

Zoology 567

Literature Review Part 3

Annotated Bibliographies

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The articles are being organized by study type. The first annotation is a secondary article that summarizes recent enrichment research in tigers. It is followed by papers in this review that were observational and did not involve any form of enrichment or enclosure manipulation. Finally, the papers that used enrichment objects (novel food or play items) are in their own category and enclosure manipulation experiments are put in their own groups. All groupings have a bolded header and are listed chronologically within these groups for convenience sake.

Secondary Article

Citation:

Szokalski, M. S., Litchfield, C. A., & Foster, W. K. (2012). Enrichment for captive tigers (*Panthera tigris*): Current knowledge and future directions. *Applied Animal Behaviour Science*, 139(1-2), 1-9. <https://doi.org/10.1016/j.applanim.2012.02.021>

Article Summary

Tigers are elusive and solitary animals that are hard to track and study. The negative effects of captivity have been heavily studied under many circumstances, and a consensus in scientific literature is that captivity induces higher rates of stereotypic behaviors. The most prevalent of stereotypes in tigers that have been documented is rates of pacing. This has been attributed to the fact that tigers-large carnivores with expansive home ranges tend to fare poorly in small enclosures. Environmental enrichment can be achieved by looking at feeding and hunting behaviors, and attempting to mimic conditions that induce natural behaviors in captivity.

This review article looked at the rates of success of a wide variety of enrichment efforts. Results show that olfactory stimulation (hanging sacks filled with spices such as cinnamon) have proven to be successful at reducing pacing rates. Novel food items are also frequently used by zookeepers as they encourage hunting behaviors. Examples include provision of animal bones, frozen carcasses and blood balls. Use of carcasses leads to an increase in cleaning behaviors such as mock killing and fur plucking, but more importantly, pacing behavior decreased significantly with the implementation of frozen fish. Other manipulations related to feeding, such as altering feeding schedules, had inconclusive results. Select studies saw an increase in pacing levels, while others noted no change.

In addition to usage of carcasses, zookeepers introduced inanimate objects such as cardboard prey that increased activity, encouraged hunting behaviors and significantly decreased pacing. It is important to note that even solitary animals have moments of interaction with conspecifics in the wild, and appropriate social enrichment via paired housing can reduce pacing. Future studies looking at keeper/felid interactions should be the next point of investigation, and preliminary studies have started looking at the use of positive operant training to keep felids active.

Article Contribution

This article is important for my review because it is the only review article I could find on tiger pacing to date. Most of the studies included are relatively recent, and the paper notes the areas in the field that are lacking. It notes that felids are quick to habituate to novel items or interactions, which is why it's important to further enrichment efforts. Emphasis was placed on the fact that ample research has been done on feeding, hunting and olfactory enrichment, but future questions should center on social enrichment, namely using keepers to interact with the tigers.

Cited: 65 times

Observational Studies

Primary Article

Citation:

Nevill, C., & Friend, T. (2003). The behavior of circus tigers during transport. *Applied Animal Behaviour Science*, 82(4), 329–337. [https://doi.org/10.1016/S0168-1591\(03\)00066-2](https://doi.org/10.1016/S0168-1591(03)00066-2)

Article Summary

Restriction of movement during transport induces stereotypies such as pacing in tigers. This paper included two studies, the first of which monitored two individually housed tigers during a four-hour journey. The second study discussed monitored four tigers transported together during two four-hour periods. Data from these two groups were analyzed separately. The stated objectives were to track pacing rates and determine if pacing led to changes in body temperature.

The individually housed tigers had access to an exercise pen ten meters in diameter and had performed prior to transport. Temperatures were recorded by feeding the tigers dataloggers. Videorecording was used throughout transport to compare the behaviors during transport to an ethogram. Scan sampling was done at five-minute intervals. Pacing was considered if the tiger walked repetitively between two points, for two cycles. Other behaviors being monitored were 'standing', 'walking' and 'lying'. These conditions were consistent for both the studies.

Results indicate that the two individually housed tigers who had performed before transport spent most of the time lying down; low activity levels and increased body temperatures were attributed to exertion from the performance.

The group of tigers paced for over 25% of transportation time. The tigers had access to a five-meter diameter exercise pen. Standing, walking, and pacing levels peaked during the first half of the

trip, but results were considered biased as only one tiger paced throughout this time, while the remainder were relatively still.

When compared to tigers that had not performed and did not have access to exercise pens, data suggests that access to exercise pens decreased pacing rates. Body temperature changes were determined to be related to performance before transport, and not attributed to pacing.

Future studies should look at transportation when all tigers have performed, to create consistency in the data.

