The following annotated bibliography entries have been organized in chronological order by publication date. This is to allow the reader to see how developments on the topic progressed over time.

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:

Before the publication of this article, it was known that wild bears spend considerable amounts of time performing complex foraging behavior. Also stereotypic pacing in captive bears was known as a widespread issue, and in captive primate studies, environmental enrichment was found to alleviate these behaviors.

This article focused on observing levels of stereotypic behavior in light of different feeding enrichment strategies. The authors conducted 3 experiments and 1 survey. Since experiment 2 and the survey are not directly related to this literature review, they have been omitted from this summary.

In experiment 1, logs with holes filled with honey were added to the enclosures of an American black bear and sloth bears. The logs were refilled with honey on specific days and the mean number of minutes the bears spent interacting with logs was recorded. Apparent habituation to the logs was noted in both species. Refilling the logs counteracted the habituation in sloth bears, resulting in higher exploration of refilled and non-refilled logs. This reaction was not seen in the black bear. Experiment 3 looked at the effects of feeding method on stereotypic pacing in an American black bear. The bear was either fed via the standard method, the tree feeding method, or the food-hiding method. The standard method consisted of the bear being given all of its food in a pile at a set time. The tree feeding method involved snacks released from a "tree" on variable schedules and locations. Food hiding meant that food was hidden throughout the exhibit for the bear to find. The food hiding method resulted in a significant increase of exploring and decrease of stereotypy. The feeder tree method had a significant increase in exploring but no decrease in pacing. Taken together findings suggest enrichment methods that encourage active foraging may decrease stereotypy.

Contribution: This article is a contribution to the field of stereotypy research since it looked at several species of bears and stereotypy frequencies in response to several applications of feeding enrichment. In terms of my literature review, this article was helpful in that it examined methods of feeding captive bears. This identified that the non-stimulating feeding strategies that many zoos use may contribute to the prevalence of pacing in captive bears. The finding that feeding methods that encourage foraging behavior tends to be associated with decreased stereotypy is supported by other similar studies.

Carlstead, K., & Seidensticker, J. (1991). Seasonal variation in stereotypic pacing in an American black bear *Ursus americanus*. *Behavioural Processes*, *25*(2–3), 155–161. https://doi.org/10.1016/0376-6357(91)90017-T

Summary:

Prior to this article, stereotypic behaviour was known as a regular issue for captive bears. Scientists had done several studies identifying lack of space and stimulation in enclosures as probable factors contributing to these behaviours. Carlstead and Seidensticker aimed to investigate the causes of stereotypic behaviours in bears through this study, with a specific focus on seasonal changes.

This study analyzed CCTV footage and volunteer observations of a captive American black bear from April 1987 to June 1990. The authors collected data on the mean minutes per day the bear spent pacing and the direction of pacing- towards the forest beyond the exhibit or towards the zookeeper station for each treatment. Treatments included a control, hiding food around the enclosure, and introducing scents from other bears. This data was compared between mating season- May to July- and foraging season- August to November.

The bear exhibited the highest frequency of pacing during May and June, which was significantly higher than in the rest of the year. During mating season, it was found that both the addition of scents from other bears and hiding food around the enclosure significantly reduced pacing, with a higher reduction from the smell introduction treatment. During August to November, hiding food significantly decreased and almost eliminated the pacing behaviour, and foraging behaviour increased in its place. Additionally, while pacing the bear tended to turn towards the forest during mating season and towards the zookeeper's post during foraging season. Taken together, the results suggest stereotypies may arise from not being able to fulfill instinctual behaviours in captivity. Increased pacing and turning towards the forest may indicate a stunted instinct to seek mates or possible competitors. The pacing-foraging tradeoff when food is hidden during foraging season may indicate that stereotypies are reduced when bear's instincts are satisfied.

