Project Title: Nutritional enrichment to improve nursery pig behavior during weaning

Principal Investigator: Grace Mercer

Principal Instructor and Title: Anna K. Johnson, Professor Animal Behavior and Welfare and Tyrone D. Artz, M.D. Chair for Faculty Excellence in Animal Science

Institution: Iowa State University

Date Report Submitted: 06/11/2021

Keywords: aggression, ethogram, environmental enrichment, swine, welfare

Scientific Abstract

Limited published research has been completed on nutritional enrichment as a tool to improve swine welfare. The objective of this study was to evaluate a novel nutritional “biscuit” on weaned pig feeder aggression. Eighty mixed-sex pigs, 19-24 days of age, were randomly allocated to 8 pens (10 pigs/pen). Pens were assigned 1 of 4 treatments: (1) biscuit with fecal semiochemical attractant, (2) biscuit with sugary attractant, (3) biscuit with no attractant (positive control), and (4) no biscuit (negative control). Each pen received 4 biscuits suspended from 2 ropes at the feeder, for the first 7 days after weaning. Pig aggressive behavior at the feeder, defined as ramming, pushing, or head turns towards a pen mate with or without biting, was recorded. Descriptive data was analyzed for frequency (number) and duration (seconds). The negative control treatment had less aggression at the feeder than the enrichment treatments. On average, the duration of aggression around the feeder between the 4 treatments was very short, with the longest aggressive bout in the positive control treatment. It would be interesting for future work to consider all nursery pig aggression performed (around the feeder and entire home...
pen), to determine if aggression frequency and duration are affected by the biscuit enrichment. It would be wise to define aggression type (push versus bite), animal effect animal (bruise, bite wound, etc.) and consider other key performance indicators, such as morbidity and mortality, average daily gain, feed to gain ratio, and growth. Overall, our results are encouraging, and we conclude that the addition of the biscuit enrichment did not detrimentally change nursery pig aggression around the feeder over the first 7 days.

**Introduction**

The time immediately after weaning is one of the most stressful periods in a pig's life. Commercial weaning occurs abruptly, when piglets are typically between 3-4 weeks of age. This early weaning age may provide some pig advantages, such as improved health (de Grau et al., 2005; Smith et al., 2008), but there are many stressors, such as sow separation, mixing with unfamiliar pigs, transportation to a new facility, and abrupt transition to solid feed (Dybkjaer, 1992; Weary et al., 2008). Young pigs are also inexperienced with eating solid food, and have not yet developed the motor patterns needed to chew food (Tucker and Widowski, 2009; Tucker et al., 2010). The stress induced by weaning may result in a period of low feed intake immediately post-weaning (Dong and Pluske, 2007). Although this period is individual pig time-dependent, on average, pigs will not eat enough solid food to fulfill maintenance energy needs until 5 days post-weaning, and may take up to 2 weeks to consume the same amount of energy as they consumed pre-weaning (Ledividich and Herpin, 1994; Le Dividich and Seve, 2000). Pigs that fail to recover from the post-weaning growth check may experience increased levels of morbidity and mortality, along with effects on health, performance, and overall welfare (Worobec et al., 1999; Bolhuis et al., 2009; Campbell et al., 2013; Wensley et al., 2021). At
weaning, pigs may also engage in aggressive behaviors to establish their dominance hierarchy (D'Eath, 2005; Fels et al., 2012; Hwang et al., 2016). Aggression can lead to tail-biting and increased injury or disease (Taylor et al., 2010; Schroder-Petersen and Simonsen, 2001).

An area that has not been explored in-depth is the use of environmental enrichment (EE) to assist the newly weaned pig to successfully and quickly transition to a solid diet. Environmental enrichment is a biologically relevant modification to a captive animal’s environment in an attempt to improve their biological functioning. Enrichment can include changes to the environment that are social, physical, sensory, occupational, or nutritional (Newberry, 1995). Pigs are attracted to environmental enrichment that is odorous, deformable, and chewable (Van de Weerd et al., 2003). Environmental enrichment offered in the nursery environment has included straw and other substrate enrichments, which have been successful in reducing harmful social behaviors and fighting (Melotti et al., 2011; Lahrmann et al., 2018).

Hanging and fixed rubber toys and ropes have shown similar decreases in harmful behaviors and lesions (Apple and Craig, 1992; Blackshaw et al., 1997; Fu et al., 2018). Therefore, a nutritional enrichment “biscuit” may appeal to the pigs’ oral-, nasal-, facial-nature, and may reduce aggressive interactions around the feeder.

**Objectives**

**Objective 1.** Learn how to properly conduct and write a literature review that covers abnormal and aggressive behaviors in the weaned pig.

**Objective 2.** Develop an objective ethogram based on the completed literature review.

**Objective 3.** Gain methodology and practical nursery management and experience during on-farm research.
Objective 4. Learn Observer XT to collect behavioral data.

Objective 5. Analyze and interpret behavioral data and determine the enrichment effectiveness.

