

Evidence-based practice

## The effect of different types of environmental enrichment on Humboldt penguin *Spheniscus humboldti* behaviour

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**Abstract**

Penguins exhibited at zoological institutions can be prone to a foot condition known as pododermatitis (or bumblefoot) if they have high levels of sedentary behaviour. Providing penguins with environmental enrichment can increase activity levels by offering opportunities to engage in species-appropriate behaviour such as swimming and locomoting around the exhibit. The goal of the current study was to provide different types of enrichment to Humboldt penguins *Spheniscus humboldti* at the Brookfield Zoo with the aim of increasing their activity levels and time spent in the water. The four types of enrichment were the provision of artificial sticks, live minnows, and a floating island, and feeding the penguins in the water. Each of the four enrichment conditions lasted two weeks and was preceded by two weeks of receiving no new enrichment. Behaviour and location (nest, land, water) were recorded for each subject during both the baseline and enrichment conditions. The artificial sticks ( $Z=-2.74$ ,  $P=0.01$ ) significantly increased activity levels for the group. No significant differences were found for the other three enrichment conditions or with time spent in the water. It is hoped that the enrichment used in this study can enhance the welfare of penguins by increasing the amount of exercise they receive which will in turn decrease the risk of acquiring bumblefoot. Future studies can test other types of enrichment to determine the types that are most effective to increase activity levels.

**Background**

Although a common species of penguin housed in zoos, Humboldt penguins *Spheniscus humboldti* have limited research surrounding the impact of enrichment on their behaviour. In the wild, Humboldt penguins were once thought to be a sedentary species that stays close to its breeding nest sites year-round (Culik et al. 2000). However, recent studies have shown that although not specified as a migratory bird, Humboldt penguins can travel long distances to avoid severe climate conditions or to search for their main source of food—anchovies and sardines (Culik and Luna-Jorquera 1997; Culik et al. 2000). For penguins in zoos, activities such as swimming and more movement around the exhibit are encouraged, as

high levels of sedentary behaviour can be associated to foot issues known as pododermatitis, or bumblefoot (Sawyer 1983). Wallace and Walsh (2005) have stated that increased swimming time is one of the ways to prevent the appearance of bumblefoot. A study with Magellanic penguins (Reisfeld et al. 2013) aimed to reduce bumblefoot lesions with increased environmental enrichment. The authors suggested that more time spent in the water correlated with a decrease of bumblefoot lesions in the five subjects (Reisfeld et al. 2013). Although studies that explicitly research the prevalence of bumblefoot are important, additional research on the use of enrichment to increase the activity levels of penguins is still needed.

There are only a few studies that specifically research the impact of environmental enrichment on Humboldt penguin

behaviours, and all have mixed results. Clarke (2003) provided Humboldt penguins with pieces of tin foil sealed in bottles (to mimic the reflective nature of fish scales) but found no significant change in activity. Similarly, Larsson (2012) aimed to increase the use of the enclosure by developing a floating enrichment device. The author observed an increase of pool usage from the subjects; however, this result was not significant, and the increased diving behaviour was most likely due to the novelty of the enrichment item (Larsson 2012; Collins et al. 2016). Given the lack of study on environmental enrichment in penguins, more research is necessary to better understand the impact of environmental enrichment on penguin behaviour.

The purpose of current study was to provide different types of enrichment to Humboldt penguins with the aim of increasing their activity levels and time spent in the water. The four types of enrichment chosen were based on behaviours seen in wild Humboldt penguins. For a natural predator, using live prey can be great enrichment item to increase activity levels (Larsson 2012). Since wild Humboldt penguins spend most of their time in the water searching for food, artificial sticks were placed in the water with the aim of increasing attention to the water and promoting species-appropriate diving and swimming behaviours. In addition, creating an enrichment item following a similar design to Larsson's (2012) floating device, it was expected that the penguins would increase their time spent in the water. Finally, hand-feeding is a common practice for zoo penguins and it is hoped that by allowing the penguins to be fed in the water, it can increase their species-appropriate behaviours of swimming and foraging. By testing different types of enrichment, this study could help determine which enrichment has the greatest impact on overall activity levels and time in the water. This information can be used to ensure zoos are meeting the behavioural needs of Humboldt penguins.

## Action

### Study animals

The subjects of this study comprised of 16 Humboldt penguins (9 males, 7 females) (Table 1). All were hatched at zoological institutions (Brandt 2015). The subjects ages ranged from 1 year old to 14 years old (Mage=6.4 years).

### Study site

The penguins are housed inside the Living Coast building at the Chicago Zoological Society — Brookfield Zoo (Brookfield, IL). The entire exhibit is surrounded by rock substrate and includes two small glass viewing windows in the front. There are 17 nest boxes along the back wall that lead to an indoor housing area. The 20,000-gallon freshwater pool in the exhibit is approximately 9 m long and 4 m wide. The exhibit is an indoor, free-flight exhibit that also houses Inca terns *Larosterna inca* and common grey gulls *Leucophaeus modestus*.

