

Organization of Bibliography: The bibliography begins with the secondary sources to provide the reader with background information on stereotypic behaviour and environmental enrichment. These are followed by the primary sources which provide evidence for the effect of various enrichment methods on stereotypic behaviours. Primary articles are ordered by the date published from the oldest to most recent in order to observe how knowledge of the field has grown.

Mason, G. (2006). Stereotypic behaviour in captive animals: Fundamentals and implications for welfare and beyond. In G. Mason & J. Rushen (Eds.), *Stereotypic animal behaviour: fundamentals and applications to welfare* (2nd ed., pp. 325-341). CABI. <https://doi.org/10.1079/9780851990040.0325>

Summary:

Using the traditional definition stereotypic behaviours are defined as behaviours that are repetitive, fixed, and lacking an objective (Mason, 2006). The nature of stereotypic behaviours such as their physical forms and tendency to be repetitive and unvarying is known and well documented. Mason (2006) uses knowledge from previous chapters and literature to discuss why stereotypic behaviours are repetitive and unvarying and how the physical form is determined. Mason (2006) suggests that there are three reasons why repetition is characteristic of stereotypic behaviours. The first is that the consistency of their captive environment provides constant reinforcement for the behaviour. The second is reward and reinforcement meaning performing this behaviour may provide them with self-coping aspects. The third is behavioural disinhibition/the inability to unlearn a behaviour meaning the behaviour has become fixed. Mason (2006) then discusses how and why stereotypic behaviours are characterized as predictable and unvarying. Once again Mason (2006) suggest there are three main reasons, these are the reiteration of particular actions, environment predictability, and routine formation. Next Mason (2006) describes three ideas to explain what determines the form of the stereotypic behaviour that is presented by the animal. The three ideas as described by Mason (2006) are surrogates for natural activities, escape attempts, and deprivation. Mason (2006) suggests pacing in large carnivores such as bears is derived from their desire to range large distances and the resultant frustration. Mason (2006) describes the physiological aspect of stereotypic behaviour which is observed through four different loops within the forebrain. Lastly, Mason (2006) discusses some of the reasons animals may perform stereotypic behaviours. These reasons include a stress-inducing environment affecting cortical-basal ganglia loops, CNS dysfunction, and captivity acting as a behavioural trigger. Mason (2006) suggests further research is required to fully understand the coping effects of stereotypic behaviour.

Contribution:

This book chapter provides a clear explanation of stereotypic behaviour with consideration of both environmental and internal conditions. The chapter contains in-depth descriptions of possible explanations of stereotypic behaviour. This chapter was included because it provides background information on stereotypic behaviours. The foundational knowledge from this chapter helps to understand the results and discussions of the primary articles to follow. The paper discusses stereotypic behaviours from a broader view as well as providing more specific and relevant examples such as pacing in carnivores.

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(3), 163–188. <https://doi.org/10.1016/j.applanim.2006.05.041>

Summary:

The paper begins by providing some context and description of stereotypic behaviour such as the prevalence among captive animals and the lack thereof in nature. Mason et al. (2007) suggest there are three main reasons why stereotypic behaviours are important. The first is that stereotypies and abnormal repetitive behaviours (ARB's) are indicators of animal welfare. The second is that these abnormal behaviours may be phenotypic indicators of C.N.S. dysfunction. Lastly, the stereotypic behaviours of zoo-housed animals can be studied, and the knowledge can be shared with other fields where stereotypic behaviours are even bigger problems such as agriculture and laboratory animals. Mason et al. (2007) propose that enrichment is the best approach for solving stereotypic behaviours. Mason et al. (2007) suggest that a successful enrichment method is created under consideration of three aspects: animal preference to the enrichment behaviour over the stereotypic behaviour, the source of the stereotypic behaviour is removed/reduced, and the animal is provided with greater control over their environment. Although the exact mechanism of how enrichment works is unknown Mason et al. (2007) suggests enrichment can help ease frustration, eliminate stress, and often occupy the time that would have been spent performing stereotypic behaviours. Mason et al. (2007) describe environmental enrichment as the most popular strategy for reducing stereotypies with very few downsides. The few downsides are non-naturalistic enrichments that cause stress or aggression and that enrichment has not yet proved to be 100% effective. The authors then discuss how enrichment should be implemented by describing the process of selection, presentation and evaluation. Enrichment should be implemented with consideration of previously successful enrichment, the type of stereotypic behaviour being performed, and the animals wild-type behaviours (Mason et al., 2007). Further research is required to understand the mechanisms behind successful and unsuccessful mechanisms.