Materials & Methods

Animals and housing: Eighty mixed-sex pigs (Camborough 1050 X 337, PIC, Hendersonville, Tennessee, USA), 19-24 days of age, were randomly allocated to 8 pens with 10 pigs/pen. Pigs were housed at the Iowa State University Swine Nutrition Farm (https://www.ans.iastate.edu/swine-nutrition-farm). Each pen measured 2.4 m long x 1.2 m wide, and pen floors were made of slatted PVC (Farmweld Flooring System, Farmweld, Inc., Teutopolis, Illinois, USA) that opened to a manure pit below the pens. Each pen was equipped with a 4-space, dry self-feeder and 2 nipple drinkers to provide ad libitum access to feed and water with a floor space of ~0.37 m²/pig. Pig diets were fed in a nutritional program with 3 dietary phases with phase 1 covering days 0-7. All diets were formulated to meet or exceed nutrient requirements (National Research Council, 2012). The nursery room temperature was set to 30.5° C when the pigs arrived, and this was decreased on a schedule by approximately 0.25° C daily until day 14. During the day, lights (Fluorescent UltraMax ECO, 28W) were on from 0700-1800 hour, and auxiliary lights (LED, 15W) were on at all times. Pigs were individually identified using a livestock-safe marking stick (Prima Tech®, Kenansville, North Carolina, USA) to aid in behavioral observations.

Experimental design and treatment: The pen was considered the experimental unit. Pens were assigned to 1 of 4 treatments: (1) biscuit with fecal semiochemical attractant (SC), (2) biscuit with sugary attractant (JAM), (3) biscuit with no attractant (positive control; POS), and (4) no
biscuit (negative control; **NEG**). Each pen received 4 biscuits suspended from 2 ropes at the feeder, for the first 7 days. Treatments and enrichments were added to nursery pens at 1500 hours on day 0 and at 0830 hours on days 1-6.

**Environmental enrichment device:** Five ingredients were used to make the biscuit; dried whey powder, corn starch, soybean oil, flour, and water. Ingredients were combined into a dough and stamped into 4 cm diameter cutouts with a 1 cm hole in the middle. Biscuits were baked at 190˚C until golden brown. All biscuits were utilized in the nursery pens within 24 hours of baking. Two biscuits were threaded onto a 3 stranded, 0.5 cm diameter plain cotton rope (R and W Rope, New Bedford, Massachusetts, USA), and the two biscuits were positioned on top of a 1 cm diameter flat washer (Lowes, Ames, IA, USA; Fig. 1). Each enrichment device was tied to the pen bars and secured in place with duct tape, so that the rope hung over the feeder and the biscuit hung at pig eye-level (Fig. 2).

![Fig 1. Biscuits hanging above feed pan](image1)

![Fig 2. Nursery pig interaction with biscuit](image2)

**Behavioral acquisition:** Color video was continuously recorded in real time (30 fps) from days 0-6 using 1080p Weatherproof CCTV Bullet Cameras, and video data was stored on a H.265+ 16 Channel 1080N DVR Recorder (ZOSI Technology Ltd., Zhuhai City, China). Cameras were
mounted to the ceiling so that 1 camera captured either 1 or 2 pens respectively. The recording system was checked daily to ensure proper video capture and view. All pigs were individually identified by numbering each pen of pigs 0-9 on their backs.

**Behavioral methodology:** A pre-determined ethogram (Table 1) was used to score video.

Behavioral observations were performed on 2 pens/treatment. The sampling protocol was continuous observation of all nursery pigs in the pen for 1 hour for days 0-6. This amounted to 56 hours of continuously observed video. The observational period occurred during the first hour after enrichment was replaced daily: day 0 1500-1600 hour and days 1-6 1000-1100 hour.

Blinding of the video was completed on all video data before it was used for behavioral training or observation. Blinding procedures involved assigning a random number to each hour video and sorting by random number, to provide videos in a randomized sequence. Two videos were randomly selected and duplicated within this sequence to determine inter-observer reliability.

One researcher, Emiline Sundman (ES: Dr. Johnson’s Masters Student), with 2 years of behavioral research experience was responsible for training Grace Mercer (GM) and ES served as the gold standard when assessing inter-observer reliability. Observer reliability was calculated using an index of concordance, as a proportion of all agreements (A) and disagreements (D) in behavioral occurrences between observer and trainer, with the formula \( \frac{A}{(A+D)} \times 100 \geq 85\% \) (Martin and Bateson, 2007). Once the observer (GM) reached \( \geq 85\% \) reliability agreement with the trainer, data collection began using blinded videos.

**Statistical analysis:** Data was sorted by pen, treatment, and hour, and checked for accuracy.

Averages and standard deviations were calculated per treatment for frequency of aggressive interactions and total aggressive interactions. Data was sorted by increasing number to find the
longest aggressive interaction. All data manipulation was completed in Excel. Results will be presented descriptively.

Results

Objective 1. Learn how to properly conduct and write a literature review that covers abnormal and aggressive behaviors in the weaned pig.