Article Contribution:

I included this article as I believed it would contain relevant information on how group housing impacts tigers. After reviewing it, the results from the group transport confirm the hypothesis that these animals prefer to be solitary if they do not have room to claim their own territory. Previous papers suggested that strategic group housing could lower pacing rates, but these results show that this may not be possible in small quarters. I think future studies might benefit from only studying one factor on the tigers behavior (i.e. performing or not performing, group or individual transport) to make results clearer.

Cited: 19 times.

Primary Article

Citation:

Mohapatra, R. K., Panda, S., & Acharya, U. R. (2014). Study on activity pattern and incidence of stereotypic behavior in captive tigers. *Journal of Veterinary Behavior*, 9(4), 172–176.
<https://doi.org/10.1016/j.jveb.2014.04.003>

Article Summary

Maintaining and caring for felids in captivity is a difficult task for zoos. Ensuring their wellbeing and meeting their ecological needs is difficult when animals such as tigers naturally maintain large home ranges. Enclosures are limiting for these animals, and they restrict the natural behaviors that are required for survival in the wild. Pacing in captive felids is a common coping mechanism used to deal with spatial constraints and unstimulating environments. This observational study monitored the behavior of 19 captive tigers over 1254 hours and aimed to see when pacing peaks throughout the day. The percentage of each tigers time spent engaged in pacing throughout the day was quantified.

The 19 tigers ranged in age including cubs up to adults. The tigers were all housed individually, and enclosures were considered ‘large’ (between 1250 and 1550 m²). Enclosures were covered with soil and grass, and four of the enclosures were open-air meaning that there was no ceiling. An ethogram was used to track a wide range of behaviors including but not limited to; grooming, sitting, sleeping, yawning, and pacing. Tigers were observed by the same person between 7:00 and 18:00 using instantaneous sampling at 1-minute intervals. Only pacing was considered ‘stereotypic’ in this study. Results indicated that tigers spent on average 23% of their time

pacing. Pacing peaked between the hours of 10:00-11:00, and 16:00-17:00. The latter peak was associated with anticipation of feeding.

A significant finding of the study noted that cubs did not pace. When comparing previous observational studies in the same zoo, records indicate that pacing begins after 1.5 years of age. A proposed explanation for this was that increasing size also increases the physical constraints on the tiger.

Future studies should include a record of enrichment efforts to reduce pacing.

Article contribution

This article was included in my review as it is a thorough observational study that quantified pacing levels throughout a typical day. The sample size is considerably large when compared to previous papers that I have reviewed, and that makes it a reliable source for the rates of pacing. The section regarding an absence of pacing in young cubs was intriguing, but pacing was observed in adolescents (pacing was assumed to occur at around two and a half years of age), and I wonder if this has developmental significance.

Cited: 31 times.

Novel Food/Item Enrichment

Primary Article

Citation:

Bashaw, M. J., Bloomsmith, M. A., Marr, M. ., & Maple, T. L. (2003). To hunt or not to hunt? A feeding enrichment experiment with captive large felids. *Zoo Biology*, 22(2), 189–198.

<https://doi.org/10.1002/zoo.10065>

Article Summary

Promoting appetitive behaviors (e.g. pouncing and stalking) in captive felids is a necessary component of maintaining animal welfare. Feeding enrichment activities are commonly used to keep animals engaged. This study looked at two methods of feeding enrichment: live fish, and bone provisioning in lions and tigers. The study objective hoped that provision of fish and bones would increase appetitive behavior while decreasing pacing. The study was carried out by comparing baseline data obtained before the study, to behavioral frequencies during and after enrichment.

Two test subjects from each species were used in the experiment. Felids were provided either the fish or bones between the hours of 9:00 and 17:00. Both types of enrichment were provided twice a week for four weeks.

Data was observed in one-hour sessions using instantaneous scanning at one-minute intervals. The data was recorded for six hours a day, between the hours of 10:00 and 16:00. Results indicate that when compared to baseline data, there was not a significant difference in pacing

rates, but data visualization shows a noticeable decline in values. This is attributed to the small sample size. The study predicted a larger sample size (six individuals per species) would yield a statistically significant result. Live fish interactions lasted an average of ten minutes in tigers, while bones prompted a minimum of 45-minute interactions from the felids.

Both lions and tigers showed an increase in non-stereotypy activity two days after enrichment. In the tigers, morning fish sessions increased appetitive behaviors more than afternoon ones.

The study concluded that use of live fish may lead to prolonged behavioral changes. Future studies should focus on increasing sample size and comparing short-term versus long-term enrichment efforts that can maintain positive behavioral changes that increase appetitive behaviors.