Contribution:

This review provides descriptions of stereotypic behaviour and enrichment outlining the most important considerations to be made when implementing enrichment. This review supports previous work the suggests enrichment is a successful way to reduce stereotypic behaviour among captive animals. This review was included because it provides some background information on enrichment and specifically as an application to reduce stereotypic behaviours.

Law, G., & Reid, A. (2010). Enriching the lives of bears in zoos. *International Zoo Yearbook*, 44(1), 65–74. <https://doi.org/10.1111/j.1748-1090.2009.00096.x>

Summary: Environmental enrichment is a strategy aimed at encouraging wild-type behaviours in captive bears and reducing stereotypic behaviour. Although widely implemented now, enrichment is a fairly new strategy in the timeline of bears kept captive. This article reviews research that describes strategies to enrich the lives of captive bears and encourage their natural behaviours. Bears have great mental and physical capabilities which is why the careful consideration of enclosure design, feeding strategies, and diet is so important for their success in captivity. Enclosures should be large and consist of soft natural substrates. Larger enclosures have been found to contribute to more births and a decrease in stereotypic behaviour. Creating a more challenging environment for bears where they have to manipulate and search for items reduces the time spent performing stereotypic behaviours. Enrichment strategies aim to encourage wild-type behaviours in the captive bears, examples include standing to obtain food, hunting, nest building, etc. The most common enrichment strategies for bears focus on how to offer food. Allowing bears to use their sense of smell to detect food helps to keep them active. Feeding enrichment strategies such as live prey was found to increase the presence of hunting behaviour in polar bears. Mixed exhibits consisting of multiple species have been successful for select bear species. When deciding on methods of enrichment the age, physical status, and sex of the bear should be considered. The success of captive bears requires the consideration of multiple factors. Factors such as the thoughtful design of enclosures, feeding methods, and exercise encouragement are factors that encourage natural behaviours. The review suggests a combination of both environmental and feeding enrichment is an integral part of keeping bears in captivity.

Contribution: This review article compiles information on the multiple ways' enrichment can be provided to various bears species. The article provides an overview of the considerations to be taken when bears are kept in captivity. The article emphasizes that the successful care of captive bears requires thoughtful design and consideration of all aspects of the bear species. This article was included because it describes the many forms of enrichment that can be implemented for captive bears as well as the research associated with enrichment methods.

Carlstead, K., Seidensticker, J., & Baldwin, R. (1991). Environmental enrichment for zoo bears. *Zoo Biology*, 10(1), 3–16. <https://doi.org/10.1002/zoo.1430100103>

Summary: Stereotypic behaviours, those categorized as repetitive and aimless, have been well documented in captive bears. Previous work found that complex environments and feeding strategies encouraged wild-type behaviours in captivity. Prior to this study, the benefits of environmental enrichment in captive bears were not known. In this study, the authors sought to determine how feeding enrichment influences various behaviours, how quickly habituation to enrichment occurs, and the effect of three different feeding strategies on American black bear behaviour. In experiment 1 honey-filled spruce logs were placed in the sloth and black bear exhibits during three separate tests and time spent per day exploration/foraging and walking/pacing were recorded. In experiment 2 freshly filled honey-logs were placed in the exhibit of a single brown bear that contained the remains of depleted honey-logs introduced 10 days prior. The time spent investigating old and new logs was recorded. In experiment 3 a single black bear was fed using three different methods, the standard method consisted of food placed on the floor, the feeder method consisted of food released from automated “feeder tree” and the food-hiding method consisted of hiding food throughout the exhibit. The time spent in behaviours of stereotypic pacing and exploratory/foraging were recorded. Experiment 1 found habituation to manipulatable objects following successive exposures and a significant decrease in pacing of sloth bears during only novel presentations of honey-logs. Experiment 2 Carlstead et al. (1991) found that the introduction of new food-containing objects can stimulate investigation of objects previously containing food. Experiment 3 found hiding food throughout the exhibit significantly reduced stereotypic pacing. These findings suggest the time spent performing a functional behaviour replaced the time spent pacing however, the time spent active was not increased. These findings suggest that maintaining multiple objects in a bear exhibit can help prevent habituation to new objects.

Contribution:

With only one other study published prior to this one, this article was one of the original studies that looked at how feeding enrichment affects the behaviours of captive bears. This article confirms that feeding enrichment is an effective method of reducing stereotypic behaviours. The article also suggests hiding food throughout the enclosure and in manipulatable is an effective way to emulate wild conditions and reduce stereotypic behaviours. The article is included because it provides foundational information about enrichment and an example of successful methods.

