MEDDOCS Open Access Publisher

ISSN: 2640-1223

Journal of Veterinary Medicine and Animal Sciences

Open Access | Research Article

The Challenges of using Camera Traps to Investigate Zoo-Housed Polar Bear (*Ursus maritimus*) Nocturnal Behaviour

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Received: Jul 20, 2021

Accepted: sep 08, 2021

Published Online: Sep 10, 2021

Journal: Journal of Veterinary Medicine and Animal Sciences

Publisher: MedDocs Publishers LLC

Online edition: http://meddocsonline.org/

Keywords: Ursid; Zoo Biology; Camera trap; Remote behaviour recording.

Abstract

The polar bear (*Ursus maritimus)* was historically a regular feature of zoological collections, but has become less common in zoos in many countries. Historic exhibit designs for polar bears were often small and did not always allow the animals to express much natural behaviour or locomotion. However, advances in polar bear enclosure design, focusing on greater roaming and swimming opportunities, may make the keeping of this species more feasible. There is a need to gather evidence on the appropriateness of these exhibits, particularly where multiple bears are being held. Behavioural and enclosure use observations were conducted on four male polar bears housed in an extensive exhibit at Yorkshire Wildlife Park, using 24-hour camera trap observations. Overall, active behaviours, such as locomotion, were identified during both the day and night, though bears appeared more active during the day. The bears displayed both affiliative and aggressive interactions toward one another, though these interactions were rare. Observations of stereotypy were rare, but did vary between individuals. Camera traps, whilst useful for recording behaviour at all hours, collected information only on active behaviours or bears rather than small behaviours or inactivity. This study is valuable in that it suggests that group housing may be a feasible option for polar bears, provided the animals are given sufficient space and environmental complexity and opportunities to move away from one another.

Cite this article: Pastorino GQ, Cartwright R, Brereton JE, Wilkins K, Preziosi R. The Challenges of using Camera Traps to Investigate Zoo-Housed Polar Bear (*Ursus maritimus*) Nocturnal Behaviour. J Vet Med Animal Sci. 2021; 4(2): 1080.

Introduction

The polar bear (*Ursus maritimus)* is a popular zoo-housed species, and has also been cited as one of the public's top ten most charismatic animal species [1]. Historically, polar bears were a popular sight in many zoos across the globe. However, many collections have phased out polar bears from their collections: this is in part due to challenges associated with their care [2, 3]. Polar bears are susceptible to stereotypy under captive conditions [4]. Many researchers suggest this is a sign that polar bears struggle to cope, particularly in smaller or in simplistic exhibits [2,3].

Polar bears have been housed in captivity for hundreds of years, with early reports including a bear housed in the Tower of London menagerie, where it was provided with opportunities to fish from the Thames [5]. Historic exhibits, such as the bear pits of Dudley Zoo and the Menagerie du Jardin des Plantes, may not have provided optimal welfare for bears as they were traditionally small, with limited enrichment or opportunities for exercise [5]. In the wild, polar bears roam over vast regions and spend much of their lives alone [4]. Restricted space, close visitor viewing and sometimes shared quarters with other bears may have resulted in stressed individuals in the past.

In response to welfare issues raised, polar bears were progressively phased out of zoological collection plans in the United Kingdom (UK) [5]. For example, collections that had historically housed the species, such as both Dudley and London Zoo, made decisions to remove them from their collection plans. Eventually, only a few polar bears remained in the UK by the early 2000's. However, the number of polar bears in the UK has since increased to 8 (7.1) individuals, which are housed at two zoological collections.

In the wild, polar bears range over expansive hunting grounds, and are often intolerant of other bears, with males often engaging in aggression and infanticide [4]. Even in areas where food is abundant, such as Hudson Bay, polar bears keep their distance from each other and display affiliative behaviour to one another only infrequently [6]. In Hudson Bay studies, polar bears were shown to segregate themselves by sex and age category. However, while interactions between individuals are low, large congregations of bears can occur in areas where food is easily available, such as in garbage dumps [6,7]. These congregations do not appear to show the same level of aggression as occurs in solitary individuals who are defending territories. Additionally, these congregations of bears may be becoming more common, particularly as a result of global warming where the ice is becoming a more challenging place to find food [7].

