The Effect of Environment and Social Dynamics on Lamb Behavior

THESIS

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ABSTRACT

Assuring farm animal welfare is of increasing concern for consumers in the United States. The assessment of welfare involves a multi-factorial approach, with one of the critical tools being the study of behavior. For sheep in particular, the behavioral repertoire primarily encompasses social and feeding behaviors. However, management strategies on-farm, such as weaning, modify these behaviors in order to meet productivity goals. There is minimal literature evaluating the long-term effects of early weaning (i.e. 60 d of age) strategies on feeding behaviors in lambs. Therefore, the objective of this thesis was to assess short- and long-term lamb grazing, feeding, standing, and lying behaviors as they relate to social groupings and the environment in which the lamb is placed in at early weaning.

The first study involved validating a scan sampling technique for behavioral observations of pastured lambs in order to improve efficiency and accuracy of data collection. Utilizing two statistical tests (generalized linear mixed model and linear regression), it was determined that a 10-min instantaneous scan sampling interval would accurately estimate grazing, lying, and standing behaviors of lambs housed on pasture.

The second study utilized the validated scan sampling technique to collect behavioral data of lambs assigned to weaning treatments in two experiments. Experiment 1 evaluated short- (three days post-weaning) and long-term (eight weeks post-weaning) grazing, lying, and standing behaviors on social dynamics in a pasture environment at
early weaning. The treatments included weaned lambs housed with similar-aged lambs (W), weaned lambs housed with similar-aged lambs and non-lactating adult ewes (SF), and lambs that remained with their maternal dam until 116 d of age (E). There were no differences in short- or long-term grazing, lying, or standing behaviors between W and SF lambs, indicating that the presence of a non-lactating adult ewe did not impact weaned lamb behavior via social facilitation. Both W and SF lambs spent a greater percentage of time grazing than E lambs long-term, indicating that E lambs continued to nurse until 116 d of age to supplement forage intake with milk. Similarly, W and SF lambs spent a lesser percentage of time lying than E lambs long-term, as decreased time inactive generally correlates with increased time active.

Experiment 2 compared short- and long-term feeding behavior of weaned lambs housed with similar-aged lambs in a feedlot (FL) to W lambs from the first experiment to investigate influences of environment at time of early weaning. There was evidence of adaptation to the new diet and environment as FL lambs fluctuated feeding behavior across weeks, primarily within the first four weeks of the trial. Weaned lambs on pasture (W) also spent 39.2% more time consuming nutrients than FL lambs, which was attributed to the influence of feedstuff composition on behavior.

The studies in this thesis demonstrate that weaning age, social dynamics, and environment influence lamb behavior, and lambs supplement milk intake with forage up to 116 d of age. This thesis provides short- and long-term behavioral data collected with a validated sampling technique in order to contribute a substantial behavioral dataset to sheep welfare literature regarding weaning strategies.
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CHAPTER 1:
LITERATURE REVIEW

Introduction

Consumers are increasingly concerned with ensuring farm animal welfare in the products they purchase. This interest has resulted in several changes in the past 10 years both from a legislative and retailer standpoint. For example, in 2009, the state of Ohio developed the Ohio Livestock Care Standards as a result of the passing of a constitutional amendment voted on by Ohio residents. Major food corporations like McDonald’s®, Kraft Heinz®, and Kroger® have developed policies that influence on-farm welfare and care. For sheep specifically, the American Sheep Industry Association has released a sheep welfare statement and published a Sheep Care Guide that particularly emphasizes handling and shearing practices (Shulaw, 2005; ASI, 2014). Additionally, third-party food labeling programs like Certified Humane Raised and Handled® and Animal Welfare Approved® provide opportunities for sheep producers to certify their products if they comply with on-farm welfare standards (HFAC, 2013; AWA, 2017).

The United States sheep industry consists of 5.3 million head of sheep (USDA, 2016), resulting in an annual total economic impact of $2.7 billion (Shiflett, 2011). This success is in part due to producing efficient, economical, and quality products (i.e. meat,
milk, and wool) for both domestic and international markets. As a result, management practices have evolved within the industry to improve profitability and productivity of the animals, such as targeting growth and nutrition through weaning and confinement facilities. However, both practices involve social, nutritional, and environmental adjustments. Exposure to novelty can result in fear and stress for sheep, which may affect food acceptance, health status, behavioral deviations, and productivity (Newbery and Swanson, 2008; Villalba et al., 2010; Rice et al., 2016). Scientific evaluation and assessment of weaning and confinement facilities with regard to lamb welfare and behavior are currently limited.

The scope of this thesis includes a literature review and two experiments that aim to evaluate lamb behavior with respect to management strategies on-farm. Chapter 1 consists of the literature review, emphasizing the behavioral repertoire of sheep and the impact of weaning and confined housing strategies on behavior. The second chapter validates a technique for behavioral observation for lambs housed on pasture, which is pertinent for data collection in the second study in the following chapter. Chapter 3 investigates how social dynamics and environment at early weaning affect short- (three days post-weaning) and long-term (eight weeks post-weaning) grazing, lying, and standing idle behaviors.
Behavioral repertoire of sheep on pasture

A.1 Social behavior: the ewe-lamb bond

The purpose of the bond between a lamb and its dam is to provide the lamb with nutritional sustenance and promote the development of behaviors that support survival, including the formation of social bonds and selective grazing patterns (Hinch et al., 1987; Napolitano, 2008). The development of this ewe-lamb bond is influenced by neuroendocrine mechanisms, maternal performance, and the learning ability of the lamb.

For the dam, neuroendocrine mechanisms promote the onset of maternal behavior, which begins in late pregnancy with the combination of sex steroids (i.e. estradiol) and vaginocervical stimulation (VCS) at parturition (Dwyer, 2008). The degree of maternal behavior is greatly influenced by steroid concentration in particular. For example, Dwyer and colleagues (1999, 2004) found that Scottish Blackface sheep demonstrated higher circulating estradiol concentrations in late gestation and thus demonstrated greater expression of maternal care behavior when compared to Suffolk sheep with lower estradiol concentrations. In addition to estradiol, oxytocin also plays an integral role in the formation of maternal behavior, as it can induce maternal care in non-pregnant ewes towards alien lambs (Newberry and Swanson, 2008).

Within one hour of parturition, dams demonstrate behavioral cues to strengthen the ewe-lamb bond, including low-pitched vocalizations, tactile stimulation (i.e. vigorous licking of the amniotic fluid off of the lamb), and olfactory signals (Napolitano et al., 2008). These cues encourage the lamb to identify its mother within 12 hours of birth and also stimulate olfactory memory formation so that the ewe can distinguish her lamb from
alien lambs (Dwyer, 2008; Napolitano et al., 2008). Perhaps the most critical behavioral aspect of establishing the ewe-lamb bond is suckling by the lamb within the first 24 hours of birth (Napolitano et al., 2008). Suckling reinforces the lamb’s attachment to its dam by providing the lamb with both oral and gastrointestinal stimuli from colostrum ingestion (Val-Laillet et al., 2004, 2006; Newberry and Swanson, 2008). Furthermore, opiate-like substances in milk and those released during any type of physical contact contribute to the strong attachment between offspring and dam (Nelson and Panskepp, 1998; Weary et al., 2008).

The factors described above positively impact and strengthen the ewe-lamb bond formed within the first 24 hours of life; however, some physiological (i.e. genetics, poor prenatal nutrition, parturition stress, low body condition score of the ewe, and poor colostrum production) and environmental (i.e. adverse weather, stocking density, and stockperson interaction) factors negatively influence maternal behavior and consequently impact lamb survival (Everett-Hincks and Dodds, 2008). For example, ewes can be assigned a maternal behavior score (MBS), which reflects the distance that a ewe retreats from her lamb(s) during stockperson handling within 24 hours of birth (Everett-Hincks and Dodds, 2008). Unfavorable ewe MBS (i.e. farther retreat distance and longer latency to return to lamb) has been correlated with increased risk of lamb starvation and decreased overall lamb survival (Everett-Hincks and Dodds, 2008).

Once the ewe-lamb bond is formed, it remains unchanged for up to 130 days and physical proximity and suckling may persist to 190 days of age or longer (Arnold et al., 1979). Initially, the ewe has a strong interest in the lamb, playing a critical role in
maintaining the bond and actively searching for the lamb when separated (Hinch et al., 1987). The lamb also promotes this relationship by soliciting care through suckling and vocalizations, with suckling identified as one of the most significant contributors to maintaining the bond (Weary et al., 2008). Suckling frequency is greatest during the first 15 days post-partum, particularly with higher milk producing ewes (Ewbank, 1967).