Carlstead, K., & Seidensticker, J. (1991). Seasonal variation in stereotypic pacing in an American black bear *Ursus americanus*. *Behavioural Processes*, 25(2), 155–161.
[https://doi.org/10.1016/0376-6357\(91\)90017-T](https://doi.org/10.1016/0376-6357(91)90017-T)

Summary:

Stereotypic behaviours are expressed widely among bears kept in captivity. These behaviours are sought to arise from a wild-type behaviour that is inhibited by the confines of the bears' captive environment. The literature at the time of this study lacks information about stereotypic behaviours in captive bears. In this study, the authors sought to discover the source of stereotypic pacing in a single black bear and determine seasonal effects on pacing behaviour. The authors observed an 18-year old wild-caught male black bear nearly three years excluding winter. The observers recorded behaviours such as stereotypic pacing, walking around, exploring/foraging, resting/sleeping, rubbing against wall, in moat, and in holding area. The three conditions the behaviours were observed under were control (normal procedures), food-hiding (food hidden around enclosure), and bear odor (bear scented object placed in exhibit). The researchers found significantly more pacing that turned mostly outwards in May and June compared to other months. The researchers found that from May-July pacing occurred after feeding while from August-November pacing occurred before feeding. From May-July the presentation of novel bear odours and food-hiding decreased stereotypic pacing compared to control. From August-November food-hiding almost eliminated stereotypic pacing and exploratory/foraging was significantly increased. The outward orientation and high frequency of stereotypic pacing following feeding suggest the pacing during May-July is derived from the wild-type behaviour of home-range patrolling during mating season. This is because pacing occurred after feeding suggesting it was not driven by foraging and the outward turns faced a female black bear and public resembling home-range patrolling and desire to search for social signals. The authors suggest pacing prior to feeding and inward orientation from late summer-fall is derived from the wild-type behaviour of foraging. This is because pacing occurred around feeding time and the inward turns faced the location of where food appears.

Contribution:

This paper found that stereotypic behaviour is influenced by seasonality and the stereotypic behaviours arise from the prevention of wild-type behaviours. The paper also found higher frequencies of stereotypic behaviour to correlate with the mating season and the time prior to hibernation. The article supports other findings that have found alternative feeding methods to be successful at reducing stereotypic behaviours. This article was included because it describes the effect of seasonality on the presentation of stereotypic behaviours.

Forthman, D. L., Elder, S. D., Bakeman, R., Kurkowski, T. W., Noble, C. C., & Winslow, S. W. (1992). Effects of feeding enrichment on behavior of three species of captive bears. *Zoo Biology*, 11(3), 187–195. <https://doi.org/10.1002/zoo.1430110307>

Summary:

Two studies completed prior to this one found pacing to be decreased by presentation of hidden food and manipulatable objects. In this study, the authors sought to identify additional methods to present opportunities that encourage wild-type behaviours and decrease stereotypic behaviours. The study was conducted on one Kodiak, one Asiatic black, and a male and female polar bear. The bears were observed three days per week for two 30-minute periods once after feeding and the other two hours later. The Kodiak and Polar bears were provided frozen ice blocks containing fish as their enrichment and the Asiatic black bear was provided fresh browse. The bears were significantly more active, less passive, and performed fewer abnormal behaviours when enriched compared to when unenriched. However, this was only found for the first observation period directly after feeding and not the observation period two hours later. These findings align with previous work in which stereotypic behaviour was decreased and exploratory increased. Forthman et al. (1992) suggest the variation between individuals may be due to a ceiling effect in which one of the bears began with higher activity levels than the others. Forthman et al. (1992) also suggest the difference between the effect of enrichment between 1989 and 1990 is because the ice blocks in 1990 contained more variation in the types of food included which ultimately had a greater effect on behaviour. Behaviour was altered only when the enrichment was present, this suggests the increase in activity and decrease in passive and abnormal behaviours were only temporary effects.

Contribution:

The article found that increasing the variety of food contributes to greater effects on behaviour. The researchers also found behaviour was only altered when the enrichment was present meaning enrichment does not have lasting effects. This article presents results similar to those of previous findings, in which providing captive bears with alternative feeding methods decreases stereotypic behaviour. This article was included because it provides another successful method of feeding enrichment.