Article contribution

I found the comparison between two novel food enrichment efforts to be useful as it noted two ways that zoos can improve felid well-being while simultaneously increasing visitor appeal. Increased felid visibility promotes zoo guests, raising funds to help with felid conservation. Bone provisioning proved to maintain the felids attention longer than live fish, and that may be related to the amount of energy spent on each respective food item. Future studies should examine if the effects of bone provisioning last beyond enrichment periods.

Cited: 64 times

Primary Article

Citation:

Skibieli, A. L., Trevino, H. S., & Naugher, K. (2007). Comparison of several types of enrichment for captive felids. *Zoo Biology*, 26(5), 371–381. <https://doi.org/10.1002/zoo.20147>

Article Summary

Enrichment can improve animal wellbeing by stimulating natural behaviors, while reducing stereotypies. Enrichment for felids traditionally involves novel food items. This study introduced three enrichment objects to six felid species: cheetah, cougar, jaguar, lion, ocelot, and tiger. The study objective was to compare rates of active behaviors to pacing.

The felids were given spices, bones, and frozen fish every day for four to seven days a week for one week. There was a two-week period where no enrichment was given to measure behavior at the baseline between experiments.

Data collection was done prior to, during, and two weeks after enrichment (behavior back at baseline). Ten observation periods were done on the first, second and last day of enrichment. Data was taken for one month before introduction of the enrichment, and one month after the enrichment had concluded. Felids were observed for two 30-minute sessions, using scan sampling at one-minute intervals.

Results show a decrease in pacing for all species, excluding cheetahs, with the introduction of enrichment types. The introduction of bones and spices benefited the ocelots and tigers the most. Both these species had the largest decrease in pacing. Cheetahs were the exception in this study as they did not show stereotypies during baseline.

Frozen fish caused a significant difference in pacing one week after enrichment, this was not seen in the use of bones or spices. Bones induced the least reduction in pacing, and spices were second to fish in pacing reduction. Four of the six species observed did not pace at all one week after the frozen fish experiment.

The paper demonstrates that zoos can access inexpensive methods of enrichment that have significant effects on felid behavior. Future studies should focus on scent enrichment as it has been less documented than other enrichment efforts.

Article contribution

I included this paper in my review as it looked at three different types of enrichment, whereas previous papers I looked at mainly focused on one. The results have been consistent for frozen fish, as multiple other papers stated this form of enrichment has the potential to change behavior in the long term. I would like to see how long these effects last, and how long the tigers take to habituate to the fish, as other papers suggested felids habituate quickly to enrichment efforts.

Cited: 119 times.

Primary Article

Citation:

Ruskell, A. D., Meiers, S. T., Jenkins, S. E., & Santymire, R. M. (2015). Effect of bungee-carcass enrichment on behavior and fecal glucocorticoid metabolites in two species of zoo-housed felids. *Zoo Biology*, 34(2), 170–177. <https://doi.org/10.1002/zoo.21192>

Article Summary

It is known that enrichment in zoos is necessary to maintain animal wellbeing. One of the most effective ways to keep felids in captivity engaged is to create scenarios that promote natural hunting behaviors. This study used feeding enrichment in the form of a bungee-carcass to encourage hunting behaviors, and quantified felid stress levels by measuring fecal glucocorticoid metabolites (FGM) and observing pacing behavior.

Researchers used a total of four felids (two tigers and two cougars) in the experiment. The bungee-carcass component was comprised of a 1.2 m bungee cord attached to a deer carcass. Felids were given the carcass individually for 2.5 hours. This process was repeated once more, one month after the first trial to allow FGMs and behaviors to return to baseline levels. Behavioral data was taken both before and after enrichment. During enrichment, scanning was done in two-minute intervals for a three-hour period. The behaviors monitored were: sitting, pacing, walking, and grooming, among others. Fecal samples were collected two days prior to enrichment to measure baseline values, then collected on the day of, and four days after

enrichment. In the week after the enrichment, fecal samples were collected twice a week until the next trial. Baseline FGM levels were based on pre-treatment fecal samples.

Results indicate that FGM levels were similar both before and after the treatments for all subjects. Pacing in tigers increased after the first treatment but decreased after the second. In cougars pacing rates decreased after both treatments. Results concluded that bungee-carcass enrichment can alter felid behavior without affecting FGM levels. The decrease seen in pacing is promising for bungee-carcass enrichment. Future studies should consider increasing the trials used and increasing sample size for more consistencies in data.