However, suckling behavior changes as early as 30 days post-partum, when the dam begins to reject suckling and is less likely to go to her lambs when separated from the flock (Ewbank, 1967; Hinch et al., 1987). These behaviors by the dam initiate a role reversal in maintaining the ewe-lamb bond, where the dam begins to associate with the flock over her lamb (Arnold et al., 1979). Suckling frequency and duration decline around 42-49 days of age as a response to declining milk supply and antagonistic behaviors performed by the dam to the lamb during suckling (Napolitano et al., 2008). Nonetheless, dams and lambs continue to maintain close contact (within five meters of one another), which plays an important role for the lamb to learn diet selection from its dam during post-ruminal development (42 days of age and on; Napolitano et al., 2008). Ewes on a higher nutritional plane produce a larger milk supply and thus sustain a stronger, longer bond with the lamb (Arnold et al., 1979).

Most lambs are naturally weaned by 150 days post-partum, when the lamb and dam demonstrate mutual disinterest in nursing behavior likely in conjunction with a low milk yield (Arnold et al., 1979). However, natural nutritional weaning does not mean that the ewe-lamb bond is terminated. Lambs weaned just prior to the next lamb being born reunited with their biological dam when they were reintroduced six weeks later (Arnold
et al., 1979). Similarly, lambs separated from their dams for eight weeks still sought out and associated with their dams (Hinch et al., 1987). Ewe-lamb associations have been reported for up to two and a half years, despite weaning and birth of subsequent lambs (Hinch et al., 1990).

A.2. Social behavior: flock interactions

Initially the dam is the primary social model, and lambs learn how to graze and develop food preferences by mimicking their dam’s dietary choices (Thorhallsdottir et al., 1990a). Breed characteristics, previous grazing experience, and conditioning influence ewes’ maternal and grazing behavior (Dwyer and Lawrence, 1999). Lambs model their dam’s intake behavior in both extensive and intensive production systems, and at six weeks of age, solid feed consumption was greater in lambs with continued social contact with their dam as opposed to lambs separated from their dam (Napolitano et al., 2003; Weary et al., 2008).

This behavioral response is an example of social facilitation, which is defined as the initiation or increase of a particular behavior when in the presence of other animals performing the same behavior at the same time (Clayton, 1978). Lambs learn how to discover resources through allelomimicry – by following and imitating experienced flock members that have already learned how to utilize certain resources (Weary et al., 2008). While the dam is the most influential for the lamb’s behavior, sheep are a gregarious species and are capable of developing a strong, persistent attachment to animals other than their dam (Cairns, 1966). Despite lambs preferring their dam as their primary social
partner, lambs will frequently congregate and play with similar-aged lambs while their
dam is grazing (Nowak, 1990; Napolitano et al., 2008). Therefore, non-related ewes and
similar-aged lambs can act as social stimulation by mediating stress and developing
social flock cohesion for lambs during natural or artificial periods of weaning
(Napolitano, 2008; Henry et al., 2012).

B.1 Feeding behavior: diurnal grazing pattern

Sheep exhibit a diurnal grazing pattern by grazing most often at dawn and later in
the afternoon, which may be due to air temperature, forage characteristics, digestion, and
predator avoidance. A diurnal pattern allows sheep to avoid grazing during the hottest
part of the day, likely to conserve energy (Bojkovski et al., 2014). Energy conservation is
particularly relevant to sheep on range or pastureland, as activity levels account for 90%
of their energy expenditure (Lin et al., 2011). Forage characteristics between legumes and
grasses result in sheep grazing legumes in the morning and then increasingly consume
more grasses in the afternoon (Rutter, 2006). This may be a result of shifting preference
from energy dense legumes to grasses with greater concentrations of non-structural
carbohydrates to dilute the potential side effects associated with toxins found in legumes
(i.e. bloat; Rutter, 2006; Lin et al., 2011). A slower passage rate in the rumen with grasses
later in the day may also reduce the need to graze at night, characteristically a time of
minimal grazing behavior (Rutter, 2006). This may be due to low visibility of pasture at
night or an evolutionary response to decrease activity in order to avoid nocturnal
predators (Rutter, 2006).
B.2 Feeding behavior: mixed diets

Grazing behavior and nutritional requirements are influenced by the animal’s prior grazing experiences, social models, physiology, and the plant’s morphology (Villalba et al., 2010). Characteristically sheep are considered selective grazers and prefer a heterogeneous diet as opposed to grazing a monoculture, as it is unlikely that the perfect balance of nutrients will come from a single plant species (Rutter, 2006). Sheep modify their feeding behavior in the presence of diverse feedstuffs to select food that meets their physiological needs to maintain homeostasis (Villalba et al., 2010). For example, sheep sample feedstuffs in their environment to assess its quality, which may be a characteristic of evolving in diverse rangelands (Dumont and Gordon, 2003). They learn preferences through both affective and cognitive systems. The affective system integrates the taste of the food with post-ingestive feedback, while the cognitive system integrates the taste of the food with its odor and appearance (Baumont et al., 2000). This feedback interaction develops physiologically learned preferences for feeds and forages, which sheep have utilized to sustain rumen health and function by selecting energy-rich feeds and avoiding toxins (Thorhallsdottir et al., 1990a; Baumont et al., 2000). Sheep also demonstrate a stronger preference for plants previously lacking in their diet, which may be an attempt to balance dietary needs and support rumen health (Parsons et al., 1994). Mixed diets promote diverse, effective rumen micro-flora and fauna as a result of the evolutionary advantage to better cope with environmental changes (i.e. fiber source availability or bloat; Rutter et al., 2006). Newman and colleagues (1994) found that sheep who had been fasted showed a lower preference for clover than non-fasted sheep, which may have
demonstrated the synthesis of post-ingestive feedback into learned grazing behavior as rapid intake of clover can result in bloat.

**B.3 Feeding behavior: social effects on intake**

Social influence from experienced conspecifics plays a major role in the efficiency and longevity of learned food preferences, particularly considering the motivation for sheep to consume a mixed diet (Thorhallsdottir et al., 1990a). Previous research indicates that the presence of the dam, non-maternal adult ewes, and similar-aged conspecifics can all influence grazing behavior and forage intake.

When the dam is present and consuming novel feed, lambs utilize olfactory cues from feed left around the dam’s mouth and nose to develop feed preferences (Thorhallsdottir et al., 1990a). Lambs are most sensitive to developing preferences prior to natural weaning, particularly at four to eight weeks of age, and exposure to novel feed during this time results in increased lamb preference for such feed when re-exposed (Hinch et al., 1987; Thorhallsdottir et al., 1990a). Ramos and Tennessen (1992) demonstrated that weaned lambs with previous grazing experience with their dams spent nearly twice the time grazing than weaned lambs that had no previous grazing experience (i.e. raised indoors). Additionally, the type of forage lambs grazed with their dams (i.e. ryegrass or white clover) had an impact on lambs’ forage preference after weaning (Ramos and Tennessen, 1992). Similarly, Green and colleagues (1984) observed that lambs introduced to wheat with their dams around nine to 10 weeks of age consistently consumed more wheat than lambs introduced to wheat without their dams when retested.
up to 34 months of age. At 34 months of age, lambs exposed to wheat with their dams had an average intake of 322 grams/head compared to 0.3 grams/head for lambs exposed without their dams (Green et al., 1984). This difference allowed lambs exposed with their dams to meet 75% of their daily maintenance energy requirement through wheat consumption (Green et al., 1984). Finally, when lambs were exposed to a food that was perceived as harmful by their dam prior to weaning, lambs demonstrated less of a preference for that food after weaning, with this disinterest persisting 10 weeks later (Thorhallsdottir et al., 1990a).

Learned preferences in sheep have also been evaluated in the presence of non-maternal adult ewes and conspecifics. Youssef and colleagues (1995) demonstrated that when 12-week-old lambs were integrated with non-lactating adult ewes at weaning, lambs increased bite rate, grazing time, and rumination time. In addition, lambs weaned at four weeks of age had greater average daily gain (ADG) and greater slaughter weights at eight weeks of age when weaned with non-lactating adult ewes compared to those lambs weaned only with similar-aged lambs (Pascual-Alonso et al., 2014). The influence of conspecifics on feed preference development has been further noted with studies demonstrating that learned, established feed aversions can be overcome in the presence of conspecifics. Lambs with a previous learned feed aversion (refusal rate 100%) increased feed consumption by 76% in the presence of non-aversive control lambs (Thorhallsdottir et al., 1990b).

The readiness in which lambs will transition to and accept feed is relevant to the sheep industry, as sheep can be trained to prefer or avoid feeds in order to meet
management objectives. Available forages and feedstuffs in extensive systems may change due to droughts or other environmental conditions, or sheep may be provided with new supplements or switched to a high concentrate diet in intensive systems (i.e. finishing period). Initial periods of nutritional transitions are commonly associated with depressed feed intake and decreased productivity; therefore, utilizing the gregarious nature of sheep to promote learned feeding behavior may ensure that the farm has sheep that can be brought onto new feed more effectively and safely (Green et al., 1984).