Fischbacher, M., & Schmid, H. (1999). Feeding enrichment and stereotypic behavior in spectacled bears. *Zoo Biology*, 18(5), 363–371. [https://doi.org/10.1002/\(SICI\)1098-2361\(1999\)18:5<363::AID-ZOO1>3.0.CO;2-H](https://doi.org/10.1002/(SICI)1098-2361(1999)18:5<363::AID-ZOO1>3.0.CO;2-H)

Summary:

Stereotypic behaviours are known to arise from a lack of stimulation in the animal's environment. Previous studies have shown that feeding enrichment is an effective way to reduce stereotypic behaviours and improve the life of zoo bears. Enrichment provides the stimulation that captive bears otherwise lack and cause stereotypic behaviour. The most effective stimulation for captive bears includes enrichment centered around eating. In this study, the authors sought to test the effectiveness of several feeding enrichment strategies paired with a complex environment and their effects on behaviour. Using three spectacled bears (two females and one male) the authors observed the bears under different feeding enrichment strategies each week with a week of conventional feeding between each new enrichment method. The enrichment methods used were food holes, branch racks, branch piles, hozrugels, and a honey tree. The bears were observed three times a day four times a week. The observers recorded behaviours such as resting, walking, eating, manipulating feeding devices, and interacting socially. There was no significant difference in stereotypic behaviours presented during enrichment and without enrichment. Stereotypic behaviour was found to decrease when foraging behaviour or social interactions increased. This suggests stereotypic behaviour was merely replaced by others. Although feeding enrichment increased the amount of time spent foraging the authors suggest feeding enrichment does not have long term effects on the behaviours of captive bears. The authors suggest the stereotypic behaviours arose from lack of an appropriate resting sites and social frustration for bears Tolima and Sanjay respectively. The results may also be affected by the fact that the bears live in an enriched environment and have had previous exposure to feeding enrichment.

Contribution:

Feeding enrichment may not be a successful strategy to reduce stereotypic behaviours when the behaviours are caused by factors other than foraging frustration. These findings support previous work suggesting stereotypic behaviour can be caused by social frustration in males. The article supports previous findings that enrichment is not a long-term effect but rather affects behaviour only during the time that it is available. This article also supports the previously known importance of adequate resting sites for bear welfare. This article was included because it provides an example of when feeding enrichment might not be the best fit for certain animals.

Anderson, C., Arun, A. S., & Jensen, P. (2010). Habituation to environmental enrichment in captive sloth bears-effect on stereotypies. *Zoo Biology*, 29(6), 705–714. <https://doi.org/10.1002/zoo.20301>

Summary:

Wild bears spend much of their time actively foraging for food which is why the presentation of food for captive bears is an important consideration. It has been found that a large majority of bears living in captivity display stereotypic behaviours, these behaviours have been reduced through the incorporation of environmental enrichment. In this study, the authors sought to determine the effect of intermittent presentation of enrichment on the behaviours and habituation tendency of the bears. Using 14 sloth bears (seven females and seven males) the authors introduced honey logs into the enclosure during two treatments, consecutive and intermittent. Baseline data was collected for five days prior to consecutive treatment which involved presentation of the honey log five days in a row. The intermittent treatment presented the honey log three of the five days with a day of no enrichment between each day of enrichment. Observations were recorded for two and a half hours at the same time each day. Several behaviours were recorded both stereotypic and normal. The researchers found that there was a significantly higher frequency of stereotypic behaviours in the control than in the rest of the periods. During the consecutive and intermittent periods, there was a reduction in stereotypic behaviours compared to baseline however, there was no significant difference between the two periods. Stereotypic behaviours were reduced, however, not to the extent they have been in previous studies. Anderson et al. (2010) suggest the stereotypic behaviours presented by the bears may be the result of their previous experiences as dancing bears. Thus, the stereotypic behaviours may not be a result of their current environment but of their past which makes them increasingly difficult to reduce. Both treatments reduced stereotypies during the presentation and after, the authors suggest that both strategies are effective strategies of enrichment.

Contribution:

The article found that intermittent and consecutive presentation of enrichment both significantly reduces stereotypic behaviours however there was no distinction between the effectiveness of the two. Intermittent enrichment was found to increase the interest in enrichment between presentations. Unlike other studies, the stereotypic behaviours remained reduced after removal of enrichment. This article supports previous findings that suggest stereotypic behaviours can become fixed and independent from their original trigger leading to a decrease in the effectiveness of enrichment. This article was included because it provided the strategy of intermittent enrichment and an example of enrichment with lasting effects on stereotypic behaviour.