Article Contribution

This study is relevant to my review as it was a deeper investigation into novel food as an enrichment effort for tigers. This topic was covered in the secondary article; the results of this study provided evidence that carcass use can reduce pacing levels in felids. I found the biochemical analysis to be especially useful as most papers I have read to date focus on observational data alone. The study indicated that future experiments should look at using a larger sample size, and I believe that it may be useful to also see if increased trials would help lower FGMs.

Cited: 18 times.

Primary Article

Citation:

Damasceno, J., Genaro, G., Quirke, T., McCarthy, S., McKeown, S., & O'Riordan, R. (2017). The effects of intrinsic enrichment on captive felids. *Zoo Biology*, 36(3), 186–192.
<https://doi.org/10.1002/zoo.21361>

Article Summary

Enrichment for captive felids can come in many forms, including use of animate and inanimate objects, novel food items and social pairings. A challenge with enrichment for captive carnivores is habituation, which desensitizes animals to the novelty of objects in relatively short periods of time. This study aimed to look at the effects of hay balls (scented and non-scented) in tigers and cheetahs as enrichment, and to determine if and when habituation for these items occurred.

The experiment involved three kinds of balls: a hay ball, hay balls sprayed with catnip, and a hay ball infused with cinnamon. The balls were given to the felids every morning for one week, and focal animal or all occurrence sampling was conducted for one hour each day. Observations were recorded one week prior to, during and after enrichment. The study period was divided weekly, with each enrichment type being separated by a week of no enrichment to allow behaviors to return to baseline levels.

Results indicate that interaction levels with each kind of ball were similar. The average time spent playing with the balls was five minutes, after which the ball tended to come apart. Cinnamon balls had the longest interaction time and was the scent that decreased pacing the most when compared to baseline levels.

Animal response decreased one hour after enrichment introduction, indicating that habituation to the stimulus occurred during the sessions, but there were no signs of habituation between different days of the same enrichment type. This indicates that hay balls can be used regularly in felids.

Article Contribution

I included this article because it is the most recent publication of the other papers in my review right now, and it included a comparative element when it mentioned the domestic cat experiments, something I had not seen yet. The results are consistent with other papers thus far; cinnamon seems to be a favorite smell for felids. This paper offered a better look at habituation and suggested that the cats can adapt within a single enrichment session, posing challenges for keepers.

Cited: 13 times.

Enclosure Rotation/Manipulation Experiments

Primary Article

Citation:

Lyons, J., Young, R. J., & Deag, J. M. (1997). The effects of physical characteristics of the environment and feeding regime on the behavior of captive felids. *Zoo Biology*, 16(1), 71–83. [https://doi.org/10.1002/\(SICI\)1098-2361\(1997\)16:1<71::AID-ZOO8>3.3.CO;2-J](https://doi.org/10.1002/(SICI)1098-2361(1997)16:1<71::AID-ZOO8>3.3.CO;2-J)

Article Summary

Previous research shows that felid behavior in captivity is affected by enclosure size. Generally, enclosures are stress inducing, and can provoke stereotypies such as pacing. This study examined pacing behavior in 19 felids from seven species (cheetahs, jaguars, jungle cats, leopards, lions, tigers, and lynxes) in 11 different enclosures to determine if differences in enclosure size and design had an impact on pacing. The animals were placed on two different feeding regimes (a three-day schedule and everyday feeding schedule, and pacing rates were compared between the two feeding schedules.

Data were collected for four hours per day, and instantaneous scan sampling was done in 15-minute intervals. Analysis of the pacing observations found that 15 of the 19 animals paced throughout the day, with rates spanning from one percent of scans to 32 percent. Tigers were considered outliers as they did not pace during the observations. Results suggest that the smaller enclosures did induce higher rates of pacing, but the changes were not statistically significant. Pacing occurred almost exclusively at the edges of enclosures.

Two feeding regimes were compared to see the effect on pacing. The three-day feeding regime involved fasting days, while the daily feeding routine did not. Results show that the animals on the three-day regime paced at a significantly higher rate on fasting days than on feeding days.

Animals on the daily feeding schedule paced during the hour before food delivery, but the results were not statistically higher than pacing at other times of day.

The results of the three-day feeding regime suggest that studies must focus on an alternative that does not increase pacing, but also mimics a natural feeding schedule more closely than daily feeding.

Article Contribution

It was surprising to see that tigers did not pace at all, as I assumed they would suffer more acutely from spatial constraints. Regardless of the pacing results, I included this paper because the feeding regime experiment was a good insight into how enrichment experiments cannot always prove to be effective. Future studies should further examine the effects of different feeding regimes that can increase natural diets.

Cited: 140 times.