Training sheep to prefer particular forages could also be utilized to meet management objectives as a method to control weed population in a field or manage the biodiversity in a field (Provenza and Balph, 1987; McCutcheon, 2014). Developing food aversions is also beneficial, particularly for the health and welfare of sheep raised on diverse rangelands with toxic plant species (Villalba et al., 2010).

Production practices influencing the behavioral repertoire of sheep

C.1 Weaning: abrupt weaning technique and behavioral deviations

In the Eastern United States, it is a common practice to wean lambs at 60 days of age in production systems (Barkley, 2014). Lambs are typically isolated from auditory and visual signals from their dam and placed onto pasture or a feedlot with lambs of similar age. This age is considered early weaning, as it is before the natural weakening of the ewe-lamb bond, and involves behavioral and physiological indicators of stress associated with the abrupt social, nutritional, and environmental changes (Weary et al., 2008). The lamb will vocalize frequently for the first two days post-weaning in an
attempt to solicit maternal care, as well as demonstrate increased locomotion, increased plasma cortisol concentrations, decreased grazing, and decreased body weight and growth rate (Orgeur et al., 1998; Napolitano et al., 2008; Damián et al., 2013). Glucocorticoid hormones (i.e. cortisol) coincide with decreased growth hormones and suppression of the immune system’s circulating lymphocytes, which results in a greater susceptibility to disease (Orgeur et al., 1998; Napolitano et al., 2008). Watson and Gill (1991) found that lambs weaned at eight weeks of age and orally dosed with nematode parasite larvae had greater fecal egg counts and lower packed cell volume (PCV) when compared to non-weaned lambs, representative of clinical signs of disease within the weaned group.

Similarly, McCutcheon and colleagues (2015) found that lambs weaned at 120 days had greater average daily gains (ADG) and thus reached market weight a month earlier than lambs weaned at 60 days. In the same study, late-weaned lambs also had less incidence of parasitic infection based on lower fecal egg counts (FEC), higher PCV, lower FAMACHAs (physical assessment of anemia), and less lambs requiring anthelmintic treatment on test.

Lambs that are weaned particularly early (i.e. 48 hours post-partum) develop non-nutritive suckling of navels of other lambs as a redirected motivation from being unable to nurse their dam (Stephens and Baldwin, 1971; Napolitano et al., 2002). This behavior is considered abnormal as it is a consequence of being unable to perform a natural behavior with the dam, and can result in decreased feed intake and increased risk of navel infection in those being suckled on (Napolitano et al., 2008).
Management strategies have been recommended in an attempt to reduce weaning stress associated with the abrupt separation technique while maintaining lamb growth and development. University Extension educators recommend preparing ewes and lambs for weaning weeks prior to the event. Lambs should be castrated, ear-tagged, vaccinated, dewormed, and started on creep feed to ease the nutritional transition that occurs at weaning (Ricketts, 1999; Barkley, 2014). Ewes should be fed only roughage one week prior to weaning to aid with milk production cessation, which can prevent mastitis and encourage lambs to be more independent (Ricketts, 1999; Barkley, 2014). At time of ewe-lamb separation, it is recommended to move ewes to another location and leave the lambs in their familiar paddocks to maintain a familiar environment and thus decrease stress on the lambs (Ricketts, 1999; Barkley, 2014).

C.2 Weaning: alternative weaning techniques

Various other weaning strategies have also been researched to provide an alternative to sudden separation. The most common alternative techniques include fence line, two-stage, progressive, and social weaning. Fence line weaning allows the ewe and lamb to maintain visual and auditory contact, but the fence prevents physical contact. In a study by Orgeur and colleagues (1999), fence line weaning resulted in lower coccidial oocysts and greater growth rates compared to those lambs weaned and isolated from their dam. However, in the same study, fence line-weaned lambs demonstrated similar plasma cortisol concentrations and greater vocalizations (i.e. higher frequencies and longer duration) compared to isolated lambs, suggesting that this alternative was still
physiologically stressful to the lamb. Fence line weaning may contribute to lamb frustration in that the dam is visible during the vocalization signal, but the dam is unable to respond (Weary et al., 2008).

Two-stage weaning is conducted by leaving the ewe-lamb pair intact, but restricting the lambs’ ability to nurse by placing udder nets on the lactating dam. This method allows the lamb to encounter one stressor at a time (i.e. loss of milk first, followed later with loss of physical contact with dam). Schichowski and colleagues (2008) compared abrupt weaning and two-stage weaning, assessing both methods at eight and 16 weeks of age. The results from that study suggest that two-stage weaning and weaning at an older age (16 weeks) were less stressful for lambs, as shown by lower agitation scores and less vocalizations. However, that same study also reported that lambs weaned abruptly at a younger age (eight weeks) had higher ADG. While two-stage weaning mitigates stress, this method is time and labor intensive due to maintaining the udder nets on the dams and it may only be feasible for smaller operations (Schichowski et al., 2008).

Progressive weaning was studied by Orgeur and colleagues (1998) who compared abrupt weaning at three months of age to progressive weaning. The progressive method involved lambs and ewes being separated on a daily basis, beginning when lambs were three and a half weeks of age. The duration of daily separation increased (i.e. two to 23 hours) until lambs were fully weaned at three months of age. Progressively weaned lambs demonstrated less vocalization and behavioral deviations when fully weaned at three months of age compared to suddenly weaned lambs (Orgeur et al., 1998). However,
progressively weaned lambs had greater coccidial oocysts throughout the trial than abruptly weaned lambs, suggesting progressive weaning implicates lambs to being more susceptible to parasitic infection (Orgeur et al., 1998).

Lastly, social weaning was evaluated by Pascual-Alonso and colleagues (2014) who studied the effects of weaning lambs at four weeks of age with similar-aged lambs, non-lactating ewes, or daily human contact (one hour). Lambs had the lowest physiological stress values (i.e. cortisol, creatine kinase) when weaned with human contact, followed by the non-lactating adult ewe group, and lambs weaned only with similar-aged lambs displayed the greatest physiological stress values (Pascual-Alonso et al., 2014).

D. Confinement management systems

Nearly 40% of sheep operations in the United States manage at least some of their sheep in a confined dry lot/feedlot system that does not allow for grazing (USDA, 2012). Lambs may be moved into long-term confinement for various reasons, such as nutritional management, disease risk, pasture availability, inclement weather, and predation avoidance. However, moving animals into a feedlot from an extensive environment involves social stressors (e.g. mixing with unfamiliar animals), environmental stressors (e.g. novel flooring, more prevalent human contact, temperature and ventilation adjustments), and nutritional stressors (e.g. novel feed, competition for resources; Rice et al., 2016). As such, newly received feedlot animals demonstrate physiological responses to stress, including general adaptive syndrome, fluctuations in endocrine and metabolic
responses, and reductions in ruminal microbe function (Loerch and Fluharty, 1999).
Furthermore, up to 20% of sheep are classified as shy-feeders, where they do not adapt to
feedlot environments and sustain low appetites for the entire duration of the fattening
period, creating a population that is consistently vulnerable to low productivity and
increased health impairments (Jolly and Wallace, 2007; Savage et al., 2008). The
environmental change from pasture to confinement can also result in deviations to the
behavioral repertoire of sheep. For example, pastured sheep spend 24% of their time
performing resting (i.e. standing or lying), 49% grazing, and the remaining time
ruminating or walking (Lin et al., 2010). In contrast, individually penned sheep housed
indoors reportedly spend 62% of their daily time budget idle, 17% consuming feed, 5%
pacing, and 14-20% performing abnormal behaviors (Marsden and Wood-Gush, 1986;
Lauber et al., 2012).

Abnormal behaviors in confined sheep consist primarily of oral stereotypies and
redirected oral behaviors, including but not limited to mouthing bars, pulling and
chewing pen fixtures (i.e. buckets, slats, or chains), and wool biting (Dwyer and
Lawrence, 2008). When defined as a stereotypy (i.e. repetitive behavior with seemingly
no purpose), abnormal oral behavior raises concern from an animal welfare standpoint, as
stereotypic behaviors are indicators of an animal coping with stressors or inadequacies in
its environment (Broom, 1983). Stereotypies are identified as a welfare concern if they
occur for more than 10% of the animal’s daily activity or in more than 5% of animals
studied (Broom, 1983; Wiepkema, 1983). Lauber and colleagues (2012) noted that 71%
of confined sheep performed oral stereotypies for more than 10% of the time. As oral
manipulation occurs most commonly post-feeding, scientists suggest that the underlying purpose of this behavior is related to unfulfilled satiety or as a means increase saliva production to aid with the buffering of high concentrate diets (Bergeron et al., 2006; Lauber et al., 2012). For example, cattle displaying oral stereotypies have less ulcer development and incidence of enteritis and hepatitis, suggesting that the function of these behaviors is to aid in reducing or preventing gastrointestinal dysfunction (Bergeron et al., 2006).

