent on each behaviour by all polar bears (N = 10) resulted from focal observation data

Pacing in water were not recorded. Lying down was performed for the longest consecutive period with an average of 48 minutes and Pacing on land is the behaviour with the highest variety in duration and the second highest duration with an average of 25 minutes (Fig. 2).

The age of the polar bear ($\beta = 2.45 \times 10^{-6}$, $SE = 1.296 \times 10^{-5}$, $P = 0.850$) and the performance of either stereotypic or normal behaviour ($\beta = 3.631 \times 10^{-4}$, $SE = 1.862 \times 10^{-4}$, $P = 0.052$) were found not to have an influence on the time spent in seconds on a behaviour. The sex of the polar bear did influence the time spent on a behaviour ($\beta = 9.949 \times 10^{-4}$, $SE = 2.319 \times 10^{-4}$, $P < 0.001$). The average time spent on inactive behaviours (i.e.: Lying down and Sitting) by females is higher (51 minutes) compared to males (38 minutes). Looking at the active behaviours (i.e.: Eliminating, Foraging, Locomotion, Manipulation, Self-directory behaviour, Standing and Swimming), males spent on average more time on such behaviours (9.5 minutes) than females (7 minutes).

There were no differences found in the time spent in seconds on either stereotypic or normal behaviour by either all polar bears and by polar bears who showed stereotypic behaviour ($\beta = 7.244 \times 10^{-6}$, $SE = 1.819 \times 10^{-4}$, $P = 0.9683$ respectively $\beta = 3.98 \times 10^{-4}$, $SE = 2.46 \times 10^{-4}$, $P = 0.1085$, Fig. 1 in Appendix 1).

The polar bear's age was found to predict the performance of either stereotypic or normal behaviour ($\beta = 0.160$, $SE = 0.071$, $P = 0.0244$). The average (10 years) and maximum (15 years) age of the polar bears showing stereotypic behaviour is lower than the average (13.4 years) and maximum (22 years) age of normal behaviour, indicating that for this data set younger polar bears were more likely to display stereotypic behaviour than older bears. Looking at the number of bears in the enclosure, being housed alone or together was not found to have an influence on the performance of either stereotypic or normal behaviour ($\beta = 18.609$, $SE = 1525.987$, $P = 0.99$).

Discussion

I studied the stereotypic behaviour in ten zoo-housed polar bears and explored if age and sex influenced the performance of such behaviour. It was found that all performed behaviours were independent, they had no influence on the time spent on any of these behaviours. In addition, age and the behaviour category (i.e.: stereotypic or normal behaviour) also did not have an influence on the time spent on a behaviour. Sex of the polar bear was found to be influencing the time spent on a behaviour, females spent more time on inactive behaviours than males whereas males spent more time on active behaviours. Furthermore, the main finding of this study was that only three (Nivi, Wolodja and Wilbär) from the ten polar bears performed stereotypic behaviour during the observation period. From my observation population could be concluded that age was a predictor for the time spent on stereotypic behaviour. Furthermore, it was found that younger bears were more likely to display stereotypic behaviour than older bears. Focusing on sex, no statistical test could be conducted since there were no females showing stereotypic behaviour. However, since from my data set solely male polar bears showed stereotypic behaviour, it implicates that in current data set males were more prone to show stereotypic behaviour. The number of bears in the enclosure was found not to have an influence on the performance of stereotypic behaviour in this study. Hence that the only stereotypic behaviour observed for this study is pacing on land. Other stereotypic behaviours, like head shaking, were also observed but solely performed simultaneously with the pacing on land. Therefore, it was chosen to not be scored separately.