Enclosure styles and husbandry routines for UK polar bears have been modified in order to better reflect their natural ecology [8]. In order to best match the wild habitat of polar bears, UK collections now house their bears in large, open-air exhibits as opposed to smaller, confined enclosures or pits [9]. However, the bears are still often maintained in small social groups of up to four individuals.

Many solitary carnivores are housed in social groups in captivity: examples include tigers (*Panthera tigris)* and leopards (*Panthera pardus)* [10, 11]. The welfare impact of social housing is in some species minimal, and in some cases, social housing may actually be beneficial. For example, affiliative interactions have been observed between non-related tigers and leopards in captive collections [12]. In captivity, there are no constraints on food availability, which appears to be one of the greatest influences on wild carnivore sociality [2].

However, for polar bears the role of social housing may be more complex. For example, two female polar bears showed social avoidance of one another when housed in a shared exhibit [8]. Whenever a bear moved into a zone occupied by the other individual, the resident bear tended to move away to another zone [8]. While aggressive behaviours occurred infrequently, social avoidance might indicate limited compatibility.

Historically, many zoo-based studies were time-limited to periods in which the zoo was open. For many studies, this means that behaviour could be studied for only a small portion of the day, leaving much of the animal's behaviour unknown. In recent studies, new opportunities have arisen using technology such as camera traps [13]. These camera traps may allow researchers to better understand the behaviour of their animals more holistically, and identify any potential welfare issues that may not be apparent during the day.

Given the limited sociality of captive polar bears, there is a need to investigate the suitability of the new, large enclosure designs. This study, undertaken at Yorkshire Wildlife Park, was undertaken to better understand the sociality and welfare of the bears housed at the collection.

Materials and methods

Study subjects and location

Prior to the commencement of the study, the Ethics Committee of Manchester Metropolitan University approved the research project. All keepers and staff involved gave their informed consent for inclusion before participation in the study.

All animals in the study were located in the Project Polar reserve at Yorkshire Wildlife Park. The four individuals in the study were male (Table 1). Victor was the first to arrive at the park in August 2014, with Pixel and Nissan arriving in 2015 and the latest addition, Nobby, arriving in February 2016.

Table 1: Species profiles.

Name	Born	Born in	Relationship to study animals
Victor	18.12.1998	Captivity	Grandfather of Pixel
Nobby	12.12.2013	Captivity	None
Nissan	14.12.2013	Captivity	None
Pixel	16.11.2012	Captivity	Grandson of Victor

The polar bears are kept in three large outdoor enclosures (Zones 1, 2 and 3) with access to a smaller indoor enclosure space (Zone 4) that contains four off show dens and a small outdoor area containing a saltwater pool and large tree trunks (Figure 1). The total size of all enclosures is approximately seven and a half acres however there are plans in the future to build another enclosure, which will increase the total size to 10 acres.

The three large enclosure zones are comprised of an open, grassy area with small hills, lakes and at least one stone cave in each that the bears can enter and climb on top of. Enclosures 1 and 3 each contain a 30ft deep lake and enclosure 2 contains a 16ft deep lake. Enclosure 3 also contains another shallower, 5ft deep lake. All enclosures are linked by connecting tunnels

(including Zone 4), which allow the bears to roam between all paddocks and be sectioned off from one another when necessary. An aerial view of the enclosures can be viewed in Figure 1.

Figure 1: Aerial View of the Zones within Project Polar.

