

Organization of Annotated Bibliographies

I have 10 annotated bibliographies on stereotypic behaviours displayed by pregnant sows that are organized by environmental factors which contribute to stereotypies. The first paper is a review which discusses stereotypies in general, then there are six papers on the effects of diet, two papers on the effects of a foraging substrate, one paper on the effects of confinement, and lastly a paper that discusses potential impacts of stereotypies on sow offspring.

Annotated Bibliography #1

Full Citation:

Radkowska, I., Godyn, D., & Fic, K. (2020). Stereotypic behaviour in cattle, pigs and horses — a review. *Animal Science Papers and Reports*, 38(4), 303-319. [\(No DOI Present\)](#).

Summary: In previous studies, stereotypies were defined as repetitive and functionless behaviours often displayed by animals in environments with decreased stimuli. The presence of stereotypic behaviours in farm animals can serve as an indicator of poor welfare. This review compiled research from 103 articles on stereotypic behaviour in various animals. The objective was to list respective characteristics of stereotypies in cattle, pigs, and horses, and to present potential ways of mitigating these behaviors. The first characteristic discussed was the etiology, or causation, of stereotypic behaviours. The authors suggest that stereotypies are a method to reduce tension in animals, and that the conditions which most commonly lead to stereotypies are barren environments, food and foraging restrictions, space restrictions, separation from other individuals in the herd, and premature weaning. The implications of these environmental factors on each respective farm animal were then discussed. For pigs and pregnant sows, natural rooting instincts and nest-building behaviours are suppressed in pigs kept in individually housed stalls, thereby leading to stereotypic behaviours. Feed restriction in pregnant sows also promotes stereotypies, but the authors note this may be mitigated by providing a high-fibre diet. In terms of weaning, piglets that are prematurely weaned express a strong suckling motivation that sometimes leads to stereotypies. The authors also identified the most common stereotypies seen in cattle, pigs, and horses. Important oral stereotypies in pigs are sham-chewing, bar biting and bar licking, while aggressive stereotypies include tail-biting and pushing or hitting objects. Suggestions for mitigating stereotypic behaviours in pigs include providing straw, ropes, wood chips, chains, or rubber or plastic toys, as well as increasing time spent in group pens. After concluding the discussion on stereotypic behaviour, the paper noted that further research could identify specific brain functions associated with stereotypies.

Article Contribution: This article provided critical background information about why stereotypies arise in animals, the environmental factors that can increase the frequency of stereotypies, how stereotypic behaviour manifests in pigs and pregnant sows, and some of the ways that stereotypies can be mitigated. It effectively summarized previous work on stereotypies in a clear and organized manner. Although the article also covered stereotypic behaviours in cattle and horses, I included this review because it contained sufficient information about the etiology of stereotypies, contributing environmental factors, and specific stereotypies and mitigation techniques for pigs and pregnant sows.

Annotated Bibliography #2

Full Citation:

Terlouw, E. M. C., Lawrence, A. B., & Illius, A. W. (1991). Influences of feeding level and physical restriction on development of stereotypies in sows. *Animal Behaviour*, 42(6), 981–991. [https://doi.org/10.1016/S0003-3472\(05\)80151-4](https://doi.org/10.1016/S0003-3472(05)80151-4).

Summary: Two environmental factors have previously been identified as majorly contributing to the development of stereotypies in sows: restricted feeding motivation, and restricted space in the environment. These appear to promote the development of inappropriate behaviours in sows by suppressing their natural motivations for rooting, feeding, or exploring their enclosures. At the time of writing the environmental proponents and specific causes of stereotypies were unknown, therefore the authors sought to identify the effects of both feeding level and confinement on pregnant sows through four treatments. These included restrained sows with low and high feeding levels as well as loose-housed sows with low and high feeding levels. Sows were mated and their behaviours during gestation (3 months) were observed and recorded in-person through time-sampling. The researchers looked at a total of 32 sows, half of which were tethered by chains in stalls to test confinement, and the rest which were housed loose. They used an ethogram to categorize behaviours of sows, which lists and defines the complete behavioural repertoire of an animal. Proportions of each observational category were used to calculate the average amount of time sows spent performing each behaviour. The specific stereotypies observed included chain and bar manipulation, vacuum/sham chewing, and excessive drinking. The authors found that food restriction was more critical than confinement, as both treatments with low feeding levels resulted in sows that displayed increased oral stereotypies. They also identified increased drinking in food-restricted sows, which they suggest may be considered a stereotypy in response to suppressed feeding motivation. Feeding rate increased over gestation exclusively in food-restricted sows, which the authors suggest may be due to compounding effects of restricting feeding motivation over time. To a lesser extent, housing also affected stereotypic behaviour, with loose-housed sows displaying less chain and bar manipulation than tethered sows.