Wool biting, also referred to as wool pulling, chewing, or eating, occurs when an individual sheep pulls with its mouth on the strands of wool on another sheep, commonly near the rump and back, and potentially ingests it (Dwyer and Lawrence, 2008). The target animal will have noticeable areas of missing wool and, in some cases, visibly inflamed skin. Sheep typically begin by biting wool from a single sheep and then progressively move to others, usually targeting the lower-ranking sheep (Sambraus, 1985; Lynch et al., 1992). Individual sheep will gradually increase the frequency and severity of this behavior over time, and more pen mates will begin to perform the behavior as it is learned through allelomimicry (Sambraus, 1985; Lynch et al., 1992; Vasseur et al., 2006).

The etiology behind abnormal oral behaviors is not clear, but they are likely a result of deviation in foraging behavior specifically, both in the time budget and feedstuff source. Unfulfilled satiety, nutrient deficiencies, gastrointestinal dysfunction (i.e. acidosis, ulcers), and environmental factors (i.e. bedding, social dynamics, barren housing) are potential causes of abnormal oral behaviors (Bergeron et al., 2006). Sheep may use abnormal oral behaviors as an attempt to find more feed, address physiological
deficiencies, or fulfill their behavioral motivations for foraging (Bergeron et al., 2006). For example, lambs may lick wooden slats that have been urinated on in an attempt to attain nitrogenous urea in a protein-deficient diet (Whybrow et al., 1995).

Wool biting in particular has been linked with diet deficiencies (primarily fiber, but also metabolizable energy and minerals), overcrowding, social dominance, and boredom (Lynch et al., 1992; Yurtman et al. 2002; Vasseur et al, 2006). Wool biting may be a result of inadequate fiber or roughage sources, thus resulting in the behavior being redirected from feed to wool. Concentrated, pelleted feed reduces the overall volume of feed intake and time spent feeding compared to a diet incorporating fiber, which decreases oral stimulation, rumination, and gut fill despite meeting nutritional requirements (Vasseur et al., 2006). Similarly in swine, reducing the volume of feed intake has been linked with increased oral stereotypic behavior (i.e. sham-chewing, manipulation of pen fixtures) despite meeting nutritional requirements (Bergeron et al., 2006; Vasseur et al., 2006). Physiological parameters indicating compromised health of wool biting sheep (i.e. weight loss, mineral deficiencies, anemia, hypoproteinemia, and higher alkaline phosphatase) compared to control sheep further support the concern that this behavior is an indicator of compromised welfare (Suliman et al. 1988; İçen et al., 2008; Aytekin et al., 2010; Ebrahim, 2015).

The health consequences of ingesting wool are dependent on the age of the animal, as there is no serious health impairment associated with wool consumption in adult sheep, aside from a possible increased risk of parasitic infection if ingested wool is soiled (Dwyer and Lawrence, 2008). However, lambs who ingest wool via wool biting
can develop compact fibrous balls called bezoars in their gastrointestinal tract (Sambraus, 1985; Stookey et al., 2009). As a result, the lamb can become anemic or endure potentially fatal pyloric or intestinal obstruction (Sambraus, 1985). Similarly in cattle, bloat and death have been reported in six-month-old feedlot calves with bezoars from hair-licking (Herd and Cook, 1989). Herd and Cook (1989) suggested that the bezoars may prevent rumination by blocking the esophageal inlet to the rumen, and surgical procedures have been implemented to remove bezoars from the small intestine of calves (Abutarbush and Radostits, 2004). Our laboratory collected wool bezoars from the rumen, reticulum, and abomasum in weaned eight-month-old feedlot lambs with wool biting behavior upon slaughter. The effects of bezoars on health and productivity was not evaluated in our laboratory.

To mitigate wool-biting in confinement systems, providing fiber as an oral stimulus in the diet or as bedding has been shown to delay and reduce wool-biting behavior (Cooper and Jackson, 1996; Vasseur et al., 2006). Reducing stocking density or providing access to outdoor husbandry conditions are other suggested methods for reducing the behavior, as the behavior has been noted to disappear when sheep are returned to pasture (Fraser and Broom, 1990; Lynch et al., 1992; Stookey et al., 2009). Shearing the stomach of the ewe prior to lambing can help to alleviate wool biting in young, unweaned lambs (Stookey et al., 2009). Modifications of the housing environment (i.e. isolating the main wool-biters, providing enrichment, and shearing sheep) as it relates to the incidence of wool-biting have not been formally studied.
Conclusion

The natural behavioral repertoire of sheep is primarily influenced by social relationships and feeding behavior. Common production practices in the United States sheep industry (i.e. weaning, housing sheep in feedlots) result in deviations to the natural behavioral repertoire of sheep, which can lead to the development of abnormal behaviors, physiological indicators of stress (i.e. cortisol), and impaired health and productivity. Conducting research that investigates alternative management methods to mitigate behavioral deviations may improve the welfare of farmed sheep.
CHAPTER 2:
VALIDATION OF SCAN SAMPLING TECHNIQUES FOR BEHAVIORAL OBSERVATIONS OF PASTURED LAMBS

ABSTRACT

The study of farm animal behavior is a critical tool for assessing animal welfare. Collecting behavioral data with continuous sampling or short scan sampling intervals (e.g., every 60th second) is considered ideal as this provides the most complete and accurate dataset; however, these methods are also time and labor-intensive. Longer sampling intervals provide an alternative in order to increase efficiency, but these require validation to ensure accurate estimation of the data. This study aims to validate scan sampling intervals for lambs (*Ovis aries*) housed on pasture. Grazing, lying, standing, drinking, locomotion, and mineral consumption were evaluated from six pens of crossbred lambs (6 lambs/pen) for 15 h. Data from 1-min instantaneous scan sampling were compared with data from instantaneous scan sampling intervals of 5, 10, 15, and 20-min in two statistical tests: generalized linear mixed model and regression analysis. Using the mixed model, the percentage of time each behavior was performed did not differ amongst sampling intervals for all behaviors except grazing, which was statistically
different at 20-min intervals. Using regression analysis, lying and grazing estimations were accurate up to 20-min intervals, and standing was accurate at 10 and 20-min intervals only. Locomotion, mineral consumption, and drinking demonstrated poor associations ($R^2$) for all tested intervals. The results from this study suggest that a 10-min instantaneous scan sampling interval will accurately estimate lying, grazing, and standing behavior for lambs on pasture. This validation will assist with the efficiency of future data collection in lamb behavior and welfare research.

**INTRODUCTION**

The study of farm animal behavior is considered an integral parameter for assessing animal welfare (Gonyou, 1994). Understanding the behavioral needs and preferences of farm animal species provides the basis for scientists to investigate the impact of animal management strategies on behavioral deviations and overall welfare of that individual or group (Gonyou, 1994). To date, the most common methods to evaluate behavior in livestock species include continuous or scan sampling. Continuous sampling is considered the gold standard for collecting behavioral data as it provides the most complete and accurate dataset (Lehner, 1992); however, this method is time and labor-intensive, particularly in studies with large sample sizes and a high number of behaviors recorded, and may not be feasible due to technological or logistical limitations. To avoid this problem, researchers often rely on scan sampling methodology by recording behaviors at selected time points within a sample period and estimating a proportion of time the animal spent performing a specific behavior (Martin and Bateson, 2007). In
particular, short scan sampling intervals (e.g. every 60th second) are especially similar to continuous observation for some behaviors (Mitlöhner et al., 2001; Miller-Cushon and DeVries, 2011). However, even a short scan interval can prove to be inefficient and identifying a longer, appropriate scan sample technique that provides accurate data in an efficient time period could be subjective. Therefore, recent research has focused on validating scan sampling techniques among a variety of farm animal species, including laying hens (Daigle and Siegford, 2014), broiler chickens (Kristensen, et al., 2007), dairy calves (Miller-Cushon and DeVries, 2011), dairy cows (Endres et al., 2005; Ledgerwood et al., 2010; Kitts et al., 2011), feedlot cattle (Mitlöhner et al., 2001), and pigs (Arnold-Meeks and McGlone, 1986; Whalin et al., 2016). Despite these recent publications, the authors are unaware of research validating scan sampling techniques for lambs in a pasture setting.