Behavioural observations

From 21st June to 6th October 2018, observations were undertaken for the polar bear group. Observational data were collected using Victure HC200 Trail Camera traps, which were placed in ten locations to cover the majority of the Project Polar exhibit. The camera traps were activated by motion and were set to take images of the bears when they walked in front of the sensor up to 80 feet away. They recorded data for a total of 101 days. Three cameras were placed in Zone 1, two were placed in Zone 2, three were placed in Zone 3 and two were placed in Zone 4. All behaviours identified using the camera traps were recorded, using *ad libitum* sampling. The pictures were then analysed and the observed behaviour at that time was categorized in the same way to the observational data using the ethogram [24].

Before data collection started, a behavioural ethogram was derived using Ames [24] as a baseline The ethogram was adjusted to include other behaviours seen during observations, which included 'yawn', shake', 'dive' and 'forage'. These observed behaviours were then grouped into nine categories so that activity budgets could be created.

Table 2: Categories of behaviours exhibited by the bears during direct observations.

Behaviour category	Description
Affiliative behaviour	Positive/friendly behaviours towards conspecifics such as playing, sniffing, watching, licking, nuzzling and rubbing.
Aggression	Aggressive/negative displays towards conspecifics, including biting and chasing.
Exploratory behaviour	Interacting with and scanning the environment. Handling, sniffing, tossing or rubbing against objects or parts of the enclosure.
Foraging	Bear is actively searching and consuming food. This includes chewing, biting and licking.
Grooming	Natural somatic behaviours such as drinking, urinating, defecating, grooming, yawning, licking, shaking and scratching.
Inactive	Bear is lying (on side, back or stomach), sitting, standing on four paws or upright on two paws whether on land or bathing in water.
Locomotion	Movement of the bear such as walking or running on land, diving into water, swimming in water, climbing on structures/hills, playing/sparring.
Stereotypy	Behaviour not exhibited in the wild. Pacing, or walking repeatedly along the same path or swimming along same stretch of water.
Out of sight	The bear is not visible to the researcher.

Data analysis

The results from the observations were uploaded into a Microsoft Excel™ 2016 spreadsheet, and then transferred to Minitab version 2.7 for analysis. For association-based information, a sociogram was developed to show the frequency of close proximity between individual bears. Close proximity was defined as being within one bear-length of another individual, and proximity was defined as being within two bear-lengths. For behaviour, the information for all polar bears was pooled to create one activity budget. Behaviours were converted into percentages and formatted as an activity budget.

Results

Behaviour

An activity budget was developed to show the most commonly observed behaviours across the 24-hour window (Figure 2). Locomotion was observed most commonly, whereas aggression was observed the least frequently.

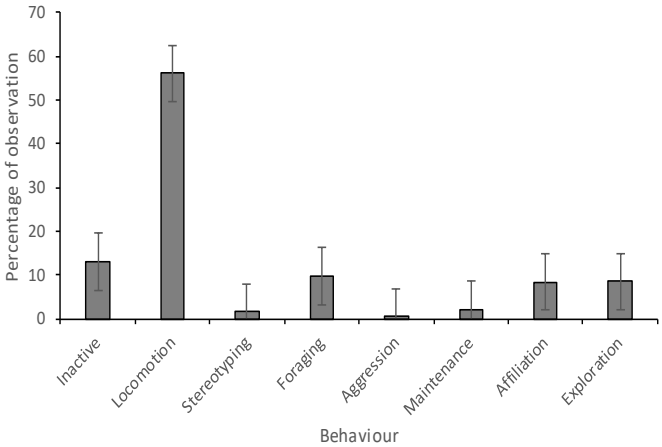

Figure 2: Activity budget for the polar bear bachelor group across the 24-hour window (+/- standard error).

Next, observations were broken down by hour, to show which behaviours occurred most commonly during each time period.

Table 3: Number of observations of each behaviour, broken down by hour.