Primary Article

Citation:

White, B. C., Houser, L. A., Fuller, J. A., Taylor, S., & Elliott, J. L. (2003). Activity-based exhibition of five mammalian species: Evaluation of behavioral changes. *Zoo Biology*, 22(3), 269–285. <https://doi.org/10.1002/zoo.10085>

Article Summary

Keeping animals active in captivity can involve moving them between zoo enclosures. New environments can promote natural behaviors and decrease stereotypies. In this study, five mammalian species (orangutans, siamangs, tapirs, babirusas, Sumatran and Siberian tigers) were rotated through exhibits and monitored for behavioral changes. The experiments lasted three months and were repeated over three years to see if long-term behavioral changes persisted. The main study objective was to track behavioral changes across enclosures.

Methods were consistent across species. Food was placed in the exhibit before the animals were moved, and each day the animals were placed in the exhibit before 10:00 and rotated in the afternoon. Holding cages were moved into holding enclosures, then the animals moved into the exhibit via connecting chutes. As a rule, outdoor exhibits were larger than indoor ones. Both indoor and outdoor exhibits differed in shape but contained similar natural elements.

Systematic observations consisted of continuous 10-minute scanning of the behavior of each animal. This was conducted over three summers, and data analysis was conducted on the exhibits that had more than ten observations per summer (the tigers, orangutans and babirusas).

Results indicate that tigers did not show changes in pacing rates despite enclosure rotation. The Sumatran tiger was shown to spray urine when placed in the enclosure after a conspecific, this was positive as it is a natural territory marking behavior. Unlike tigers, orangutans and babirusas

did show changes in pacing based on enclosure. Orangutans only paced in the holding areas, and babirusas paced the most in enclosure three, but showed little to no pacing in other exhibits.

Concluding statements indicate that there were no negative implications to increased transportation in the holding enclosures, however further studies should study the rates of habituation to enclosure movement over time.

Article Contribution

This article was a good comparative study between mammalian species. Studying the effects of novel enclosures, and it was interesting to see that pacing in tigers was not actually affected significantly by movement to new enclosures. I assume this is related to the olfactory cues left behind by other animals causing the tigers stress, this is supported by the fact that the tiger sprayed urine to mark its territory. Future studies might need to see if they can introduce the conspecifics scent to the focal animal earlier and see if this reduces stress levels when accessing a new enclosure.

Cited: 49 times.

Primary Article

Citation:

Bashaw, M. J., Kelling, A. S., Bloomsmith, M. A., & Maple, T. L. (2007). Environmental effects on the behavior of zoo-housed lions and tigers, with a case study of the effects of a visual barrier on pacing. *Journal of Applied Animal Welfare Science*, 10(2), 95–109.

<https://doi.org/10.1080/10888700701313116>

Article Summary

Previous documentation indicates that pacing in captive felids is partly a result of an inability to control access to social partners. Pacing is also affected by other factors including how many animals are housed together and enclosure size. The study aimed to research environmental effects on the behavior of captive tigers and lions, and determine if placement of physical barriers to limit visual access to people and conspecifics would decrease pacing in tigers.

This paper was comprised of two parts, an observational study tracking the frequencies of resting, resting but awake, pacing and ‘other’ in both tigers and lions. The latter section was an experimental case study on the effects of a visual barrier on a tiger. The observational study was conducted at three times; morning, midday and afternoon, and one lion as well as two tigers were physically isolated from conspecifics but were still able to see and hear them. Instantaneous scanning was conducted in one-minute intervals in one-hour blocks. The animals were observed in relatively large and small enclosures. Results indicate that pacing increased in smaller enclosures.

The case study conducted observations one month before the placement of the barrier, during the month while the barrier was present, and one month after the barrier had been removed. The barrier visually separated the tiger from conspecifics. Data was recorded in 90-minute blocks in the morning, midday, and afternoon. Results showed that pacing increased with implementation

of the barrier, since the tiger was not able to see conspecifics but could still detect them by smell and sound.

Use of the visual barrier is significant as it considered how tigers are affected by social stimulus when they can detect, but not see, conspecifics. This study prompted a new question of whether blocking olfactory and auditory signals would help decrease pacing.

Article Contribution

This article was useful because it addresses the main causes behind pacing, and it alluded to the ways that tigers communicate when it mentioned the impact that visual, auditory and olfactory cues have. Based on the other articles that I have read, it supports previous findings that larger enclosures reduce pacing. The case study presents a new question for future studies about whether or not blocking the other sensory aspects of conspecifics (auditory and olfactory triggers) could be arranged to see if pacing would then decrease.

Cited: 66 times.