A 6-page literature review entitled, “The influence of environmental enrichment on piglet behavior during early weaning” was written using Google Scholar, PubMed, and ScienceDirect primarily to search for peer-reviewed papers. Keywords used included swine, pig, behavior, enrichment, weaning, aggression, tail biting, belly nosing, post-wean, and nutritional enrichment. Cited papers were from the Journal of Animal Science, Applied Animal Behavior Science, or other reputable journals if possible. The final literature review included 45 citations. This literature review was broken down into 3 components that covered (i) weaning process and the piglets transition experience, (ii) undesirable behaviors that may occur during this transition, and (iii) how environmental enrichment can be used on-farm to reduce the likelihood of these unwanted behaviors (Appendix A).
**Objective 2.** Develop an objective ethogram based on the completed literature review.

Table 1. Ethogram for commercial mixed-sexed nursery pig feeder aggression on day of placement and over days 0-6 with 2 pens/treatment: negative control, positive control, fecal semiochemical, and jam.

<table>
<thead>
<tr>
<th>Definition</th>
<th>Description</th>
<th>Involvement</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ramming, pushing, or head turns towards pen mate, with or without biting (Oostindjer et al., 2011) that begins while at least one involved pig is interacting with or attempting to interact with the feeder or enrichment devices.</td>
<td>Behavior begins when one pig makes physical contact with another pig in an aggressive manner. Contact does not have to be maintained at all times during a fight. Behavior ends when the pigs are not actively engaged in fighting with each other anymore.</td>
<td>Aggressor pig Recipient pig</td>
<td>Fight must begin while at least one involved pig is interacting with or attempting to interact with the feeder or enrichment devices.</td>
</tr>
</tbody>
</table>

**Objective 3.** Gain methodology and practical nursery management and experience during on-farm research.

Over the 2 research trials (October 6-15 and December 1-10, 2020), Mercer assisted 9 days on-farm under Emiline Sundman’s mentorship. Duties included behavioral equipment setup and removal, remarking pig numbers, weighing pigs, adding the biscuit enrichment to the nursery pens, and observing whether there was still a biscuit hanging from the previous day.

**Objective 4. Learn Observer XT to collect behavioral data.**

Emiline Sundman explained how Observer XT worked (https://www.noldus.com/observer-xt) and practiced using this software with Mercer with an example YouTube horse video. The behavior that was being sought was grazing. Video data collected from this trial was not compatible with the Observer XT program, and therefore, this software was not utilized further. Instead, nursery videos were uploaded and viewed in Google Drive and observations were recorded in Google Sheets (https://www.google.com/sheets/about/).

**Objective 5.** Analyze and interpret behavioral data and determine the enrichment effectiveness.

Total frequency of nursery pig aggressive interactions over the first 7 days following biscuits placement was: NEG: 258 ± 39; POS: 795 ± 59; JAM: 725 ± 55 and SC: 1171 ± 122. Average duration for an aggressive interaction was 1 second over all treatments, except for JAM which was 0 seconds. The longest duration for an aggressive interaction was POS group at 21 seconds in length, followed by 11 seconds JAM, 9 seconds SC, and 6 seconds NEG.
Figure 3. Average frequency of aggressive interactions for commercial nursery pigs in the first hour that a nutritional biscuit enrichment was placed into the pen from day of placement (day 0) to day 6.

*NEG (negative treatment), POS (positive treatment), JAM (sugary attractant treatment), SC (semiochemical treatment)

**Discussion**

**Objective 1. Learn how to properly conduct and write a literature review that covers abnormal and aggressive behaviors in the weaned pig.**

Researching and writing my literature review really helped me understand the important steps in conducting a thorough literature review. From this I was able to comprehend the multitude of effects weaning has on the pig. Knowing what reputable databases were available, what we consider to be sound science, thinking through what key words and phrases are important to find the needed information, and then reading, understanding, and recognizing the value or faults of the published work has been extremely impactful. Taking all of the information and distilling it into
new work was challenging and thinking through the themes and messaging will help me with future professional writing efforts. By going through the references section of the research articles, I became familiar with the landmark research trials that had been published and were referenced countless times by other researchers, like the work done by McGlone (1985) on pig behavior. Completing my literature review also helped me see how little had been done in the area of swine nutritional enrichment. This helped support the justification for completing this research project. Finally, writing the literature review helped me to fine-tune my scientific writing skills, and Dr. Cassandra Stambuk (Dr. Johnson’s Postdoc), was an enormous help and support in assisting me in editing my paper into a finished product (Appendix A).

**Objective 2. Develop an objective ethogram based on the completed literature review.**

After completing my literature review, I had a solid background on pig abnormal and aggressive behaviors, allowing me to create an ethogram for this project (Appendix B). I brainstormed a list of behaviors and definitions, and then compared mine with Emiline Sundman’s. This original ethogram was then used to create a visual ethogram, which included depictions of referenced behaviors (Appendix B). The visual ethogram was created solely for another graduate student in agriculture engineering, who was using computer algorithms to identify and evaluate animal behavior. Emiline Sundman and I then worked together to create a final ethogram that we would use in the video analysis (Table 1). We decided to narrow the original ethogram’s scope and focus specifically on feeder aggressive interactions for a few reasons. We had preliminary observed the majority of the aggressive altercations occurring around this key pen resource, and some of our camera placements did not allow for full view of the nursery pens, hence we were unable to observe every pig continually in other areas if the pen.
**Objective 3.** Gain methodology and practical nursery management and experience during on-farm research.