Hour	Affiliation	Aggression	Exploration	Foraging	Inactive	Locomotion	Maintenance	Stereotyping
00					1			
01				1	2	2		
02	1	1	1	1	3	1	2	1
03	1	1	1	1	2	3	1	1
04				1	3	1		
05	1		2	1	7	7	1	
06	2	1	5	3	6	12	3	1
07	5	1	4	13	6	37	3	2
08	9	2	12	9	10	57	2	1
09	12	1	21	18	15	87	2	2
10	9	1	29	31	7	110	3	1
11	7	1	11	17	6	68	2	
12	8	1	9	9	10	50	2	1
13	3	1	12	9	4	47	2	1
14	5	1	12	5	3	35	1	1
15	8	1	9	11	8	45	1	
16	6		7	7	8	40	2	
17	2		1	5	7	29	1	
18	5		4	7	11	25	4	
19	5		2	5	8	18	3	
20	1		1		3	8		
21			1		2	9		
22	2			2	5	7	1	
23				1	3	3		
T	92	13	144	157	139	701	36	12

Sociality

Out of 758 observation with proximity information available, bears were observed to be alone in 522 (68.87%) instances. For the remainder, bears were seen in proximity 78 (10.29%) and close proximity in 158 (20.84%) observations respectively. A sociogram was also constructed (Figure 3).

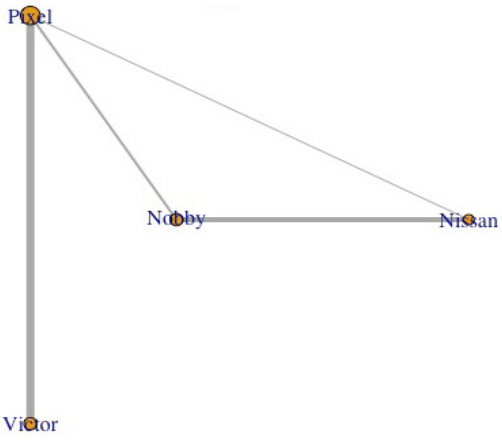

Figure 3: A sociogram of the bears, based on proximity. The thickness of the edge (line) between individuals indicates the frequency in which the two individuals were seen together.

Discussion

Behaviour

The most commonly observed behaviour in the study was locomotion, with foraging and exploration appearing slightly less commonly. In part, the camera data collection method might have resulted in more active behaviours being captured, as inactive behaviours may have been more difficult to observe. It is important to note, however, that stereotypy, an active behaviour that normally involves route tracing, was observed the least number of times of all behaviours. This is despite the fact that stereotypy has been commonly observed in captive polar bears [8, 2]. This is promising as the camera trap method was likely to pick up movement-related behaviours, as shown by the high locomotion scores. This suggests that stereotypy is occurring, but at a much lower rate than has been seen in some studies [2,3]. Stereotypy may sometimes occur long after the original stressful scenario has disappeared [14], so it is possible that the relatively small amount of stereotypy was an example of a 'behavioural scar', rather than indicative of poor welfare.

The individuals Victor and Pixel were seen most often in close proximity. Victor was rarely seen in proximity to any individual other than Pixel. Weak proximity-based associations were also seen between Nobby, Nissan and Pixel. In the enclosure, there was sufficient space for all individuals to avoid one another so interesting to note that the animals had chosen to spend time in proximity to one another.

Polar bear behaviours were observed less frequently during the night. From roughly 20:00 until 04:00, few behaviours were captured by the trail cameras. The cameras were able to function throughout the night and were equipped with good night vision, so it is unlikely that this is an artefact of the cameras themselves. Instead, it appears that the zoo-housed bears were less active during these time periods. It is promising to note that stereotypy did not appear to occur during nocturnal hours: it was instead typically associated with zoo open hours. Instead, bears engaged occasionally in bouts of foraging and locomotion, though inactivity was occasionally also caught using the trail cameras. Providing the bears with constant access to all areas of their exhibit may be important to allow the animals to engage in occasional night behaviours, and to prevent frustration-related stereotypy occurring if animals are locked in [3].