Contribution: This article was a great addition to the field as it identifies a potential cause for stereotypic behaviour as the outlet of bears not being able to carry out their instinctual seasonal behaviour in captivity. This article agrees with previous articles in that it found feeding bears in one place without any effort on the bear's part might be associated with more frequent stereotypic behaviour. I felt it useful to include this article in the literature review since it focuses on several potential causes for stereotypy in American black bears.

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:

Before publishing this article, it was known that bears spent a considerable amount of time foraging, and that in captivity it is particularly challenging to fulfill the foraging instinct of bears. It was also known that the use of enrichment can dramatically decrease the stress responses to the lack of mental stimulation these bears receive.

The goal of this study was to further investigate if the use of feeding enrichment alters the activity levels and stereotypic frequencies of captive bears. Data was collected in the morning when enrichment methods were provided after feeding, and again two hours later. This was done for six months for two years. Instantaneous point sampling was used, and behaviors were classified based on an ethogram. Enrichment mostly took place in the form of ice blocks containing food.

The results of the study indicated a significant change in behavior associated with the introduction of enrichment items. Bears showed higher levels of activity and less frequent stereotypic behavior during the morning observation period when the bears were interacting directly with the enrichment items. This indicates that stereotypies may be caused due to a lack of mental stimulation and that mental stimulation needs to be consistently provided to increase welfare. The same trend was not seen for the observation period taking place once the ice of the enrichment items had melted. Additionally, the positive effects of enrichment were more pronounced during the second year of the study, which was likely attributed to adding a greater variety of food to the ice blocks during that time. This could be related to the fact that bears are omnivorous and eat a grand variety of foods in the wild, and thus the increased variety may have been more in line with the natural instincts of the bears.

Contribution: This article was a valuable contribution to the field of research as it presented the findings that enrichment is effective when the enrichment object is present, but not much afterwards. It agreed with previous findings that environmental enrichment might be associated with increased normal activity and lowered frequency of stereotypic behaviors. The reason this article is of particular interest to my literature review is that stereotypic behavior decreased just after being given the enrichment object and when presented with a higher variety of foods, which may indicate that stereotypies arise due to lack of mental stimulation.

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

Summary:

Previously, it was known that stereotypies could be an indication of insufficient welfare in captive animals and that they are associated with frustration and stimulus deficit. The goal of this study was to see how feeding enrichment devices affected stereotypy frequencies.

This was done through alternating weeks in which standard and enriched feeding methods were used for one male and two female spectacled bears. The enrichment method involved scattering or hiding 70-80% of the bears' food around the yard using feeding holes, honey logs, branch piles, and suspended containers to encourage foraging behavior. The bears were observed for an hour in the morning, afternoon, and evening via scan sampling at 1-minute intervals.

The study found a significant increase in foraging in the morning, which was paired with a resultant decrease in time spent pacing. Since this decrease in stereotypy only occurred shortly after food placement, results may indicate that enrichment objects are effective while the bears interact directly with them, but effects are not lasting.

Interestingly, after feeding the older female either rested or paced following foraging. It appeared that the distinction between whether the female paced or not was weather dependent. If the weather was too hot, cold, or otherwise too severe to comfortably rest on her favorite perch, the female tended to initiate stereotypy. Additionally, it was found that the male bear only engaged in pacing behavior during mating season after the other females in the enclosure refused mating attempts from the male. These results taken together may imply sex differences in the motivating factors behind stereotypic pacing.

Contribution: This article provided noteworthy results for this literature review as it indicates that stereotypy may be caused by inability to fulfill different instinctive needs in males and females. In the scientific field, it contributes the idea that feeding enrichment is more effective when there is food inside and thus the bears interact with the devices directly. Conversely, when the devices are empty, the effects of enrichment may not be lasting. These results are in agreement with some papers such as Forthman et al. (1992), but studies such as Carlstead et al. (1991) provided contrary results.