In the United States, over 60% of sheep flocks are primarily managed on pasture (i.e. any fenced area specifically cultivated to raise forage or browse; USDA, 2012). This trend is similar internationally with the majority of sheep raised in either pasture or rangeland systems (Nowak et al., 2008). Therefore, most sheep behavioral research has been conducted on pasture systems, including work evaluating behavioral deviations due to influences of stocking density (Lin et al., 2010), flock dynamics (Bojkovski et al., 2014), restricted grazing time (Chen et al., 2013), forage preferences (Villalba et al., 2011), and mother-young bond (Dwyer and Lawrence, 1999). These studies utilized scan sampling methodology to collect behavioral data for sheep on pasture (1-min, 3-min, and 5-min intervals), but a validated technique for the chosen sampling interval was not
referenced. As behavior is a critical tool to evaluate animal welfare, refining behavioral recording methodology for lambs housed on a pasture system is critical for future sheep research. Therefore, the objective of this study was to validate the accuracy of four different instantaneous scan sampling intervals (i.e. 5, 10, 15, and 20-min intervals) when compared to a 1-min instantaneous scan sampling technique for lambs housed on pasture. In this case, a 1-min instantaneous scan sampling technique was chosen for comparison due to its demonstrated similarity to continuous sampling in ruminant species (Mitlöchner et al., 2001; Miller-Cushon and DeVries, 2011) and the inability to collect continuous data from the video recordings.

**MATERIALS AND METHODS**

The Ohio State University Institutional Animal Care and Use Committee approved the protocol for this study. The animals were cared for in accordance with the Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching.

*Animals and housing*

The study was conducted at the Ohio Agricultural Research and Development Center Sheep Unit in Wooster, Ohio, USA (40º 43’44.71 N, 81º 54’4.25’W) in July 2015. Animals were housed on established pasture dominant in fescue forage, which utilized rotational grazing with an average stocking density of 26,000 kg body weight/hectare.
Thirty-six, 60 d old Hampshire x Dorset and Suffolk x Dorset crossbred twin lambs (*Ovis aries*; 17.7 ± 2.0 kg) were blocked by sex and body weight and randomly assigned to one of six pastures with six lambs/pasture. Animals had *ad libitum* access to water and minerals throughout the trial (VitaFerm Sheep Mineral, BioZyme® Inc., St. Joseph, Missouri, USA).

**Behavioral measurements**

Behavior was recorded with one of six color wireless outdoor IP video cameras per pasture (Foscam, Model F19805P, Houston, Texas, USA) recording at 30 frames/s. Each camera was positioned centrally in front of the pasture at a height of 2.4 m from the ground. All video was captured digitally utilizing portable laptops with external USB hard drives. Video output was viewed during recording with Foscam software (V4.1) to ensure picture clarity and camera positioning prior to the behavioral recording session. Video was recorded continuously for 15 h (06:00-21:00) in five pastures and for 12 h (06:00-18:00) in one pasture (n = 6 pastures; 87 total hours). Behavioral data (Table 1) was collected using a 1-min instantaneous scan sampling technique (i.e. every 60th second; Altmann, 1974; Martin and Bateson, 2007) for all animals in each pasture by one trained observer using Windows Media Player (Version 12, Microsoft, Redmond, Washington, USA). Due to video image quality, it was not possible to individually identify animals at all times for continuous focal animal sampling. As such, a 1-min instantaneous scan sampling technique was chosen as the standard for comparison, and previous validation literature has demonstrated that 1-min scan intervals are similar to
continuous observation in ruminant animals (Mitlöchner et al., 2001; Miller-Cushon and DeVries, 2011).

**Statistical analysis**

The experimental unit in this study was the pasture (n = 6). Two statistical methods were used to assess the sampling intervals: generalized linear mixed model and regression analysis. All observations from the 1-min instantaneous scan sampling technique for each behavior in each pasture were summed, then divided by the total possible observations (i.e. 15 h x 60 min/h x 6 lambs = 5,400 total observations) to create one percentage of time spent performing each behavior per pasture. To calculate percentages for each sampling interval (5-min, 10-min, 15-min, 20-min), data were extracted from the 1-min dataset every fifth, 10th, 15th, and 20th min. Differences in the percentage of time each behavior was performed between the five different instantaneous scan sampling techniques (1-min, 5-min, 10-min, 15-min, 20-min) were identified using a Generalized Linear Mixed Model (PROC GLIMMIX) in SAS version 9.4 (SAS Institute Inc., Cary, NC, USA). The model included sampling technique as a fixed effect and pen as a random effect. The means for each sampling technique were compared to the 1-min interval using contrast statements. A sampling interval was considered adequate if it was not statistically different from the 1-min interval.

A regression analysis was conducted to identify accuracy and bias of the behavioral values from each sampling technique (5-min, 10-min, 15-min, 20-min) when compared to the 1-min instantaneous scan sample data using linear regression (PROC
REG) in SAS version 9.4 (SAS Institute, Cary, NC, USA). A sampling interval was considered to accurately estimate the behavior if the following criteria were met: $R^2 \geq 0.9$, slope not statistically different from 1 ($P > 0.05$), and intercept not statistically different from 0 ($P > 0.05$; Ledgerwood et al., 2010). The combination of these values reflects the strength of association ($R^2$), linear relationship (slope), and over- or underestimation of the duration values of each behavior (intercept; Ledgerwood et al., 2010; Daigle and Siegford, 2014).

**RESULTS**

Differences in the mean percentage of time each behavior was performed among the various sampling intervals is shown in Table 2. Values from the four intervals assessed did not differ ($P > 0.05$) from the values obtained from the 1-min sampling technique for all behaviors except grazing. The percentage of time estimated for grazing at the 20-min interval was statistically different from the 1-min interval ($P = 0.008$).

Using regression, the relationship between each sampling interval assessed compared to the 1-min sampling technique is illustrated in Figure 1 for all behaviors. Both lying and grazing behaviors met all three criteria ($R^2$, slope, and intercept) at 5, 10, 15, and 20-min instantaneous scan sampling intervals. Standing behavior met only $R^2$ criteria at the 5-min interval (slope = 1.22, $P = 0.027$; intercept = -1.31, $P = 0.037$) but met all three criteria at 10 and 20-min intervals. Mineral consumption, locomotion, and drinking did not meet the $R^2$ criteria, but did meet slope and intercept criteria, for all sampling intervals tested in this study.
DISCUSSION

The objective of this study was to determine the accuracy of four different scan sampling intervals (i.e. 5, 10, 15, and 20-min intervals) when compared to behavioral estimates collected using 1-min instantaneous scan sampling for lambs in a pasture setting. Two statistical methods were utilized to validate the sampling intervals: a generalized linear mixed model and regression analysis.

Using a generalized linear mixed model, the comparison of mean percentages of behavior yielded no differences between sampling techniques for all behaviors except grazing. The percentage of time that lambs spent for standing, lying, locomotion, mineral consumption, and drinking had similar estimates across all sampling intervals up to 20-min. The percentage of time that grazing behavior was performed had similar estimates across sampling intervals up to 15-min. The results from this statistical test alone prompt a recommendation of 15-min instantaneous scan sampling to retrieve similar values compared to a 1-min sampling technique for all tested behaviors. These results are supported by previous methodologies utilizing 15-min scan intervals in grazing cattle behavior research (Senft et al., 1985; Hart et al., 1993), and they are similar to other publications that have utilized a generalized linear mixed model to validate sampling intervals for standing and feeding behaviors at 15-min scans for feedlot cattle (Mitlöchner et al., 2001) and sows (Whalin et al., 2016). However, these results should be taken with caution, as the standard error in the model was high, particularly for behaviors that were performed at low frequency (locomotion, mineral feeding, drinking). Thus, the sample
size used in this study (n = 6) may have been too small to detect real differences between the 1-min and other sampling techniques for these variables.

Using a regression analysis, accuracy and bias could be validated regarding the percentage of time each behavior was performed between different sampling techniques when compared to the 1-min scan sample. Both lying and grazing behaviors met all three criteria up to 20-min scans, whereas standing behavior met all three criteria at 10 and 20-min scans only. Standing time (not grazing) had a high R² for 5-min, but the slope was not demonstrative of a linear relationship and the negative intercept value indicates that data was underestimated at this interval. It is unclear why standing time did not meet all three criteria for 5-min and 15-min scans; a possible explanation is the presence of an outlier (lambs in one pasture had almost double the amount of standing time than all other pastures in the 15-min scans), however, there was no explanation for this outlier that warranted its removal. Nonetheless, the results from the regression analysis suggest that 20-min scan intervals would accurately estimate lying, grazing, and standing behaviors for lambs housed on pasture-based systems. This suggested interval is longer than findings from previous validation studies utilizing only correlation coefficients, which recommend 10-min scan sampling intervals for feeding behavior in lactating cows (Endres et al., 2005) and dairy heifers (Kitts et al., 2011), and utilizing regression criteria to recommend 5-min scan sampling intervals for calf feeding behavior (Miller-Cushon and DeVries, 2011). The difference in findings between our study and others may be due to our animals being in an extensive environment as opposed to a stall, where sheep reportedly perform long durations in grazing and idling bouts for the majority of the day.
(1.6 h grazing bouts and 28.8 min idling bouts for 61.2% and 23.1 % of a 14 h day, respectively; Pokorná et al., 2013). If a behavioral bout is long in duration, then longer scan sampling intervals are able to be utilized to report accurate data. Other differences that may arise between our studies and others is that our behavioral collection utilized the scan of a group as opposed to a focal animal. Consequently, individual animal differences do not contribute to variation in our data that may have resulted in a more conservative time interval.