### Enrichment conditions

The study was conducted from January to April 2015. Four new enrichment items were introduced to the subjects. Each enrichment condition lasted two weeks, preceded by two weeks of baseline data collection. The four conditions were: six artificial sticks, live minnows *Notemigonus crysoleucas*, a floating island, and feeding the penguins their normal diet in the water. The artificial sticks were made of plastic and were placed around the exhibit and in the water. Each artificial stick was approximately 25×7 cm, and all were filled with foam for buoyancy (Figure 1). For the live minnows, one bucket of approximately 100 to 200 live minnows were casted into the water. The use of live minnows as enrichment followed the study institution's guidelines that establishes a framework to ensure the appropriate and humane

**Table 1.** Descriptive information of study subjects.

Name	Sex	Age (years)
P1	Male	8
P2	Female	3
P3	Male	12
P4	Female	5
P5	Male	3
P6	Male	7
P7	Female	7
P8	Male	1
P9	Male	6
P10	Male	5
P11	Female	8
P12	Male	3
P13	Female	14
P14	Female	12
P15	Female	5
P16	Male	4



**Figure 1.** Photo of the artificial sticks used in the study.

**Table 2.** Ethogram of behavioural states.

Category	Behavioural state	Definition
Active	Swimming	Focal animal is beneath the surface of the water, using flippers to move from one point to another.
	Locomoting	Focal animal is moving on land in the form of walking, hopping or running.
	Feeding	Focal animal is actively consuming or manipulating food items (i.e., fish).
	Preening self	Focal animal is using beak to maintain feathers.
	Self-maintenance	Focal animal is using flippers, objects, or environment to scratch anywhere on the body, or shaking head or body to remove water.
	Interacting with enrichment	Focal animal is manipulating an enrichment device (e.g., artificial sticks, live minnows, floating island).
	Social negative	Focal animal is engaging in negative behaviour with another penguin (e.g., chasing, pecking).
	Social positive	Focal animal is engaging in positive behaviour with another penguin, includes reproductive behaviour (e.g., allo-preening, bill clattering, flipper patting, mounting).
Inactive	Resting	Focal animal is on land and is lying down on stomach with eyes open or closed.
	Floating	Focal animal is resting or moving on the surface of the water, without sinking or moving flippers.
	Standing	Focal animal is on land and in an erect position.
Other	Other	Focal animal is engaging in any behaviour not listed above.
Not visible	Not visible	Focal animal is not visible.

care of live prey (Schaeffer 1992). For the floating island, a raft was created specifically for this study (Figure 2). The floating island was a 1 m<sup>2</sup> raft made of foam buoyancy billet material and encased in polyvinyl chloride (PVC) to protect it from the penguins. The raft has four to five PVC pipes on two of its sides to look like branches. The floating island was not tethered down and floated around the



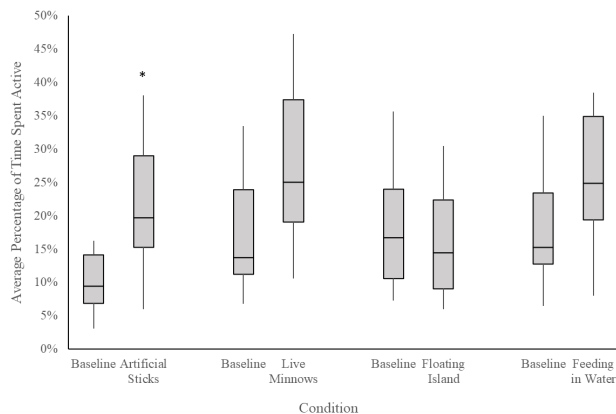
**Figure 2.** Photo of the floating island with one of the study subjects (P16) interacting with it.

exhibit pushed by the water's current. The intention was for the penguins to swim up to it and interact with other birds on it. For the final condition, the penguins were hand-fed their normal diet in the water.