Sociality

Affiliative and aggressive behaviours were observed only rarely, with affiliative behaviour seen more frequently than aggression. While it is likely that the cameras did not pick up every incidence of interactions, it should also be noted that other behaviours were picked up far more commonly. This suggests that the polar bears engaged in social interactions only rarely. This is interesting to note, as the bears did often spend time in close proximity to one another. The bears may have sent time in proximity to one another yet rarely interacted during these time periods.

Aggressive behaviours occurred rarely. The distance between bears may have been a more effective way of dealing with disputes than by fighting, as bears could choose to avoid conspecifics. There were only a handful of occurrences of aggressive behaviour observed throughout the 24-hour window. It should also be taken into account that aggressive behaviours might actually be play fighting as the two behaviours look similar. It is therefore important not to take the aggression as a negative welfare indicator [7]. Similar results have been identified in previous captive polar bear research [8, 15].

However, the higher proportion of affiliative behaviours should be noted as this has not been reported elsewhere. The affiliation is surprising as all individuals were adult males, and only two individuals were related to each other. This higher level of affiliation between individuals suggests that polar bears may be able to alter their social behaviour to suit different contexts. This may link to the congregations of bears in areas of plentiful food in the wild [6].

It has been suggested by previous authors [7] that polar bears have a level of social plasticity, and are able to adjust their tolerance of other bears to suit their situation. A similar plastic sociality is seen in other carnivores, such as tigers. Where food is scarce, these carnivores become intolerant of one another and maintain large territories in order to secure sufficient food [2]. By contrast, where food is available, the animals may become much more tolerant of one another [6]. The availability of food and large exhibit design at Yorkshire Wildlife Park may allow the bears to be more social, and thus coexist in their shared exhibit.

Camera traps and future directions

Camera traps allowed data to be collected during time periods when zoo visitors would not normally have access to the animals [13]. In this respect, the cameras allowed a gap in the literature to be filled that is not typically covered in zoo studies [14]. Furthermore, the trail cameras identified that there was relatively little evidence of welfare concerns during these time periods. However, the cameras did possess several limitations which could be overcome in future studies.

One major challenge was the motion-triggered nature of the cameras. This may have resulted in active behaviours being picked up more than inactive, resting behaviours. For the purpose of this study, which focused on social interaction and stereotypy, this was not a major problem. However, it does limit the application of the activity budget to other studies as the true prevalence of inactivity is likely to be under-represented. Future studies could make use of cameras that take pictures at a pre-set time period (e.g. once per ten minutes). Whilst this may increase the proportion of 'out of sight' observations, it would allow findings to be generalised against other studies.

Similarly, the importance of small postural changes and auditory communication is underappreciated in camera trap footage. Vocalisations, for example, could not be detected. Auditory communication between bears may indicate aggression or affiliation, and could therefore provide further context for the interaction and proximity data found in the study. To overcome this issue, future studies could make use of decibel readers or cameras with audio recording capabilities, in order to investigate behaviour in greater depth.

Conclusion

This study identified some social interaction between the four male polar bears of the study. The limited aggression (which may also be play fighting) yet relatively higher occurrence of affiliative behaviours is interesting, particularly amongst adult males. This suggests that polar bears may actually be better able to cohabit than existing research suggests. There may be some level of social plasticity for the bears, allowing them to coexist with others. However, the size of the exhibit may be cru-

cial. It is therefore essential that any new polar bear exhibits being developed should contain sufficient space and visual barriers that bears can choose to spend time apart.

Project Polar has received considerable media attention and as such, has become a focus for polar bear welfare and husbandry in captivity. As such, it is essential that further research is conducted to determine whether the new initiative is a success.

Based on the research of this study, it is reasonable to conclude that polar bears do exhibit social behaviours, particularly affiliative behaviours on occasions and should not be categorised as completely asocial. As there are still research gaps on wild and captive polar bear social behaviour, it is important that further research continues to enhance this understanding, improving the best practice guidelines for captivity for this species.

Acknowledgements

The authors are grateful to the keepers at Yorkshire Wildlife Park for their support throughout the project.

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