Of the six behaviors tested in this study, lying, grazing, and standing were the only behaviors that met all three criteria in the regression analysis for at least one of the intervals tested. This is likely due to these three behaviors collectively representing 80% of the daily time budget and thus being conspicuous events, which is a characteristic recommended by Martin and Bateson (2007) for instantaneous sampling. On the other hand, behaviors such as drinking, mineral consumption, and locomotion collectively made up 2% of total time budget for pastured lambs. These behaviors had the largest standard errors relative to the estimated value in the generalized linear mixed model. In addition, none of these three behaviors met the $R^2$ criteria for the regression analysis, indicating all tested intervals had a poor association when compared with the 1-min standard. Martin and Bateston (2007) state that instantaneous sampling is not appropriate for behaviors that are short in duration or are rare behavior patterns, which may be characteristic of drinking, mineral consumption, and locomotion.

Sheep provided ad libitum water spent 0.2% of a 24 h day drinking (Al-Ramamneh et al., 2012), which is similar to our results of 0.1%. Additionally, free-choice
mineral intake in grazing ruminants is highly variable amongst individuals in terms of intake and number of visits, and 40% of visits reportedly occur in the evening after 8:00 PM (Tait and Fisher, 1996). In this case, our behavioral observations did not account for individual variation and occurred between 0600-2100 h for five pens and 0600-1800 h for one pen, which may not have been optimal for collecting mineral consumption behavioral data. Lastly, locomotion that does not include grazing behavior in pastured sheep can vary from 1.8 to 2.8% of a 16 h day (Lin et al., 2011), which is similar to our results of 1.2% within a 15 h day. The overall performance of these behaviors in the time budget indicates infrequent and rare behavioral patterns, which may be inappropriate for the instantaneous scan sampling intervals tested in this study. The association (R²) of these behaviors drops at 10-min intervals, rises at 15-min intervals, and then drops again at 20-min intervals (Figure 1). An explanation for this is that it is likely a statistical anomaly given the overall disassociation with the 1-min data at all tested intervals. The results for drinking, mineral consumption, and locomotion should be interpreted with caution as there were outliers and, due to the small sample size, this caused inconsistencies in the data. Additionally, they were less normally distributed when the instantaneous scan sampling interval became longer. If an instantaneous scan sampling interval is longer in duration than the bouts that a behavior is performed, then the accuracy of estimating that behavior within the time budget will be poor (Miller-Cushon and DeVries, 2011). Therefore, a shorter scan interval (e.g. 1-min) or continuous observation would be recommended to provide greater accuracy in estimating infrequent behaviors such as drinking, mineral consumption, and locomotion.
When considering both statistical tests, the generalized linear mixed model recommends a 15-min scan interval for all behaviors and a regression analysis recommends a 20-min scan interval for three behaviors (e.g. lying, grazing, and standing). Combining the statistical tests provides the most robust analysis of intervals for the validation. Since standing behavior is not accurate for a 15-min interval in the regression analysis, we ultimately conclude that a 10-min scan interval is supported by both tests to accurately estimate lying, grazing, and standing behaviors of lambs kept on pasture. Based on these results, evaluating lamb behavior with an emphasis on grazing and activity patterns can be accomplished utilizing 10-min scans as opposed to the more conservative scanning methodologies conducted in previous sheep research (3-min scan: Lin et al., 2011; Chen et al., 2013; 5-min scan: Key and MacIver, 1980; Bojkovski et al., 2014).

**CONCLUSION**

Ultimately the scan sampling methodology is determined by the researcher based on the behaviors of interest, logistics, and statistical approach to validating the sampling technique. The results from this study suggest that 10-min scan intervals can accurately estimate lying, grazing, and standing behaviors of lambs on pasture.
<table>
<thead>
<tr>
<th>Behavior</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lying</td>
<td>At least 50% of the stomach or side in contact with ground; body not supported by all four legs.</td>
</tr>
<tr>
<td>Grazing</td>
<td>Standing or walking with muzzle close to the grass (i.e. head is below shoulders).</td>
</tr>
<tr>
<td>Standing</td>
<td>Body supported by all four legs not in motion. Head is above shoulders.</td>
</tr>
<tr>
<td>Locomotion</td>
<td>Body supported by four legs while in motion; excludes standing or walking while muzzle is in close contact with grass (i.e. grazing).</td>
</tr>
<tr>
<td>Mineral consumption</td>
<td>Standing with muzzle inside mineral feeder.</td>
</tr>
<tr>
<td>Drinking</td>
<td>Standing with muzzle close to water (i.e. head is below shoulders).</td>
</tr>
<tr>
<td>Out of view</td>
<td>Lamb behavior is unable to be identified because lamb is in blind spot of camera, blocked by another lamb or ewe, or head is not visible.</td>
</tr>
</tbody>
</table>

Table 2.1. Behavioral ethogram for validation of instantaneous scan sampling intervals for pastured lambs.
<table>
<thead>
<tr>
<th>Behavior</th>
<th>1-min</th>
<th>5-min</th>
<th>10-min</th>
<th>15-min</th>
<th>20-min</th>
<th>SE</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lying</td>
<td>35.3</td>
<td>35.4</td>
<td>35.6</td>
<td>35.9</td>
<td>35.6</td>
<td>0.3</td>
<td>&gt; 0.05</td>
</tr>
<tr>
<td>Grazing</td>
<td>39.3</td>
<td>38.9</td>
<td>38.1</td>
<td>39.0</td>
<td>37.0*</td>
<td>0.5</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Standing</td>
<td>6.3</td>
<td>6.3</td>
<td>6.7</td>
<td>6.4</td>
<td>6.7</td>
<td>0.4</td>
<td>&gt; 0.05</td>
</tr>
<tr>
<td>Locomotion</td>
<td>1.2</td>
<td>1.5</td>
<td>1.1</td>
<td>1.6</td>
<td>1.1</td>
<td>0.5</td>
<td>&gt; 0.05</td>
</tr>
<tr>
<td>Mineral</td>
<td>1.0</td>
<td>0.9</td>
<td>0.9</td>
<td>0.8</td>
<td>0.9</td>
<td>0.2</td>
<td>&gt; 0.05</td>
</tr>
<tr>
<td>Drinking</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.2</td>
<td>0.1</td>
<td>0.1</td>
<td>&gt; 0.05</td>
</tr>
<tr>
<td>Out of view</td>
<td>17.0</td>
<td>17.2</td>
<td>17.5</td>
<td>16.8</td>
<td>18.0</td>
<td>0.6</td>
<td>&gt; 0.05</td>
</tr>
</tbody>
</table>

Table 2.2. Least square means and standard errors for percentages of behavior for different sampling techniques.

Behaviors performed by six pastures of cross-bred lambs. Values are percentage of total duration for 15 hours. Asterisk (*) indicates statistical difference (P < 0.05) between the results from the 1-min instantaneous scan sampling method and the tested interval. P-value represents overall P-value of the model.
Figure 2.1. Strength of association (R²) between the percentage of time each behavior was performed using 1-min instantaneous scan sampling compared to 5, 10, 15 and 20-min scan intervals.
CHAPTER 3:
THE EFFECT OF SOCIAL DYNAMICS AND ENVIRONMENT AT TIME OF EARLY WEANING ON SHORT- AND LONG-TERM LAMB BEHAVIOR IN A PASTURE AND FEEDLOT SETTING