During my time on farm, I was able to gain first-hand experience with the implementation of a pig research trial. There was a lot of data to be collected, and it was interesting to observe Emiline Sundman and how she kept everything well organized and on schedule. I also learned a lot about the daily needs of recently weaned pigs, including feeding protocols, feeder management, veterinary oversight that included antibiotics as needed, finding pigs that needed additional help, moving pigs to hospital pens, and environmental management (temperature, relative humidity and air quality) of the room.

**Objective 4.** Learn Observer XT to collect behavioral data.

I enjoyed trying out the Observer XT video software. It let me see a commonly used software for behavior research, and how the program can be used to speed up and streamline data collection. Not being able to use the software challenged Ms. Sundman and I to produce a creative and efficient alternative way to collect the video data. We ended up creating a document on Google Sheets that allowed easy yet accurate data collection from the collected videos, that was then used in the analysis for this work.

**Objective 5.** Analyze and interpret behavioral data and determine the enrichment effectiveness.

Very few aggressive interactions with the enrichment device on day 0 (Fig. 3) may be attributed to pigs being placed in a new environment after experiencing multiple stressors (Bruininx et al., 2001). Peak of aggression occurred on day 3, and we could hypothesize that this coincided with pigs’ maximum interest in the biscuit. Animals that are not habituated to an
object will be more likely to spend more time with it, increasing the chances of aggression over said object (Van de Weerd et al., 2003; Tarou and Bashaw, 2007). Day 4 to the end of the project resulted in decreased feeder aggressive interactions.

In this limited study, most aggressive interactions were in the semiochemical group, followed by the positive treatment, jam treatment, and negative control. This was unexpected because previous work using fecal semiochemical has reported a 30% reduction in aggression (Aviles-Rosa et al., 2020). However, frequency and duration of feeder aggression was low over the first 7 days. The longest aggressive interaction was in the positive control (21 seconds), with the negative control being the shortest (6 seconds). Average aggressive encounter durations were 1 second. Thus, we can question if this is even biologically relevant and affects pig welfare. Although little to no aggression occurred in the negative control treatment (no biscuits), we hypothesize that aggression was occurring in other areas of the nursery pen. Therefore, we encourage future work in this area to look for aggression around the biscuit, as well as in other areas of the nursery pen. Another important consideration is the type of aggressive interaction. In this study we did not delineate these differences, but McGlone, (1985) reported that there are differences between threat (posture and contact) and harm (bite and push). Anecdotally from watching the video, the most aggressive interactions displayed were head turns at a quick speed with little direct physical contact with a pen mate. Overall, our results are encouraging, and we concluded that the addition of the biscuit enrichment did not detrimentally change nursery pig aggression around the feeder over the first 7 days. Future work (preferably in a commercial situation) should expand and include other key performance indicators, such as morbidity and mortality, average daily gain, feed to gain ratio, and growth.
**Desired outcomes achieved:**

1. A professional and in-depth mentor-student relationship was developed (Grace and Cassandra). Grace will begin as a professional student at the ISU-College of Veterinary Medicine, Fall 2021.

2. Actively involved in the research development and implementation. Mercer clearly understands how (a) objectives and hypothesis were generated, (b) experimental designs were created, (c) on-farm research was conducted at a high professional level, (d) problem-solving skills were used to overcome unforeseen obstacles, (e) experience gained in working individually and as part of the team, and (f) unparalleled insight into nursery management.

3. Mercer collected the data, quality controlled, and conducted descriptive statistics. Mercer was highly trained by Sundman on continuous behavioral sampling technique and completed an Honors abstract, poster, the SREE report, and will complete an Animal Industry Report, Fall 2021.

4. Attended the Midwest American Society of Animal Science (ASAS) meeting. All of the above outcomes have provided Mercer with an in-depth and well-rounded SREE experience that has prepared the student to serve as a future leader in the US swine industry.

**Student Performance Evaluation:** From project initiation to completion, mentoring has been a team approach with Dr. Stambuk and Ms. Sundman leading these efforts. There has been clear and consistent communication with Ms. Mercer on expectations, objectives, deliverables, and project timeline, and Ms. Mercer worked diligently for 20 h/wk. The mentor-student relationship remained a primary focus throughout this project, and we successfully achieved our overall goal to support Ms. Mercer. Ms. Mercer completed this project in conjunction with her Honors expectations and was duly awarded an A (https://www.cals.iastate.edu/student-services/honors).
In addition, these efforts helped Ms. Mercer secure a prestigious placement at Iowa State University College of Veterinary Medicine to become a professional student, whereby Ms. Mercer is interested in continuing her efforts in large animal practice. We hope that this will eventually lead Ms. Mercer into a key leadership role to serve the US swine industry.