Vickery, S. S., & Mason, G. J. (2003). Behavioral persistence in captive bears: Implications for reintroduction. *Ursus*, *14*(1), 35–43. https://www.jstor.org/stable/3872955

Summary:

Prior to publishing this article, there was an identified need to improve conservation through reintroduction. It was known that failure rates for reintroduction of bears were high, especially for those bred in captivity. This was thought to be because these bears often lack natural behaviors of wild bears and tend to exhibit abnormal behaviors like stereotypies. Additionally, species with larger home ranges tended to pace more in captivity.

This study aimed to assess different forms and frequency of stereotypies and how stereotypic behavior relates to behavioral persistence. Behavioral persistence is the continuation of a behavior even after the reward has stopped being given. In this study, twelve bears were randomly selected for learning a spatial awareness task where bears were rewarded for selecting specific objects. Reinforcement continued until the bear could perform the task with a 90% success-rate over six weeks, at which time rewards were stopped. Researchers measured how long it took for the bears to stop responding to the task, as defined as a 65% decrease in performance frequency of the task. Levels of different stereotypies were measured before the learning activity and observations were taken using scan sampling 30 times throughout the day.

The study found that pacing was the most common form of stereotypy and bears that had been in captivity longer tended to display higher levels of pacing. The frequency of stereotypy did not affect learning ability, but was positively associated with time taken to stop the spatial awareness behavior after rewards had stopped being given. It was also found that lower behavioral persistence, which indicates higher behavioral flexibility, might be more helpful for reintroduction efforts into the wild. As a future study, the authors expressed interest in looking at orphaned American black bears to see how stereotypies in cubs affect reintroduction success.

Contribution: This article contributes to the scientific field as it indicates that bears exhibiting stereotypies may not make good candidates for reintroduction. These results are interesting in the scope of the literature review as it indicates that bears who have been in captivity longer might tend to exhibit stereotypic behavior more frequently. The idea that pacing is the most common form of stereotypy in bears is consistent with previous data from this field of study.

Vickery, S., & Mason, G. (2004). Stereotypic behavior in Asiatic black and Malayan sun bears. *Zoo Biology*, *23*(5), 409–430. https://doi.org/10.1002/zoo.20027

Summary:

Prior to this article it was known that bears are one of the most susceptible carnivore groups to develop stereotypies. Pacing is the most common of these behaviors in bears, but things like head-swaying and tongue flicking are also common. In other species, studies have found that age and anticipation of feeding have been positively correlated with stereotypic behavior.

The goal of this study was to look at how stereotypies develop in bears. The researchers used an instantaneous scanning method to collect data during both day and night in intervals over a 2-year period. Stereotypic frequency was measured and analyzed as a function of age, species, and sex of the bears both before and after feeding. Observed stereotypic behaviors were classified as locomotory, oral, or other.

As a result of the analysis, the researchers found that 93% of the studied individuals exhibited some form of stereotypic behavior. The most common form of stereotypy was locomotory, with pacing being the most frequent. There was no significant difference seen between the stereotypic frequency of the Malayan sun bear and Asiatic black bear species or between male and female bears. However, sun bears tended to pace near where food entered the enclosure and black bears paced equally between where food was given and the side of the enclosure with a neighboring bear enclosure. Other trends found included higher pacing pre-feeding opposed to post-feeding and was most pronounced in the morning before feeding, indicating potential anticipatory behavior. Stereotypies were less common at night overall, but individuals with higher frequencies during the day were also higher at night. Older bears tended to exhibit more frequent stereotypies, however this trend also extended to less active individuals, so it was unclear whether age or activity levels altered the stereotypic frequency.

Contribution: The findings of this article contribute to captive animal welfare studies because it adds information about stereotypic behavior for less studied bear species. This is good because Malayan sun bears had not previously undergone a lot of research in this area. It agrees with previous literature in that stereotypies are strongly correlated with anticipatory behavior. This is a valuable article to include in the literature review because it touches on where and under what circumstances stereotypy might be most prevalent.