ABSTRACT

Lambs are commonly weaned around 60 d of age to meet management objectives of the farm, which is before the natural weakening of the ewe-lamb bond. This age is also considered a sensitive period for lambs to learn long-term feeding strategies from their dams or other adults. The objective of this study was to assess the effect of social and environmental factors at early weaning on short- (3 d post-weaning) and long-term (8 wk post-weaning) feeding, lying, and standing idle behavior of lambs on pasture or in a feedlot. Two experiments tested this objective: Experiment 1 investigated social dynamics at time of weaning for lambs housed on pasture, and Experiment 2 investigated the effect of weaning into a feedlot compared to a pasture environment. At 60 d of age, 72 crossbred twin lambs were assigned to one of four treatments: lambs weaned and placed with similar-aged lambs onto pasture (W); lambs weaned and placed with similar-aged lambs and non-related adult ewes onto pasture (SF); lambs that remained with their dam on pasture (E); and lambs weaned and placed with similar-aged lambs into a feedlot.
(FL). Each treatment had three replicates with six lambs/replicate. Behavioral data were collected with instantaneous scan sampling for 15 h/d for 55 d. During the first 3 d after weaning in Experiment 1, W lambs spent more time standing than SF lambs (P=0.03), and all lambs decreased standing idle time over the 3 d (P<0.0001). During the 8 wks after weaning, W and SF lambs spent more time grazing (P=0.03) and less time lying (P=0.02) compared to E lambs. In Experiment 2, feeding time of FL lambs increased on d 3 compared to d 1 and 2 (P<0.05). There was also an effect of week on feeding time, whereby FL lambs fluctuated their time spent feeding across weeks (P<0.0001). When the time-budgets of lambs from both experiments were compared, W lambs spent 39.2% more time grazing compared to the amount of time that FL lambs spent feeding. Results suggest that keeping non-related adult ewes (SF) with weaned lambs did not influence the grazing and lying behavior of lambs on pasture. Lambs that stayed with their dams and were weaned later (E) had the lowest grazing time, likely because they are still receiving milk. Lambs in the feedlot environment increased their time spent feeding in the first few days, suggesting an initial adaptation to stress after weaning.

**INTRODUCTION**

In the Eastern United States, lambs are typically weaned from their dam at 60 d of age and placed onto pasture or a feedlot with similar-aged lambs (Barkley, 2014). This practice is done to accommodate management and production practices on-farm, such as targeted growth rates and market weights, livestock show competitions, and breeding schedules. Weaning involves abrupt social, nutritional, and environmental changes for
both the lamb and ewe (Weary et al., 2008). A weaning age of 60 d may be an additional stressor, given natural weaning occurs gradually when the lambs are 100-150 d of age (Arnold et al., 1979). Previous research has demonstrated that weaning lambs early can lead to behavioral and physiological indicators of stress, including decreased grazing behavior (Damián et al., 2013), increased pacing and vocalizations (Schichowski et al., 2008), and increased plasma cortisol (Pascual-Alonso et al., 2014). While these behavioral changes have been demonstrated to occur up to three days post-weaning, long-term effects of early weaning on feeding behavior in particular have not been assessed.

Restricting the dam’s influence early in life can hinder the development of lambs’ long-term forage and feedstuffs preferences (Ramos and Tennessen, 1992; reviewed by Baumont et al., 2000). The ewe-lamb bond promotes nutritional sustenance through milk, social bonds, and selective grazing patterns on pasture (Hinch, 1987; Napolitano, 2008). Both physical proximity and communication to synchronize behavioral activities are recognized as critical factors that contribute to the development of lamb grazing and feeding behaviors, particularly around the time of post-ruminal development (i.e. 42 d of age; Hinch et al., 1987; Michelena et al., 2008). Lambs spend more time grazing (Ramos and Tennessen, 1992), develop long-term forage preferences (Green et al., 1984), and learn aversion to toxic feedstuffs (Thorhallsdottir et al., 1990a) more effectively in the presence of their dams.

Lamb behavior is also influenced by social interaction with non-related conspecifics. Sheep are a gregarious species capable of developing strong, persistent attachment to animals other than their dam that can influence their behavior (Pascual-
Alonso et al., 2014). Social facilitation is defined as the initiation or increase of a particular behavior when in the presence of other animals performing the same behavior at the same time (Clayton, 1978). Non-related adult ewes may contribute to lamb grazing strategies through social facilitation (Napolitano et al., 2008). Previous research found that lambs weaned at 90 d of age and integrated with non-lactating adult ewes on pasture increased bite rate and rumination time (Youssef et al., 1995). Lambs weaned at 30 d of age with non-lactating, adult ewes into finishing pens had greater slaughter weights and average daily gains compared to lambs only weaned with similar-aged lambs (Pascual-Alonso et. al, 2014).

Lamb behavior is also influenced by changes in environment. Lin and colleagues (2010) reported that free-ranging sheep spent on average 49% of their time grazing, 24% resting (e.g. standing, lying), and the remaining time ruminating and walking. In contrast, Lauber and colleagues (2012) reported that individually penned sheep housed indoors spent on average 62% of their time idle, 17% feeding, 14% performing abnormal behaviors (e.g. chewing and nosing pen fixtures), and the remaining time drinking and walking. Changes to behavioral time budgets and the development of abnormal behaviors indicate the strong influence that environmental resources have on lamb behavior.

Early weaning creates welfare concerns for lambs as this practice results in substantial changes to their nutritional resources, social dynamics, and environment. Therefore, the objectives of this study were to assess the effect of social and environmental factors at early weaning on short- (3 d post-weaning) and long-term (8 wk post-weaning) feeding, standing idle, and lying behavior in lambs. The first experiment
investigated the effect of housing early weaned lambs with non-lactating adult ewes on pasture. The second experiment investigated the effect of weaning lambs onto pasture compared to those placed into a feedlot.

**MATERIALS AND METHODS**

The Ohio State University Institutional Animal Care and Use Committee approved the protocol for this experiment. The animals were cared for in accordance with the Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching (FASS, 2010).

**Animals and housing**

Experiment 1

Fifty-four Hampshire x Dorset and Suffolk x Dorset crossbred twin lambs (17.7 ± 2.0 kg) from the Ohio Agricultural Research and Development Center (OARDC) Sheep Unit in Wooster, Ohio, USA were used in this study between July and September, 2015. At approximately 60 d of age, lambs were allotted by sex, blocked by body weight using three weight categories (small, 16.1 ± 1.1 kg; medium, 17.6 ± 1.8 kg; large, 20.0 ± 2.2 kg), and randomly assigned to one of three treatments (3 replicates per treatment, 6 lambs per replicate):

1) Early-weaned lambs (W): lambs weaned at 60 d of age and placed with similar-aged lambs in a paddock (n=6 lambs per replicate; 18 lambs total).
2) Social facilitator (SF): lambs weaned at 60 d of age and placed with similar-aged lambs and non-related, non-lactating adult ewes in a paddock (n=6 lambs and 3 ewes per replicate; 18 lambs and 9 ewes total).

3) Late-weaned lambs (E); lambs remained with their dam at 60 d of age, then weaned at the completion of the trial at 116 d of age (n=6 lambs and 6 ewes per replicate; 18 lambs and 18 ewes total).

Animals were housed on a 4.0 ha established pasture dominant in tall fescue forage, which was divided into nine paddocks based on equal stocking density (one replicate/paddock). Each paddock contained six internal divisions that were made with electrified temporary fence (VersaNet® Plus, Premier1Supplies, Washington, Iowa, USA). Paddocks utilized rotational grazing with an average stocking density of 26,000 kg/ha amongst the six internal divisions. Animals were moved every three to four days, allowing for approximately 21 d of rest and re-growth of forage for each internal division. All animals had ad libitum access to water and minerals throughout the trial (VitaFerm Sheep Mineral, BioZyme® Inc., St. Joseph, Missouri, USA).

**Experiment 2**

Eighteen Hampshire x Dorset and Suffolk x Dorset crossbred twin lambs (17.8 ± 2.7 kg) from the OARDC Sheep Unit in Wooster, Ohio, USA were used in a second experiment in this study between July and September, 2015. At approximately 60 d of age, lambs were allotted by sex, blocked by body weight using three weight categories (small, 15.6 ± 1.2 kg; medium, 17.0 ± 1.0 kg; large, 20.7 ± 1.0 kg), weaned from their
dam, and randomly assigned to one of three pens for the feedlot (FL) treatment (3 replicates, n=6 lamb per replicate; 18 lambs total). Pens were located in an indoor covered research feedlot facility (4.1 x 1.5 m, length x width of pen). Pens consisted of expanded metal floor with three metal gates and a wooden fence line feed bunk (3.7 x 0.3 x 0.3 m, length x width x depth) on the fourth side. Lambs were provided ad libitum access to water via an automatic waterer (Ritchie® Industries Inc., Conrad, Iowa, USA) and fed a custom diet of 70% whole shelled corn, 15% supplement pellet, 10% alfalfa pellets, and 5% soybean hulls. The supplement was a separate pellet that was custom-formulated to provide additional protein, minerals, and vitamins to meet, or exceed, recommended nutrient requirements (NRC, 2007).