Article Contribution: This article dramatically improved current knowledge in the field by concluding that suppressing feeding motivation in pregnant sows leads to increased instances of oral stereotypies. It also supported housing and feeding level as causal environmental factors of stereotypies, which provided a base for more specific areas of future research, such as looking at each of these effects separately. One of the main ways in which this article contributed was compiling the known research on stereotypies at that time and outlining clear conclusions. For this reason, this particular article is cited in many of the scientific studies that followed.

Annotated Bibliography #3

Full Citation:

Bergeron, R., Bolduc, J., Ramonet, Y., Meunier-Salaün, M. C., & Robert, S. (2000). Feeding motivation and stereotypies in pregnant sows fed increasing levels of fibre and/or food. *Applied Animal Behaviour Science*, 70(1), 27–40. [https://doi.org/10.1016/S0168-1591\(00\)00142-8](https://doi.org/10.1016/S0168-1591(00)00142-8).

Summary: Suppressing the feeding motivation of pregnant sows can encourage oral stereotypies. In previous studies, researchers found that diets with more fibre or bulk decreased feeding motivation and thus lowered the frequency of stereotypies. The objective of this study was to see if diets with increased levels of plant fibre affected stereotypic behaviour. The authors also investigated how high-fibre diets compared to ad libitum diets (where a constant source of food is available) and control diets. The authors used 21 gestating sows in their fourth parity (expecting their fourth litter) and split them into four treatments. Treatment VHF had a very high-fibre diet, HF had a high-fibre diet, C had a control diet, and CAL had a control diet provided ad libitum. Behaviours were observed using continuous sampling in-person and using 24-hour recordings for each sow. Recorded stereotypies included object-biting, nose-rubbing, vacuum-chewing, and chain-manipulation. The authors also assessed food motivation using operant conditioning, where sows received food rewards by pushing a button. After every reward, the number of required button pushes increased by five (until a maximum of 95). The more rewards gained over 60 minutes, the more food motivation was inferred for the individual. The results showed that VHF sows displayed less stereotypic behaviour than sows in other treatments, and also spent more time lying down after eating. The authors suggest that these sows are more satiated from the high-fibre diet. The HF and VHF treatments did not decrease feeding motivation, which the authors identify could be due to the older age of the sows or lower palatability of the reward pellets. Another important result was high-fibre diets took longer for sows to eat, which could have also decreased foraging motivation. The authors suggest serving high-fibre diets as a mash to increase foraging time and further mitigate stereotypies.

Article Contribution: This article contributed to its field by supporting the possible mitigation of oral stereotypies through providing high-fibre diets. In addition to learning that sows fed high-fibre food displayed less stereotypies, this study was also important because it outlined a few reasons why these diets were effective: namely that they increased sow satiety, as well as took longer to eat. They found that food motivation was not impacted by any of the diets except for control ad libitum, which could promote future studies to investigate the optimal diet amount for pregnant sows.

Annotated Bibliography #4

Full Citation:

Van der Peet-Schwering, C. M. C., Spoolder, H. A. M., Kemp, B., Binnendijk, G. P., den Hartog, L. A., & Verstegen, M. W. A. (2003). Development of stereotypic behaviour in sows fed a starch diet or a non-starch polysaccharide diet during gestation and lactation over two parities. *Applied Animal Behaviour Science*, 83(2), 81–97. [https://doi.org/10.1016/S0168-1591\(03\)00112-6](https://doi.org/10.1016/S0168-1591(03)00112-6).