It was hypothesized that the performance of stereotypic behaviour in polar bears would vary between polar bears of different age and different sex (Ames, 2000; Montaudouin & Le Pape, 2004). My results showed a variation in stereotypic behaviour influenced by age, with younger polar bears being more prone to show stereotypic behaviour than older polar bears. A plausible explanation for this is that older animals are more restricted in their physical ability and therefore show less motor stereotypic8 behaviour like pacing than younger individuals (Gottlieb et al., 2013, 2015). This could be a reason for the younger bears being more likely to display stereotypic behaviour than older bears and the little to no movement by the two oldest bears in the study population, Rocky (20 years) and Felix (22 years). Moreover, age being a predictor for the performance of stereotypic behaviour is in line with the study of Montaudouin & Le Pape, (2004), who studied stereotypic behaviour in 16 European brown bears (*Ursus arctos arctos*) in six different parks. Subsequently, in their study, young and medium aged bears performed the most stereotypic behaviours, which is also in line with our study. Contradictory to this hypothesis are the results of other studies who found that red pandas (*Ailurus fulgens*) and different bear species displayed more stereotypic behaviour with an increasing age (Khan et al., 2022; Vickery & Mason, 2003). A possible explanation for this result could be the longer exposure to risks associated with captivity which could be a trigger for displaying stereotypic behaviour. One could also argue that the performance of stereotypic behaviour is enhanced by the inability to perform species specific behaviour (Browning, 2020; Clubb & Mason, 2007). And that older bears may experience this inability for a longer period and therefore display more stereotypic behaviour. As for the variable sex being a predictor for the performance of stereotypic behaviour, no statistical test could be performed and no results were available.

Regarding the fact that in our study only males showed stereotypic behaviour could be either coincidence or correlated to biological factors like experiencing frustration evoked by being housed with (unreachable) females, which in this case could be true for Wilbär (Ames, 1993). In addition, in this study, males spent on average more time on an active behaviour than females. The physical activity level could also be correlated with the result of only males showing motor stereotypic behaviour like pacing. However, this can only be concluded when future studies perform statistical analyses on this matter. For this study, the number of bears in an enclosure did not influence the performance of stereotypic behaviour. However, these results are questionable and may not be representative for the actual situation because of limited data. There were 32 observation hours for the polar bears who performed stereotypic behaviour, from which only 2 hours Nivi and Wolodja were housed together. It is crucial that this will be elaborated on in future studies since polar bears in the wild mostly live solitary and only meet once per year to mate, being housed together or alone could be an important parameter and therefore it is crucial to look into this (Ames, 1993; Armstrup, 2003).

Although my research is an important start, more elaborate studies need to be conducted regarding the subject to optimize the welfare of zoo-housed polar bears and other species. One future recommendation is regarding the influence of sex on stereotypic behaviour. Since no statistical test could be conducted regarding the influence of sex on stereotypic behaviour in current study, a potential future study could be performed with more polar bears or other species from both sexes to gain more knowledge on the influence of sex on stereotypic behaviour. Also, all estimates retrieved in the model are very close to zero and their standard errors are close to the values of the estimates. A possible explanation for this could be the rather small sample size and that only three polar bears displayed stereotypic behaviour. Therefore, it is recommended to repeat this study with a bigger sample size and more data. To further extend research on this subject, varying weather conditions need to be taken into account. Current study was conducted in late fall / winter, where ambient temperatures were fairly low and are most similar to the natural habitat of polar bears. To gain more representative results to the current housing conditions of captive polar bears in zoos, this study should be conducted in warmer weather conditions as well, where polar bears are likely to feel more stressed. This is indicated in the study of Leishman et al., (2022), where was found that an ambient temperature of 20 °C and above, caused cortisol levels of zoo-housed polar bears to be significantly higher. In addition, since male polar bears are only sexually active during spring (Spörndly-Nees et al., 2019), it is important to observe during this period too. In this way comparisons can be done and potential seasonal variance in the performance of stereotypic behaviour may be concluded. Most importantly, since stereotypic behaviour is not only common in polar bears, it is essential that the influences of age and sex on abnormal behaviour, and other variables, are explored in other captive species as well. Lastly, since visitors are a crucial component in a zoo, for future studies one could also add the influence of these visitors as a predictor for the performance of abnormal behaviour.