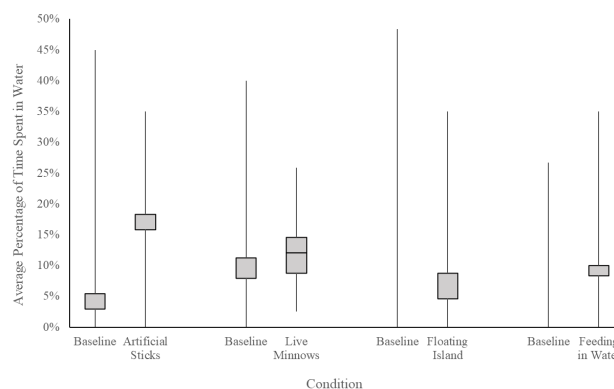
The penguins were offered a diet comprised mostly of capelin *Mallotus villosus* and a small portion of Atlantic herring *Clupea harengus*. Each feeding session started when an animal care staff member entered the exhibit and lasted approximately 10 min. The penguins are normally hand-fed twice a day at 1030 h and at 1530 h. The conditions of artificial sticks and floating island were presented to the subjects each day of its enrichment weeks at approximately 1030 h and were removed at 1545 h. The condition of the live minnows was presented at 1100 h, after the morning feed (a new bucket of minnows was presented every morning of its enrichment weeks because all the minnows would be eaten by the end of each day). For the final condition, animal care staff fed the penguins their normal diet at 1030 h and 1530 h and only fed the penguins when they were swimming in the water.

#### **Data collection**

Data were collected between January 2015 and April 2015. Behaviours were observed prior to the study period and an ethogram was developed from these behaviours (Table 2). The observation schedule was based on observer availability and observations were balanced throughout the study. Each subject was observed for a total of 10 min either in the morning (1100 h to 1400 h) or in the afternoon (1400 h to 1700 h) in a random order for three days a week, based on a schedule using Microsoft Excel. Behavioural data and location (nest, land, water) were collected from each subject using instantaneous sampling at 1-min intervals (Altmann 1974). Each subject had a total of 120 min of data for each four-week period (baseline and enrichment condition), for a total of 480 min per subject throughout the 16-week study. A new baseline was established after each enrichment condition in case there were seasonal changes in penguin behaviour.



**Figure 3.** Median (and IQR) percentage of time spent active of the group between the baseline weeks and enrichment weeks for each condition. \* $P < 0.05$ .



**Figure 4.** Median (and IQR) percentage of time spent in the water of the group between the baseline weeks and enrichment weeks for each condition.

### Statistical analysis

All data were corrected for time visible. The average amount of minutes an animal was not visible during the study was 0.89 [interquartile range (IQR)=0.63] min. Activity levels for each subject were calculated by combining eight behavioural states for a simplified analysis to reduce the chance of type one error. These eight behavioural states were: swimming, locomoting, feeding, preening self, self-maintenance, interacting with enrichment, social negative and social positive (Table 2). Percentage of time each subject spent in water was calculated by dividing the number of minutes in the water (regardless of behaviour) by the total number of minutes visible. The activity levels and time spent in water were compared between the baseline weeks and enrichment weeks for each condition using a Wilcoxon signed-rank test. The Wilcoxon signed-rank test is a non-parametric test and was chosen based on the non-normal distribution of the data. All data were analysed using SPSS (Version 22) and alpha levels were considered significant at  $P < 0.05$ .

### Consequences

#### Results

Significant differences in activity levels were found for one out of the four conditions. The artificial sticks ( $Z = -2.74$ ,  $P = 0.01$ ) significantly increased percentage of time active for the group. No significant differences in activity levels were found for the other three conditions: live minnows ( $Z = -1.34$ ,  $P = 0.18$ ), floating island ( $Z = -0.10$ ,  $P = 0.92$ ), feeding in the water ( $Z = -1.71$ ,  $P = 0.09$ ). The median (and IQR) percentage of time spent active were calculated comparing each baseline and condition: artificial sticks [baseline=7.29 (6.40), condition=13.75 (13.79)], live minnows [baseline=12.66 (6.97), condition=18.33 (14.47)], floating island [baseline=13.39 (9.46), condition=13.34 (8.49)], and feeding in water [baseline=10.64 (8.78), condition=15.52 (16.92)] (Figure

3). In addition, Table 3 displays median (IQR) percentage of time spent active for each individual animal.

No significant differences in time spent in the water were found for any of the conditions: artificial sticks ( $Z = -0.60$ ,  $P = 0.55$ ), live minnows ( $Z = -0.16$ ,  $P = 0.88$ ), floating island ( $Z = -0.63$ ,  $P = 0.53$ ), feeding in the water ( $Z = -0.46$ ,  $P = 0.65$ ). The median (IQR) percentage of time spent in the water for each condition is as follows: 2.50 (18.33) for artificial sticks, 5.83 (9.58) for live minnows, 4.17 (8.75) for floating island, and 1.67 (10.00) feeding in water (Figure 4).

Zoos and aquariums have increased focus on using environmental enrichment to promote the occurrence of species-appropriate behaviours and high behavioural diversity, which may suggest good animal welfare (Mellen and Sevenich MacPhee 2001; McPhee and Carlstead 2010; Miller et al. 2016). In this study, the addition of the artificial sticks significantly increased activity levels, which suggests that certain environmental enrichment can impact overall activity in the Humboldt penguins housed at the Brookfield Zoo. Although the study did not investigate the presence of bumblefoot with the subjects, with increased activity levels it is possible the enrichment provided in this study can enhance the subjects' welfare through increased exercise and decreased risk of bumblefoot (Reisfeld et al. 2013).