Summary: Previous literature has stated that food restriction leads to oral stereotypies in sows and high-fibre diets may mitigate this behaviour. It is also noted that stereotypies can become fixed over time and are more common in higher parity sows (where parity is the number of times an animal has given birth)^[1]. Diets rich in fibre from fermentable non-starch polysaccharides (NSP) appear to be more effective at mitigating stereotypies than diets rich in fibre from non-fermentable NSPs. The objective of this study was to determine if gestating and lactating sows displayed differences in stereotypic frequency when fed diets high in starch or fermentable NSPs. Additionally, the researchers investigated if lactation diets affected behaviour in subsequent gestation. There were two treatments for gestating sows in their first parity: one fed the starch diet, and one fed the fermentable NSP diet. This was the same for lactating sows in their first parity, and these treatments were also repeated in the same gestating and lactating sows for their second parity (eight treatments total). There were 109 sows in the experiment, which were artificially inseminated and kept on experimental trial for two full parties (which included gestation, birth, lactation and weaning). The sows were housed in groups of 12 except for feeding, which took place in individual stalls. Stereotypic behaviours (as well as other innocuous behaviours) were recorded during multiple scan sampling sessions. The researchers found that gestating sows fed diets high in non-fermentable NSPs displayed less stereotypic behaviours than those fed starch diets. As well, feeding lactating sows diets high in non-fermentable NSPs reduced the frequency of stereotypies during their subsequent gestation. The authors conclude that diets with increased fermentable NSP fibre are effective at mitigating stereotypic behaviour in gestating and lactating sows over multiple parties.

Article Contribution: This article will be important to my literature review because it supports a possible solution for reducing stereotypies in food motivated pregnant sows: increasing the amount of fibre in gestation diets. The study concluded that fermentable NSPs were effective at reducing stereotypic behaviour in gestating sows, which supports previous findings and encourages the use of this fibre in sow diets. The authors also presented new findings on the long-term benefits of high-fibre diets, as lactating sows fed these diets had reduced stereotypies in future parities. This provides future questions on how lactation and gestation diets can be optimized.

[1] This definition also used for annotated bibliographies 6, 7, 8, and 9

Annotated Bibliography #5

Full Citation:

Robert, S., Rushen, J., & Farmer, C. (1997). Both energy content and bulk of food affect stereotypic behaviour, heart rate and feeding motivation of female pigs. *Applied Animal Behaviour Science*, 54(2–3), 161–171. [https://doi.org/10.1016/S0168-1591\(97\)00067-1](https://doi.org/10.1016/S0168-1591(97)00067-1).

Summary: Increasing the bulk, energy or fibre in gestation diets can reduce oral stereotypies in sows. The mechanism for stereotypic behaviour is thought to be restricted food motivation, which is strongly present directly after feeding, however the physiological consequences of stereotypies are not well-known. This article looked at how the bulk and energy content of sow gestation diets impacted the feeding motivation, heart rate, and frequency of stereotypic behaviours in pregnant sows. The authors used 40 nulliparous sows (sows that had never given birth), and observed heart rate prior to mating. The sows were split into 4 feeding treatments: concentrated diet with high energy and crude fibre (CONC), wheat high-fibre diet (WHEAT), low-energy oat diet (OAT-LE) and a high energy oat diet (OAT). These diets are in order of increasing bulk. A heart rate monitor measured the heart rate of sows before meal time, when the food trolley was visible, and during feeding. After the sows became pregnant, operant conditioning was used in the same way as Bergeron et al., (2000), where higher amounts of rewards received in a 45 minute period correlated to stronger feeding motivation. During gestation, sow behaviours were observed using recordings taken before and after feeding, where the stereotypy observed was chain manipulation. The results indicate that high-fibre diets reduced the frequency of stereotypies. Stereotypies also lessened with increasing diet bulk, as OAT diet sows showed less stereotypies than WHEAT diet sows. The authors suggest that this is due to increased satiety of bulky meals, as sows with the less bulky WHEAT diet also displayed higher feeding motivation during operant conditioning tests. The authors conclude that both energy content and bulkiness of sow diets are important for reducing stereotypies, and that a combination could be used for mitigation.