The results of this study can function as a starting point for further investigation regarding the different housing conditions in relation to stereotypic behaviour of polar bears and other zoo-housed animals. In the results of this study can be found which polar bears do and do not show stereotypic behaviour, which may be correlated to their housing and other living conditions. This allows zoos the opportunity to re-evaluate their housing and consult with

other zoos housing polar bears, in order to maximize the welfare of these individuals. Some potential housing factors influencing the behaviour and well-being of polar bears could be the level of enrichment, positioning of the exhibit influencing their vision and smell or mixing females and males in one enclosure.

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Appendix 1

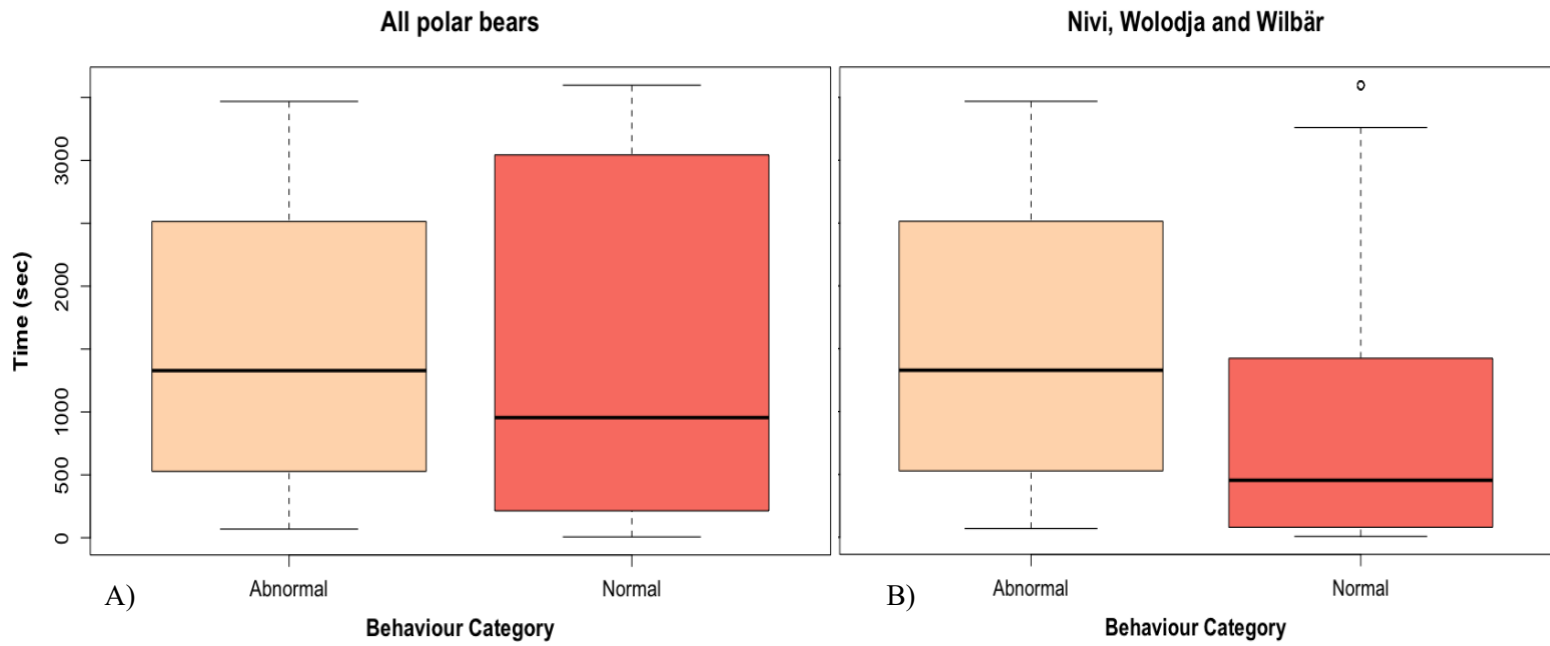


Figure 1 A) Boxplots of time spent on abnormal and normal behaviour by all polar bears (N = 10). B) Boxplots of time spent on abnormal and normal behaviours by only polar bears who showed stereotypic behaviour (N = 3).