**Student Statement:** I am very grateful to have been a part of the SREE program over Fall 2020 and Spring 2021. I feel like I have a much better grasp on the research process, the effort that goes into it, and how this research can be useful and applied in the swine industry. Data collection and analysis are some of the most important parts of a research trial, and through this project I know varying ways to approach these problems including many behavioral sampling techniques. Learning how to write a literature review was a rewarding task, and I enjoyed reading the pertinent research for the successful completion of my project. I have also learned a lot about graduate school, research in academia, and the swine industry from working with Dr. Stambuk and Ms. Sundman on this project. I had frequent meetings with both over this past year where they guided my path and directed me in the creation of documents and posters related to this project.

Through my work on this project, I have gained skills in time management, organization, and working as part of a team, also known as “soft skills”. These skills are vital for success in any career path and will especially aid me as I start efforts in the veterinary profession. I understand that the research process is constantly evolving, and though you might start with one question, you may end up answering and focusing on a completely different one by time the process is over. I started this project hoping to analyze abnormal and aggressive behaviors, including tail biting, belly-noising, and ear biting, but by at the project’s conclusion, due to outside constraints and narrowing the scope, I ended up focusing on aggression at the feeder.
My favorite part of the SREE project was analyzing data and being able to see and think through the results. It was rewarding to see all of the hard work come together into something tangible and practical for US producers. I also enjoyed learning about the statistical analysis and methodology that goes into research projects, though the sample size for this project did not warrant advanced analysis. I also enjoyed creating a poster for my CALS-Honors project that could be understood by academics and stakeholders alike.

Working on this project also afforded me the opportunity to network with highly educated individuals in the swine industry. Though the COVID-19 global pandemic put some constraints on in-person meetings and conferences, I was able to virtually attend the ASAS (American Society of Animal Science) Midwestern Section Virtual Meeting that took place March 8-10, 2021. This afforded me a fantastic opportunity to hear from professionals around the US and even Canada about topics of interest to me, including swine welfare and behavior. For example, Dr. Jennifer Brown, University of Saskatchewan, presented “Where Is On-farm Animal Welfare in the United States Headed? A Canadian Perspective.” I also gained insight and had great examples to look at from the virtual poster and presentation sessions, which were fundamental in helping me create my own poster and presentation.

I presented my project during the Iowa State University Honors Capstone Project Virtual Poster Presentations this spring (https://www.cals.iastate.edu/student-services/honors). For it I created a poster and a 5-minute presentation (Appendix C). This project will also be published in the October 2021 edition of the National Hog Farmer of this year, and it will be included in an Animal Industry report from the ISU Animal Science Department sometime this fall (https://lib.dr.iastate.edu/ans_air/). Data from this project will also be a part of Emiline Sundman’s Masters thesis.
I have graduated with a Bachelor degree in Animal Science from Iowa State University this May 2021. Fall 2021 I will be starting veterinary school at Iowa State University. At this moment I am interested in animal behavior, but I would not like to limit myself too much so soon into my studies. I would like to pursue board certification in behavior after receiving my DVM. In order to complete the certification, I would have to complete a research trial and I believe what I have learned from this project will greatly assist me in these goals (https://www.dacvb.org/page/Certification).
References


Appendix A. Literature Review

The Influence of Environmental Enrichment on Piglet Behavior During Early Weaning

Modern animal production has thoroughly changed from the practices of the past. Every part of it has been improved to be as efficient, economical, and time conscientious as possible. Weaning is one aspect of pig production that has been thoroughly modernized. Piglets are weaned at a much younger age and are instantly removed from their mothers to complete the process. This has led to adverse effects on the developing pig, including the increased prevalence of abnormal and aggressive behavior. One way to alleviate these detrimental behaviors is through the use of environmental enrichment. The aim of this paper is to review the weaning process and transition that pigs experience, the undesirable behaviors that can arise from it, and how environmental enrichment can be employed to reduce the likelihood of such behaviors.

Weaning is the time period when a mammal transitions from dependence on its mother’s milk to other food sources (Counsilman and Lim, 1985). In the wild, this is a gradual transition for piglets starting at eight weeks of age ranging up to seventeen point two weeks (Newberry and Woodgush, 1985; Jensen and Recen, 1989). The sow slowly stops initiating suckling interactions, and then becomes the one to terminate piglet suckling (Jensen and Recen, 1989). Weaning in a commercial setting is an abrupt change for piglets at about three to four weeks of age. It is the act of completely removing a pig’s access to its mother and mixing it in a new group of piglets. Weaning is used to decrease disease spread in the nursery between the sow and piglets, decrease the amount of time it takes for a pig to reach market weight, and increase sow yearly reproductive outputs (Pyburn and Schwartz, 1995).