Article Contribution: This article looked at a new aspect of the interaction between diets and stereotypies by studying both the energy content and bulkiness of sow gestation diets. The result that bulky oat diets with higher energy were the most effective support previous research and also provide a practical example of a sow gestation diet that could be used in practice. I included this paper in my literature review because it provides knowledgeable background on the interaction between diet bulk and energy, as well as further comments on the effectiveness of high-fibre diets in satiating sows and lessening feeding motivation.

Annotated Bibliography #6

Full Citation:

Bergeron, R., & Gonyou, H. W. (1997). Effects of increasing energy intake and foraging behaviours on the development of stereotypies in pregnant sows. *Applied Animal Behaviour Science*, 53(4), 259–270. [https://doi.org/10.1016/S0168-1591\(96\)01169-0](https://doi.org/10.1016/S0168-1591(96)01169-0).

Summary: Pregnant sows demonstrate feeding motivation directly after feeding due to restricted diets, which can lead to stereotypic behaviours. Providing bulky diets, food with increased fibre, high energy diets, or a foraging substrate are methods to lessen the frequency of stereotypies. This study looked at the effects of increasing foraging time and providing high energy diets to determine their role in decreasing stereotypic behaviour. To accomplish this, 24 sows in their second parity were housed individually and randomly split into three treatments: a control treatment with a restricted diet and no foraging substrate (C), a high-foraging treatment with a control diet and feeding system that increased foraging time (HF), and a high energy treatment (HE) with a soybean and dry-fat diet that contained more energy than the control diet. The HF treatment placed chains on top of the food to increase foraging time. Behaviours of sows were recorded once a week for eight weeks through scan-sampling, where stereotypies were chain manipulation and vacuum chewing. The authors found that HE sows performed less chain manipulation and vacuum chewing behaviours compared to C and HF sows. Sows in the HE treatment also spent more time lying down, which the authors suggest is due to increased satiety. They also noted that HF sows displayed less vacuum chewing, however chain manipulation was not affected by this treatment. One reason suggested by the study is that the pigs may have associated manipulating the chains with obtaining food rewards due to the presence of chains on the food. The authors also note that in the HE treatment, chain manipulation occurred at the same levels as the control during the afternoon period post-feeding, which leads them to propose a combination of increasing food energy and food bulk or fibre in order to completely eliminate stereotypic behaviour.

Article Contribution: This article supports previous studies that show that increasing the amount of energy in sow gestation diets is effective at mitigating oral stereotypies, including vacuum chewing and chain manipulation. The nature of the study design also shows that increasing feeding time by using a system of chains that lay on top of the food may actually encourage stereotypies in sows by unintentionally conditioning them. I chose this article for my literature review because it looks at two factors of diet that may mitigate stereotypies and supports the use of high energy diets for gestating sows.

Annotated Bibliography #7

Full Citation:

Whittaker, X., Spooler, H. A. M., Edwards, S. A., Lawrence, A. B., & Corning, S. (1998). The influence of dietary fibre and the provision of straw on the development of stereotypic behaviour in food restricted pregnant sows. *Applied Animal Behaviour Science*, *61*(2), 89–102.
[https://doi.org/10.1016/S0168-1591\(98\)00183-X](https://doi.org/10.1016/S0168-1591(98)00183-X).

Summary: Food restriction for gestating sows is common practice in commercial farms, however this can lead to the development of oral stereotypies. As stereotypies emerge due to suppressing feeding motivation, previous studies have suggested that the presence of a foraging substrate may alleviate the need to perform inappropriate behaviours. Increasing dietary fibre in gestation diets has also been shown to reduce stereotypies in sows. The aim of this paper was to determine the relative effectiveness of increasing dietary fibre and providing foraging substrates in reducing stereotypic behaviour. The authors obtained 48 nulliparous sows and split them into 4 treatments: conventional diets with no straw (NC) and with straw (SC), and high-fibre diets with no straw (NH) and with straw (SH). Sows were group-housed and their behaviours were observed during their second pregnancy. Observers recorded all behaviours on five different days during gestation, as well as on 24-hour video recordings (two recordings per sow). The posture, behaviour, and object manipulation (chain, bar, or straw) was recorded for each individual. The authors found that sows spent less time manipulating straw in the SH diet compared to the SC diet, and suggest that high-fibre is more effective than straw at lowering food motivation. Sows that were fed high-fibre diets also spent less time manipulating chains and bars, therefore the authors support previous studies that found that increasing fibre reduced the frequency of stereotypies. When straw was present, sows preferred to manipulate it compared to chains and bars, which supports its use as a foraging substrate to reduce other stereotypies. The authors questioned if rooting in straw improved sow welfare, and suggest that future studies look at the reasons behind why straw is preferred to chains and bars, and if straw manipulation could be considered a stereotypic behaviour in itself.