The addition of the artificial sticks significantly increased penguin activity levels. The artificial sticks were placed all around the exhibit but mostly in the water, where they floated. Although there was another floating enrichment condition, the floating island, it is believed that the artificial sticks promoted more interest as there were multiple sticks spread around the exhibit. The artificial sticks may have increased attention to the water as floating objects can add to the complexity of the exhibit which allowed the penguins to explore more of their environment (Clark 2013). While the behaviours are different, polar bears and brown bears may have engaged more in aquatic play when floating objects

**Table 3.** Median (IQR) percentage of time spent active per individual animal.

ID	Artificial sticks	Live minnows	Floating island	Feeding in water
P1	20.00 (29.17)	30.00 (45.00)	5.00 (17.50)	10.00 (10.71)
P2	18.33 (15.83)	5.56 (25.28)	10.00 (23.75)	30.00 (29.17)
P3	10.00 (15.00)	0 (7.50)	0 (15.00)	25.00 (20.00)
P4	10.00 (20.00)	0 (0)	10.00 (16.67)	0 (0)
P5	15.00 (27.14)	21.11 (23.06)	10.00 (12.50)	28.75 (34.38)
P6	5.00 (10.00)	5.00 (17.50)	17.14 (31.43)	0 (0)
P7	11.25 (17.29)	11.11 (20.00)	0 (0)	5.00 (17.50)
P8	25.00 (20.00)	20.00 (20.00)	0 (11.11)	0 (0)
P9	20.00 (15.00)	0 (0)	10.00 (21.67)	0 (7.50)
P10	0 (7.50)	10.00 (27.50)	20.00 (30.00)	0 (0)
P11	0 (0)	16.11 (40.56)	10.00 (10.00)	10.00 (20.00)
P12	15.00 (55.00)	15.00 (10.00)	15.56 (27.22)	5.56 (17.78)
P13	0 (0)	18.33 (15.83)	0 (7.50)	26.67 (33.33)
P14	6.25 (25.63)	25.00 (30.00)	0 (7.50)	15.00 (20.00)
P15	0 (0)	25.00 (32.50)	10.56 (15.28)	10.00 (22.50)
P16	7.14 (26.07)	5.00 (25.00)	0 (15.00)	21.67 (43.33)

were in their exhibit (Carlstead et al. 1991). The artificial sticks did not increase total time spent in water; however, the increase in overall activity levels could be suggestive of good animal welfare due to meeting an animal's energetic needs (Mellen and Sevenich MacPhee 2001; McPhee and Carlstead 2010).

It is important to note that the presentation of each enrichment condition differed: the conditions of artificial sticks and floating island were presented in longer durations each day, while the conditions of live minnows and feeding in water were presented in shorter periods each day. If an object stays in an environment for longer periods of time, animals may start to lose interest in a process called habituation (Domjan 2000; Kuczaj et al. 2002). Kuczaj et al. (2002) tested the effects of habituation on zoo-housed animals and found that animals were more likely to interact with enrichment when presented in shorter intervals (i.e., 1 to 15 min at a time) than presented in longer durations (i.e., 60 min at a time), suggesting that habituation can occur quickly. While examining the process of habituation was not part of the current study, future research could examine the impact of introducing an item intermittently over a longer period of time.

When focusing on the welfare of animals, it is always important to consider individual differences. While there were significant changes for the group with the addition of one type of enrichment, the individual variation within each condition was apparent (Table 3). While individual results were not examined, the variability observed demonstrates the importance of assessing each individual's behaviour. This information can help zoos and aquariums ensure their enrichment programmes are meeting each individual animal's behavioural needs.

Overall, the purpose of this study was to provide different types of environmental enrichment to Humboldt penguins with the aim of increasing their activity levels and time spent in the water. Even though one condition significantly increased activity levels, it is

important to consider the individual as individual variation was prominent. Other factors that were not measured should also be considered for future studies—such as the differences in age, sex and breeding status and how this affects individual responses to enrichment. Given that three of the conditions had no significant effects, there is a need for future research to understand other types of enrichment that can promote species-appropriate behaviours of penguins as well as longer-term studies to gather the effect of the enrichment over time. In addition, future research could include how environmental enrichment can improve not only activity levels of the animals but also their physical health (e.g., reducing the risk and presence of bumblefoot), as high activity levels possibly indicate good physical health (Condon et al. 2003). It is hoped that the information gathered from this study can add to the limited research of penguins in zoo settings and can help with the assurance that individuals of this species continue to thrive in zoos and aquariums.

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