Weaning is one of the most challenging times in a developing pig’s lifespan (Colson et al., 2006). During the weaning process, piglets experience many social, environmental, and nutritional changes. First, they are removed from the sow which leads to an instantaneous change
in time-budget. Before weaning, piglets aged three to four weeks spent on average three to nine hours each day with the sow (Bøe, 1991). To achieve weaning, the piglets are transported from the nursing facility to a weaning facility in large groups mixed with piglets from other litters. This transport can take from one to twenty-four hours, and the piglets are not allowed access to food or water (Lewis and Berry, 2006). The piglets are formed into another group at the weaning facility based on age and weight (Harris, 2000). The transport process and mixing at the new facility offer two opportunities for piglet to display aggression. Previously unacquainted pigs will fight vigorously for one hour after mixing, and for up to twenty-four hours at less intense levels before a hierarchy is established and aggression drops off (Meese and Ewbank, 1973). A hierarchal relationship is established between pigs once one of them flees or retreats.

Piglets face an abrupt change in diet with a transition from the sow’s milk to creep feed. Some piglets face a learning curve as they learn to consume solid food instead of liquid. Physical problems can impede the piglets from transitioning to this new feed. Teeth eruption occurs between one to five weeks of age and can affect the feeding patterns of weaned piglets (Tucker and Widowski, 2009). Younger pigs are inhibited from feeding when their premolars first erupt, while older pigs with more advanced dentition are more likely to feed (Tucker et al., 2010).

All of these factors lead to physical and psychological ramifications on the developing pig. Stress is an additional multifactorial issue that is a constant presence during weaning and has a detrimental effect. Separation from the sow, transport without food or water, regrouping with unfamiliar pigs in an unfamiliar environment, and a new feed are all potential stressors. These issues can lead to a period of decreased feeding and increased diarrhea post-wean (Leibbrandt et al., 1975; Rhouma et al., 2017). This leads to a plateau in growth rates, decreased intestinal villus height, and decreased immune activity (Hampson, 1986; Vente-Spreeuwenberg et al., 2003). In
relation to behavior, the stress of weaning at a young age potentially leads to the emergence of aggressive or abnormal behaviors not otherwise seen in the pig.

There are a vast number of differences between the behavior of pigs weaned under natural or semi-natural conditions compared to those weaned under commercial conditions. Immediately after removal from the mother, piglets begin to call out in high pitched squeals or low pitch grunts (Weary and Fraser, 1997). This is not seen in semi-natural weaning where there is a gradual process of separation of the piglets from the sow. Piglets that are raised in conditions similar to those found in the wild have relatively unchanged time budgets before and after weaning (Jensen and Stangel, 1992). They spend most of their time foraging or lying and display little or none at all of the abnormal and aggressive behaviors observed in commercial settings.

Abnormal behavior of pigs weaned in a commercial setting has been observed in many trials. Research has shown that the younger the age of the piglet when weaned from the sow, the higher the prevalence of such behaviors (Mason et al., 2003). One trial looked at the effect of weaning age on pig behavior (Worobec et al., 1999). Piglets weaned at seven or fourteen days of age showed more belly nosing and chewed on litter mates more than piglets weaned at twenty-eight days of age. Belly nosing is an action that is similar to the piglet massaging the udder of the sow and is an undesirable behavior as it leads to skin lesions (Worobec, 1997). Belly nosing is thought to indicate stress due to premature separation from the sow (Weary et al., 1999). Another study showed that pawing and belly noising were common in litters after weaning and were practically nonexistent before separation from the sow (Fraser, 1978). Both studies showed a higher prevalence of restlessness within the first twenty-four hours of separation from the sow and that piglets had difficulty lying down and resting. Tail biting is another abnormal behavior observed in pigs of all life stages, but most predominantly in recently weaned piglets. It is a nuanced issue with no one source causing the behavior. Tail biting is an important behavior to
catch early, as it can lead to the spread of disease or cannibalism (Vanputten, 1969). Many studies have focused on observing tail biting and its causes and have worked on ways to recognize the early signs and prevention of it (Zonderland et al., 2009; Taylor et al., 2010).

Aggression is also a common behavior displayed post-wean. As mentioned earlier, the mixing of unfamiliar piglets during weaning leads to higher aggression than the mixing of piglets already familiar with each other. This is due to a new hierarchy needing to be set between unintroduced pigs (Meese and Ewbank, 1973). Aggression between piglets can contain a broad range of interactions. Many studies have been conducted on the aggressive acts of pigs post-wean and what can influence its frequency and intensity (Tan and Shackleton, 1990; Colson et al., 2006; Hwang et al., 2016). One study by McGlone (1985) focused specifically on the aggressive and submissive behaviors after weaning. Piglets aged twenty-six weeks were placed in groups of four and video recorded for forty-eight hours. Six hundred thirty individual bites and eight hundred and sixty-six pushes were recorded, with both combined accounting for eighty-one percent of the total behaviors observed in the study. Prevalent areas targeted for acts of aggression were the ears, neck or shoulder, and face. Other aggressive acts recorded during this study included head knocking and jumping (McGlone, 1985). Both aggression and abnormal interactions are behaviors producers want to reduce in their swine production systems. They lead to decreased productivity and welfare conditions for commercial swine farms. One successful way of reducing these behaviors is the use of environmental enrichment.