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:

Based on the previous knowledge on bear captivity, historical captivity methods have failed to meet the environmental and psychological needs of the bears involved. Studies showed stimuli deficiencies and small sizing of enclosures negatively impacted captive bears.

This review article sought to compile data from several studies looking at the needs of bears in captivity and how environmental enrichment and enclosure design can help to meet those needs. The authors did this by collecting articles on stereotypic behaviour in bears and different methods that have been studied to improve the welfare of captive animals.

The compilation of data suggested that larger, more complex enclosures with "softer" features such as grass and plants opposed to concrete might reduce stereotypic* behaviours. From the environmental enrichment methods studied, it appears that enrichment via feeding is an effective form of mental stimulation. Some notable methods include honey trees, where the bear must stand or climb on a pole to reach honey that drips from a dispenser, and wobble trees, which involve the bear rocking a tall pole which in turn causes food to drop. A common theme for effective enrichment strategies appears to be that the food rewards come as a result of completing a high energy activity, much like what is required for survival in the wild. Certain non-food-related enrichment strategies also showed promise, including non-edible objects such as plastic balls, and creating scent trails by dragging heavily scented objects around the area. The authors also suggested that having enclosures where two animal species live together might be helpful in lessening boredom behaviours. The authors of the article present a call for further consideration and study of the seasonal variation of bears in terms of activity levels and feeding patterns as it relates to the needs of bears in captivity.

Contribution: This article was useful in informing stereotypic behaviours in bears by identifying potential sources of the behaviour in terms of health, mental stimulation, and living space. This agrees with previous literature as it focuses on the captivity environment and mental stimulation received. It also addressed different forms of enrichment that can help to reduce these behaviours from a welfare standpoint and explains how these methods can help fill the deficits to the bear's lifestyle that cause the stereotypic behaviour. Overall, it gives a broad overview of the topic, providing a potential source for finding useful primary articles.

Shepherdson, D., Lewis, K. D., Carlstead, K., Bauman, J., & Perrin, N. (2013). Individual and environmental factors associated with stereotypic behavior and fecal glucocorticoid metabolite levels in zoo housed polar bears. *Applied Animal Behaviour Science*, *147*(3–4), 268–277. https://doi.org/10.1016/j.applanim.2013.01.001

Summary:

Previously, stereotypic behavior was known as a coping mechanism or compensation for unfulfilled natural instincts in captivity. Bear species with larger home ranges were more likely to exhibit stereotypies. Additionally, temperament was known to influence stress behaviors. The combination of studying physiological traits and hormones had proven helpful in understanding behavior. Lastly, glucocorticoid metabolites, which are a substance created by breaking down stress hormones, can be measured non-invasively.

The authors of this article wanted to study the prevalence of pacing in zoo bears. They also looked at how fecal glucocorticoid metabolite (FGM) levels are related to pacing and what traits make bears more susceptible to stereotypy. In this study, 55 polar bears from 20 zoos were studied via video data for one year with fecal samples collected every 2 weeks for measuring FGM levels. Environmental characteristics for each bear were measured and characterized for factors such as the layout and size of enclosures, and what the bears were able to see out of their exhibit if at all. Next the researchers looked at individual traits like temperament by comparing the bear's reaction to two novel objects places in the exhibit.

Results of the study indicated that bears with more enrichment, a view out of their enclosure, and more cohoused conspecifics tended to pace less frequently. Additionally, the bears with more curious temperaments paced less than those that were more hesitant to approach the novel objects. This may indicate that both environmental and dispositional factors contribute to stereotypy. FGM levels low for bears were more curious and that had a more dry-land area in their enclosure. High FGM levels were associated with more pacing. Overall, 85% of bears displayed stereotypy. If researchers can find the genetic link to temperament, they may be able to determine likeliness of stereotypy later on.