Article Contribution: This article is important because it provides important background on stereotypic behaviour in sows, including discussion on why increasing energy and bulk in gestation diets may not be practical in commercial farms. It also expands on diet as an environmental factor by demonstrating that straw can be used as a technique to reduce stereotypies, but is not as effective as providing a high-fibre diet. It is important to its field because it supports previous research showing that stereotypies can be reduced through these methods, and also poses new questions concerning the use of straw as a foraging substrate.

Annotated Bibliography #8

Full Citation:

Spoolder, H. A. M., Burbidge, J. A., Edwards, S. A., Howard Simmins, P., & Lawrence, A. B. (1995). Provision of straw as a foraging substrate reduces the development of excessive chain and bar manipulation in food restricted sows. *Applied Animal Behaviour Science*, 43(4), 249–262. [https://doi.org/10.1016/0168-1591\(95\)00566-B](https://doi.org/10.1016/0168-1591(95)00566-B).

Summary: Stereotypic behaviours are caused by numerous factors, including food-restriction, space-restriction, and lack of environmental stimuli. Previous studies concluded that when sows do not have an appropriate outlet for food motivation, they may perform stereotypies on less appropriate objects such as bars or chains. The objective of this study was to compare how the presence of straw as a foraging substrate in conjunction with food level affected the stereotypic behaviours of gestating sows over two parities. They also wanted to know if straw and food level influenced drinking behaviours. The researchers obtained 96 sows and randomly assigned them to one of four treatments: high food level with straw, and without straw, and low food level with straw, and without straw. The sows were housed in groups of six and had access to drinkers, a food trough, and chains for manipulation. Sows were artificially inseminated and kept for experimental trial for two parities. Behaviours were recorded for each sow, including feeding, drinking, sleeping and the manipulation of substrates. Three different observation time periods were used (two-hour, six-hour and 24-hour sampling periods), each on different days. The study found that sows with low-fibre diets drank more during their second parity, which could suggest a loss of normal function. Sows provided with low levels of food demonstrated increased food motivated activity compared to sows in the high food level treatments. When straw was present, sows preferred this substrate for manipulation, however when straw was absent, low food level sows more commonly manipulated chains and stall bars. The authors also note that food motivation in low-food level sows occurred frequently just after feeding, suggesting they were not properly satiated after their meal. The study states that providing straw and increasing food levels for gestating sows can reduce the frequency of chain and bar manipulation.

Article Contribution: This article provides important information on substrates that can be used to limit stereotypic behaviours in gestating sows. It also supports previous research which states that gestating sows should be fed more food or high-fibre food in order to decrease the frequency of oral stereotypies. I am using this article for my literature review because it provides a good solution to limiting food motivation in addition to using higher quality diets. It also poses future questions concerning how beneficial straw is for the welfare of sows, and if straw manipulation may be a manifestation of stereotypic behaviour in itself.

Annotated Bibliography #9

Full Citation:

Zhang, M., Li, X., Zhang, X., Liu, H., Li, J., & Bao, J. (2017). Effects of confinement duration and parity on stereotypic behavioral and physiological responses of pregnant sows. *Physiology & Behavior*, 179, 369–376. <https://doi.org/10.1016/j.physbeh.2017.07.015>.