Commercial production farms have faced problems with providing pigs the stimulation they need to combat boredom and decrease abnormal behaviors. Environmental enrichment is a way to improve a captive animal’s environment (Newberry, 1995). Pigs are intelligent animals that routinely explore their environment. They are stimulated by novel objects and will repeatedly choose a pen that contain such items over a barren one (Woodgush and Vestergaard,
Young pigs can be encouraged to play by providing a novel object or stimulated to join in play by the play of other piglets (Newberry et al., 1988; Held and Spinka, 2011). Play has been defined as a luxury activity and is evaluated as a high standard of welfare of pigs.

Different areas of interest have been explored in regard to environmental enrichment for pigs. The use of straw has been researched in many studies, as it promotes species specific behavior, such as rooting, and allows for manipulation of the environment by the pig’s mouth and snout (Fraser et al., 1991; Scott et al., 2007; Stewart et al., 2008). Other avenues of enrichment include, but are not limited to, plastic and rubber toys, hanging chains and rope, salt licks, and peat (Horrell and Ness, 2000; Manciocco et al., 2011; Guy et al., 2013).

Enrichment has been shown to have positive influences on pig performance and behavior. Research has shown environmental enrichment leads to increased feed consumption and growth rates which also leads to increased carcass weight at slaughter (Beattie et al., 2000). Decreased time inactive and harmful social interactions like aggression and abnormal behavior, including tail biting, have also occurred due to use of different enrichment devices (Schaefer et al., 1990; Petersen et al., 1995; Blackshaw et al., 1997).

One relatively unexplored area of research is nutritional enrichment. One study introduced a trough with feed in the farrowing stall to pre-weaned piglets to acclimate them to how feeding would occur post-weaning (Delumeau and Meuniersalaun, 1995). Piglets that had been given access to flavored feed before weaning had higher average feed intakes and growth rates than piglets only given accessed to flavored feed after weaning. Another studied tested a cookie shaped and donut shaped enrichment toy and discovered weaned piglets routinely interacted with both devices (Duran et al., 2019). Although the study was not statistically significant since there was not a difference between the live weights of the control group and enrichment group, the piglets did interact extensively with the device and it showed promise for
future research. Pigs are particularly attracted to environmental enrichment devices that are odorous, deformable, and chewable, categories that a nutritional device fulfills (Van de Weerd et al., 2003). More research should be allocated towards swine nutritional enrichment devices.

The weaning process in swine is one of the most stressful periods a pig can experience during commercial production that can have widespread effects on the developing pig. Focusing specifically on behavior, abnormal and aggressive interactions between recently weaned pigs lead to decreased performance and impediments in physiological condition. Environmental enrichment can be used to redirect and alleviate these behaviors, along with other benefits like increasing feed intake and growth rates. More research into nutritional environmental enrichment would benefit the swine industry, as preliminary research has been limited but already demonstrated favorable results. Nutritional enrichment has many possible uses in the swine industry, such as supplemental nutrition that could help mitigate postweaning anorexia, redirection of stereotypical behaviors, and increase pig welfare.

References


### Appendix B. Original ethogram of aggressive and abnormal behaviors displayed by swine

<table>
<thead>
<tr>
<th>Behavior</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aggressive</strong></td>
<td></td>
</tr>
<tr>
<td>Biting</td>
<td>Use of teeth to make aggressive physical contact with a pen mate</td>
</tr>
<tr>
<td>Head knock</td>
<td>Rapid upward movement of the head directed at a pen mate (Fraser, 1991)</td>
</tr>
<tr>
<td><strong>Abnormal</strong></td>
<td></td>
</tr>
<tr>
<td>Belly nosing</td>
<td>Rhythmic up and down motion on a pen mate’s belly (Fraser, 1978)</td>
</tr>
<tr>
<td>Chewing</td>
<td>Use of teeth to manipulate the skin on a pen mate or an object</td>
</tr>
<tr>
<td>Suckling</td>
<td>Holding the skin of a pen mate in the pig’s mouth and sucking</td>
</tr>
<tr>
<td>Tail biting</td>
<td>Use of teeth to manipulate another pen mate’s tail (Van Putten, 1969)</td>
</tr>
</tbody>
</table>

Definitions adapted from:


Visual ethogram created for software development team member

**Swine Ethogram**

Left Pig – Target Pig  
Right Pig – Acting Pig

<table>
<thead>
<tr>
<th>Behavior</th>
<th>Definition</th>
<th>Illustration</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aggressive</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biting</td>
<td>Use of teeth to make aggressive physical contact with a pen-mate</td>
<td><img src="image1" alt="Illustration" /></td>
<td>Acting pig will be orientated towards the general direction of the target pig. The acting pig will use its teeth to bite the target pig. Common spots for biting are the ears, neck, and face.</td>
</tr>
<tr>
<td>Head Knocking</td>
<td>Rapid upward movement of the head directed at a pen-mate (Fraser, 1991)</td>
<td><img src="image2" alt="Illustration" /></td>
<td>Acting pig will be oriented towards the head of the target pig. The acting pig will use its head to make contact with the target pig using a fast upward motion.</td>
</tr>
<tr>
<td><strong>Abnormal</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Belly nosing</td>
<td>Rhythmic up and down motion on a pen-mate’s belly (Fraser, 1978)</td>
<td><img src="image3" alt="Illustration" /></td>
<td>Acting pig will be oriented towards the belly of the target pig. The acting pig will be making contact using the snout with an up and down motion on the target pig.</td>
</tr>
<tr>
<td>Chewing</td>
<td>Use of teeth to manipulate the skin on a pen-mate or an object</td>
<td><img src="image4" alt="Illustration" /></td>
<td>Acting pig will be orientated towards the general direction of the target pig. The acting pig will use its teeth to chew the target pig. This action is longer than a bite.</td>
</tr>
<tr>
<td>Suckling</td>
<td>Holding the skin of a pen-mate in the pig’s mouth and sucking</td>
<td><img src="image5" alt="Illustration" /></td>
<td>Acting pig will be orientated towards the general direction of the target pig. The acting pig will use its lips to hold the skin of the target pig in its mouth. This is a longer action.</td>
</tr>
<tr>
<td>Tail Biting</td>
<td>Use of teeth to manipulate another pen-mate’s tail (Van Putten, 1969)</td>
<td><img src="image6" alt="Illustration" /></td>
<td>Acting pig will be standing oriented towards the back end of the target pig. The acting pig will have the target pig’s tail in its mouth.</td>
</tr>
</tbody>
</table>
Definitions adapted from:


Pictures drawn by Grace Mercer
Appendix C. ISU CALS Honors Capstone poster and presentation

**Effects of Novel Nutritional Enrichment on Pig Feeder Aggression During Early-Weaning**
Grace Mercer, Cassandra Stambuk, Emiline Sundman, Anna Johnson
Department of Animal Science
Honors Capstone Project

### INTRODUCTION
- The time after weaning is one of the most stressful in a pig’s life.
- Pigs may display increased aggression levels to establish a hierarchy when mixed with new penmates.
- Environmental enrichment has been shown to improve welfare conditions of animals, along with having positive effects on behavior and performance.
- Pigs are attracted to environmental enrichment that is odorous, deformable, and chewable.

### OBJECTIVE
To evaluate the effect a novel nutritional “biscuit” had on feeder aggression in early-weaned pigs.

### MATERIALS & METHODS
- Forty mixed-sex pigs, aged 19-24 days, were randomly allocated into 4 pens (10 pigs/pen).
- Pens were assigned 1 of 4 treatments:
  1. biscuit with fecal semi-chemical attractant
  2. biscuit with sugary attractant (jam)
  3. biscuit with no attractant (positive control)
  4. no biscuit (negative control)
- Each pen received 4 biscuits suspended from 2 ropes at the feeder, for the first 7 days.
- Pig aggressive interactions at the feeder was recorded for the first hour after biscuit placement each day.

### RESULTS

<table>
<thead>
<tr>
<th></th>
<th>NEG (negative control)</th>
<th>POS (positive control)</th>
<th>JAM (sugary attractant treatment)</th>
<th>FSC (fecal semi-chemical treatment)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frequency</strong></td>
<td>128 ± 24.5</td>
<td>492 ± 47.6</td>
<td>341 ± 25</td>
<td>462 ± 64.5</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>00:01</td>
<td>00:01</td>
<td>00:01</td>
<td>00:00</td>
</tr>
<tr>
<td><strong>Longest</strong></td>
<td>00:06</td>
<td>00:21</td>
<td>00:11</td>
<td>00:04</td>
</tr>
</tbody>
</table>

![Image 1. Hanging biscuits](image1.png)
![Image 2. Pig interacting with biscuit](image2.png)

**Definition of Aggressive Interaction:** Ramming or pushing penmate, with or without biting (Oostindjer et al., 2011), that begins while at least one involved pig is interacting with or attempting to interact with the feeder or enrichment devices.

### CONCLUSIONS
- Novelty of enrichment could have influenced higher frequency of aggression at the beginning of the week.
- SC treatment had an average duration of 0, and the shortest bout of the longest aggressive interactions.
- We cannot conclude whether the enrichment influenced pig aggression at this point due to small sample size and short durations.
- We will analyze more data and look at effect of pig size on aggressor and recipient in aggressive interactions.

### ACKNOWLEDGEMENTS
- This project was funded by the U.S. Pork Center of Excellence and the National Pork Board and the Foundation for Food and Agriculture Research.

Link to Honors Presentation ([https://www.honors.iastate.edu/program/uhp/project/spring-2021-virtual-poster-session](https://www.honors.iastate.edu/program/uhp/project/spring-2021-virtual-poster-session))

36