Contribution: This article aligns with the literature review in that it identifies several potential contributing factors of stereotypy in captive bears. It also contributed to the scientific field for similar reasons, as it talks about perhaps being able to look at metabolites and personality traits to identify the risks of developing pacing behavior. Additionally, the results of the article were consistent with previous findings in that it appears enrichment and the view out of a bear's enclosure may lower pacing frequency.

Perdue, B. (2016). The effect of computerized testing on sun bear behavior and enrichment preferences. *Behavioral Sciences*, *6*(4), 19. https://doi.org/10.3390/bs6040019

Summary:

Leading up to this article, it was known that cognitive research is good for determining learning, problem solving, and other similar factors in animals. Studies had shown that this type of research was good for examining the effects of enrichment in zoo animals. It was also recognized that there was a gap in cognitive research for bears. Stereotypic behaviors such as pacing were known to be a widespread problem in captive bears.

The goal of this study was to look at how training a bear to use a touchscreen computer as an enrichment device influenced the levels of stereotypy displayed. This was done by placing the bears in a training area and allowing voluntary interaction with a touch screen device. The bears were trained using honey to touch their tongues to the screen, triggering the release of a food pellet. Once initial training was done, the area of screen that led to reward was paired with a sound and transitioned into a clipart distinction task. Once the bears had reached this point they were tested once a week for nine months and the stereotypic frequencies of the bears were observed via focal animal technique before and after testing. Researchers also observed whether bears preferred the touchscreen or traditional enrichment toys.

Results showed an increase in pacing for both bears involved after the introduction of the computer, however the increase was only significant for one of the bears. This trend may have been a result of anticipation of interacting with the computer as much of the pacing happened while the other bear was using the computer. This may indicate stereotypy as a way to cope with increased stress added by other members of the species. Additionally, both bears displayed a preference for the computer enrichment opposed to the traditional enrichment toy.

Contribution: The findings of this paper contribute to the field in that they identified computers as a potential habituation-resistant enrichment method. In terms of the literature review, it may provide insight into stereotypic behavior that can be influenced by stress or anxiety created by conspecifics or at the anticipation of mental stimulation. The result of increased pacing being associated with enrichment methods contradicts previous findings in this field, as many articles published prior to this article indicated negative relationships between enrichment and stereotypic frequency.

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:

Large home ranges in the wild were previously known to make bears predisposed to stereotypic behavior. It was known that feeding enrichment tends to lower the frequency of stereotypies. Also, understanding natural behavior is vital for designing effective enrichment for captive animals.

The goal of this study looked at how the time distribution of feeding enrichment affected stereotypies. Additionally, the authors looked at habituation to feeding enrichment methods. To do this, the authors conducted two experiments. The first of which involved differential feeding times in four species of bears. After establishing baseline observations, researchers subjected the bears to 10-day trials where they were fed on either variable or fixed time intervals, followed by an 11-day control window. For the fixed time interval, the bears were fed consistently at 10:00am and 4:00pm. For the variable time interval, feeding occurred once in the morning and evening at a randomly selected time within a 3-hour window. In both cases, food was provided via enrichment methods requiring cognitive and physical effort to obtain. This included climbing, swimming, and extracting food from ice blocks. The results of this experiment indicated decreased pacing for both the fixed and variable feeding treatments opposed to the control. The variable time trial also showed an increase in exploratory behavior. This may indicate variable feeding times being more like situations in the wild, thus encouraging more natural behavior.

For the second experiment, each enrichment item was used for two consecutive days using the variable feeding method for a timeframe of 30 days. During this time, the researchers watched for signs of habituation to the enrichment methods. Data was collected using instantaneous group scans and the behaviors seen were classified based on an ethogram for the species. Results from this study found no indication of habituation within the 30-day period.

Contribution: The article is useful to include in the literature review as it connects ideas of how feeding times may affect the frequency of stereotypic pacing. The results of the study contributed to the field by indicating that the timing of enrichment provision may impact levels of exploratory behavior. Additionally, this agrees with previous studies in the field in that stereotypic pacing may decrease with higher levels of foraging.