Schneider, M., Nogge, G., & Kolter, L. (2014). Implementing unpredictability in feeding enrichment for Malayan sun bears (*Helarctos malayanus*). *Zoo Biology*, 33(1), 54–62. <https://doi.org/10.1002/zoo.21112>

Summary:

In captivity, food is easily available which does not reflect their lives in the wild where bears spend much of their time foraging. Prior studies have confirmed that feeding enrichment encourages a wide range of beneficial behaviours and reduces stereotypic ones. However, habituation to enrichment and the long-term application of enrichment has proven to be a challenge. The authors sought to determine the effect of spatial unpredictability of food on behaviour and whether habituation will occur. Four female captive-born Malayan sun bears were observed twice a day at varying times. The researchers used three different feeding strategies to determine the effect of spatial variability. Experiment 1 consisted of numerous small pieces of food scattered widely. Experiment 2a consisted of scent tracks that lead to both empty and food-filled hiding places that changed daily and were offered once per day. Experiment 2b was the same as 2a except food was hidden twice per day. The experiments were compared to the control feeding strategies. To test habituation the researchers combined the strategies from 2a and 2b and tested this method for 12 consecutive days. Experiment 2b was found to significantly reduce the amount of stereotypic behaviour displayed by female 2 compared to the control. Scent tracks and food hiding with spatial variability was determined to significantly decrease walking in three of the bears. During the habituation test, the researchers found no significant difference between the behavioural observations for each of the twelve days. The researchers suggest the combination of scent and spatial variability of hidden food encourages exploratory behaviour, a key part of foraging and wild-type behaviours. The researchers were unable to determine whether the decrease in stereotypic behaviour was due to solving the motivation of the stereotypy or if the time spent foraging replaced time, they would have spent performing stereotypies.

Contribution:

The study found the feeding method to be a successful strategy at decreasing stereotypic pacing although the motivation behind the stereotypic behaviours was not determined. The finding that the feeding method had lasting effects on behaviour contradicts previous work. This article supports previous findings that suggest novelty is an important component of enrichment. This article was included because it looks at the effect of the combination of various enrichment methods when applied together.

Wagman, J. D., Lukas, K. E., Dennis, P. M., Willis, M. A., Carroscia, J., Gindlesperger, C., & Schook, M. W. (2018). A work-for-food enrichment program increases exploration and decreases stereotypies in four species of bears. *Zoo Biology*, 37(1), 3–15. <https://doi.org/10.1002/zoo.21391>

Summary: When in captivity bears frequently display stereotypic behaviours, which are often indicators of negative welfare. Feeding enrichment has proven to decrease stereotypic behaviour and increase signs of positive welfare. However, there is a potential for captive bears to habituate to feeding enrichment. This article investigated how a fixed versus variable-time feeding enrichment schedule affects behavioural indicators of both positive and negative welfare. The article also investigated whether a sustained semi-variable feeding enrichment leads to habituation in bears. The ideas were explored using two experiments conducted on eight adult bears two from each of the four different species; black bear, grizzly bear, sloth bear, and spectacled bear. The bears were observed for one month to establish a baseline. The first experiment consisted of two 10-day feeding enrichment periods followed by carryover periods. The first enrichment period tested the fixed-time while the second tested the Variable-time feeding schedule. Experiment 1 found that feeding enrichment resulted in more exploratory behaviour and a decrease in stereotypic behaviour compared to the baseline. In the second experiment, the bears were subjected to a 30-day enrichment period with a semi-variable feeding schedule and intermittent presentation of enrichment. Experiment 2 found there was an increase in exploratory behaviour and a decrease in stereotypic behaviour during periods of enrichment compared to baseline. Experiment 2 also found that no habituation occurred during the 30-day period. This study is significant because it suggests that habituation to enrichment is avoidable with the proper techniques. The decrease in stereotypic behaviour following feeding enrichment suggests the stereotypic behaviour is the result of inadequate feeding methods and subsequent frustration. Additional research should be conducted to assess the effectiveness of feeding enrichment during the night rather than only in the daytime.

Contribution: This article provides new insight into variable-time feeding and the prevention of habituation. The research found that a variable-time feeding schedule increased exploratory behaviour, an effect that had not yet been reported. The research found no habituation to enrichment, contradicting previous studies that suggest gradual habituation to feeding enrichment will occur. This article was included because it provides evidence confirming the effectiveness of feeding enrichment as a strategy to reduce stereotypic behaviour. The article suggests further strategies that may improve the success and longevity of the enrichment.

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