Summary: Restricted housing conditions have been shown to increase stereotypies in gestating sows. Previous literature indicated that this is due to restricting motivation of natural behaviours, such as exploring and rooting. This is thought to lead to increased stress in an individual, which can be measured by identifying the relative amounts of cytokines and acute phase proteins (APP) in the body (which are released as part of a non-specific immune response). This study wanted to identify the effects of confinement on behaviours and physiological responses of gestating sows in differing parities. To achieve these objectives, 120 sows were used, 20 from each parity (they used sows of parities 0-5). Stress tests began when sows were placed in confinement crates, and in each parity 12 sows were randomly observed for behaviours. Observations occurred on 4 different days for nulliparous sows, and for 6 different days for gestating sows (as nulliparous sows were confined for a shorter amount of time, whereas gestating sows were confined throughout pregnancy). Observations were done on 12-hour video recordings using scan-sampling. The stereotypic behaviours were trough-biting, vacuum chewing, and bar-biting. Eight blood samples were taken to determine the amounts of cytokines and proteins in sows from each treatment. The authors found that as confinement time of gestating sows increased, the frequency of stereotypic behaviors also increased. The amounts of cytokines and APPs initially decreased during confinement, which the authors suggest is an adaptive response to being repeatedly exposed to environmental stress. They also note that higher parity sows displayed less physiological changes to environmental stress, whereas younger sows showed increased stress from confinement. However, the amount of certain cytokines significantly increased over full confinement duration, and the authors conclude that confinement is a serious source of stress for gestating sows that can damage their short-term stress response.

Article Contribution: This article advances knowledge in the field by determining the physiological effects of confinement on sows and supporting confinement as a contributing factor of stereotypies. It provides new areas of research concerning sow parity, as it is unclear if older sows more or less stereotypic behaviours and stress. The use of blood samples to infer stress in gestating sows can be used to support confinement as a welfare issue. I included this article because it focuses on the effects of confinement on stereotypies and provides important conclusions about how environmental stress can impact the physiology of pregnant sows.

Annotated Bibliography #10

Full Citation:

Tatemoto, P., Bernardino, T., Morrone, B., Queiroz, M. R., & Zanella, A. J. (2020). Stereotypic behavior in sows is related to emotionality changes in the offspring. *Frontiers in Veterinary Science*, 7, 79. <https://doi.org/10.3389/fvets.2020.00079>.

Summary: Stereotypic behaviours are generally thought to be negative reactions generated from feelings of frustration or anxiety. The effects of stereotypic behaviours in domestic pigs were previously investigated in terms of how stereotypies impacted a single individual, as well as the information stereotypies provided about individual welfare. This article investigated how the stereotypic behaviours of pregnant sows affected the offspring, specifically the offspring's emotionality after they were born. To do this, the researchers obtained female pigs, artificially inseminated them and observed them multiple times during gestation. There were two types of pregnant sows observed: ones that displayed high stereotypic behaviour, and ones that displayed low stereotypic behaviour. The stereotypic behaviour observed in the mothers was sham-chewing, which is when a pig demonstrates a chewing motion without eating any food. The researchers recorded the birth of the piglets, weaned the piglets, and used two types of tests on the piglets to determine their emotionality. The two types of tests were the open field test, where the piglet is placed in an open field and its exploratory movements and activities are recorded, and a novel object test, where an object is introduced and the piglet's behaviour toward this object is recorded. The findings of this study showed that piglets from mothers with a high rate of stereotypies demonstrated more exploratory behaviours, while piglets from mothers with a low rate of stereotypies demonstrated more fearful behaviours and made more vocalizations, presumably due to separation anxiety. These findings present new questions, as it is unclear whether the offspring actually benefited from having mothers that showed increased stereotypic behaviours. The authors state that more studies are needed to clarify this relationship. This paper suggested looking into whether differences in offspring emotionality are more closely linked to personality or genetics.

Article Contribution: I chose this article because it outlines some of the consequences of allowing stereotypic behaviours to persist in pregnant sows; not only can stereotypic behaviours impact an individual animal, they may also affect their offspring. This paper explored how piglets were impacted by maternal stereotypic behaviours based on the knowledge that during gestation, hormonal changes in the mother may alter the developing phenotype of a fetus. The findings of this study required more research, and therefore this paper generated a new set of questions in addition to providing context to the current research in the field.