**Behavioral measurements**

**Experiment 1**

Behavior was recorded using nine color wireless outdoor IP video cameras (Foscam, Model F19805P, Houston, Texas, USA) recording at 30 frames/s (one camera/paddock). Each camera was positioned centrally in front of the active internal division within the paddock at a height of 2.4 m from the ground. Video was captured digitally utilizing portable laptops with external USB hard drives. Picture clarity and camera positioning were verified prior to each behavioral recording session with Foscam software (V4.1). Video was recorded continuously for 15 h (06:00-21:00) each day for a total of 55 d. Behaviors may have occurred outside of this time window, but visibility due to daylight did not permit observations during 21:00-06:00 h.
Behavioral data (Table 1) were collected utilizing an instantaneous scan sampling method at 10-min intervals by four trained observers (validated by Pullin et al., 2017). Each 15-h day consisted of 90 scan sample values per paddock, with behavior for all six lambs recorded at each sampling interval, for a total of 55 d. All behavioral data were collected with Windows Media Player (Version 12, Microsoft, Redmond, Washington, USA). To ensure inter-observer reliability between the observers and the trainer, 24 instantaneous scan sampling values for each treatment (72 total values) were compared until 90% accuracy was achieved.

Experiment 2

Behavior was recorded using the same equipment described in experiment 1. One camera was positioned centrally in front of two pens and a second camera was positioned centrally in front of the remaining pen (1.8 m from pen front) using an elbow bracket at a height of 3.0 m from the floor. The video recording protocol was the same as described in experiment 1.

Behavioral data (Table 1) were collected utilizing an instantaneous scan sampling method at 5-min intervals by two trained observers. The sampling interval was chosen based on regression and ANOVA analyses to validate an accurate instantaneous scan sampling interval for feeding, lying, and standing behaviors of feedlot lambs (unpublished data). Each 15-h day consisted of 180 scan sample values per pen, with behavior for all six lambs recorded at each sampling interval, for a total of 55 d. All behavioral data were collected with Windows Media Player (Version 12, Microsoft,
Redmond, Washington, USA). To ensure inter-observer reliability between the observer and the trainer, 24 instantaneous scan sampling values for two pens (48 total values) were compared until 90% accuracy was achieved.

**Statistical analysis**

**Experiment 1**

Data were analyzed using SAS software (Version 9.4; SAS Institute Inc., Cary, North Carolina, USA) considering the paddock as the experimental unit. Before analysis, observations from the 10-min instantaneous scan sampling method were summed for each behavior in each paddock, then divided by the total possible observations (15 h x 6 scan samples/h x 6 lambs = 540 total observations/d) to calculate the percentage of time spent performing each behavior per paddock per day. Percentages for behaviors (Table 1) were then screened for normality and homogeneity of variances by using a PROC UNIVARIATE procedure for all treatments.

To determine the impact of early weaning with and without a social facilitator on the short-term behavioral response of lambs (3 d post-weaning), a generalized linear mixed model (PROC MIXED) was used. The model included weight group (small, medium, and large), treatment (E, SF, and W), day (1, 2, and 3), and a treatment by day interaction. Paddock within treatment was considered a random effect, and day was a repeated measure modelled using first-order autoregressive covariance structure based on lowest BIC. When treatment effects were found (P<0.05), contrast statements were used to determine differences between treatments.
To determine the long-term impact of treatments on lamb behavior (8 wk post-weaning), daily percentage data were averaged per week for each behavior and paddock. Long-term behavioral data were analyzed on a weekly basis for a total of 8 wk post-weaning using a generalized linear mixed model (PROC MIXED). The model included weight group (small, medium, and large), treatment (E, SF and W), week (1, 2, 3, 4, 5, 6, 7, and 8), and a treatment by week interaction. Paddock within treatment was considered a random effect, and week as a repeated measure modelled using first-order autoregressive covariance structure based on lowest BIC. When treatment effects were found (P<0.05), contrast statements were used to determine differences between treatments.

**Experiment 2**

The pen was considered the experimental unit. Behavioral scan sampling data were summarized using a similar method as Experiment 1. Behaviors were also screened for normality and homogeneity of variances using a similar approach to Experiment 1. To determine the impact of day or week on the behavior of feedlot lambs, mixed models were used. The models included weight group (small, medium, and large) and day or week, pen as the random effect, and day or week as the repeated measure. Based on visual inspection of the graphs, contrast statements were used to determine differences between consecutive weeks.

In addition to the specific statistical analysis conducted within the experiment, we were also interested in describing the time budgets of lambs weaned at 60 d kept on
pasture (W) and moved to the feedlot (FL). Time-budgets were constructed by averaging the percentage of time lambs in each experiment spent performing each behavior.

**RESULTS**

**Experiment 1**

*Short-term behavioral response (3 d post-weaning)*

During the first 3 d post-weaning, no treatment or treatment by day interaction effects were found for time spent grazing (P>0.05). Regardless of treatment, lambs increased time spent grazing across day (P=0.01). Time spent standing idle (not grazing) differed by treatment (P=0.03, Fig 1). Pair-wise comparisons revealed that W lambs spent more time standing idle compared to SF lambs (P=0.01), and tended to spend more time standing idle than lambs in the E group (P=0.08); in addition, E lambs tended to spend more time standing idle than SF lambs (P=0.09). There was also an effect of day on standing idle (P<0.0001; Fig 1), whereby lambs in all treatments reduced their idle standing time over the three days. There was no treatment by day interaction for standing idle (P>0.05). There was no effect of treatment, day, or their interaction for lying time (P>0.05).

*Long-term behavioral response (8 wk post-weaning)*

Time spent grazing was different for lambs in each treatment (P=0.03); W and SF lambs performed a greater percentage of grazing behavior compared to E lambs, but there was no difference in grazing time between W and SF lambs (Fig 2). Week also impacted
grazing time (P<0.0001); grazing behavior increased throughout the study. There was no treatment by week interaction for grazing time (P>0.05).

Time spent lying was affected by treatment (P=0.02). Both W and SF treatments spent less time lying compared to E lambs, but there was no difference in lying time between W and SF lambs. Lying time was also affected by week (P<0.0001); regardless of treatment, lambs generally decreased lying time in the second-half of the trial (Fig 3). There was no treatment by week interaction for lying time (P>0.05).

There was a treatment tendency (P=0.06), a week effect (P < 0.0001), and a treatment by week interaction for idle standing time (P=0.002). SF lambs spent less time standing idle than W and E lambs during the first 2 wk, but were not different thereafter. No differences were found between W and E lambs for long-term standing idle behavior.

**Experiment 2**

*Short-term behavioral response (3 d post-weaning)*

Day affected the feeding time of FL lambs in the first 3 d after weaning (P<0.05); lambs spent a greater percentage of time feeding on d 3 compared to d 1 and 2 (Table 2). Lying and standing behaviors were not affected by day in the first 3 d post-weaning (P>0.05).

*Long-term behavioral response (8 wk post-weaning)*

In FL lambs, there was a week effect for feeding, lying, and standing behaviors (P<0.0001; Table 3).
**General time budget**

Within the 15 h-day periods, FL lambs spent on average 14.7% of their time feeding, 58.0% lying, and 22.6% standing. Lambs in W pasture treatment spent 62.5% of their time grazing, 29.7% lying, and 5.4% standing.

**DISCUSSION**

The objective of this study was to assess the effect of social and environmental factors at early weaning on short- (3 d post-weaning) and long-term (8 wk post-weaning) feeding, lying, and standing idle behavior of lambs on pasture or in a feedlot. This objective was assessed in two experiments evaluating 1) placing early weaned lambs with non-lactating adult ewes on pasture and 2) comparing early weaned lambs kept on pasture to those placed into a feedlot. We expected the SF lambs to differ in grazing behavior from the W lambs due to social learning. We also hypothesized that the FL lambs would gradually increase feeding behavior in the first two weeks and demonstrate less feeding behavior in their time budget overall compared to W lambs.

**Short-term behavioral response on pasture (3 d post-weaning)**

We anticipated that lambs in both weaned groups (W and SF) would differ in grazing time compared to those kept with their dams; however, this was not the case. Although there was no impact of treatment on grazing behavior, grazing time increased across the first 3 d after weaning for all lambs. Weaning is known to influence feeding behavior as this process results in the removal of the primary nutrition source for the
The abrupt loss of milk eliminates suckling behavior and requires physiological changes for lambs to transition to a forage, concentrate, or mixed diet (Ungerfeld et al., 2009). As a result, weaned lambs and calves initially reduce grazing behavior but then rebound to a level higher than pre-weaning, likely to compensate for hunger, energy requirements, or deviations in the behavioral time budget (Ungerfeld et al., 2009; Hötzel et al., 2010; Damián et al., 2013). Similarly, Damián et al. (2013) found that lambs weaned at 75 d of age increased the percentage of time grazing on d 1 and 2 post-weaning, and Ungerfeld et al. (2009) noted that calves increased grazing behavior as much as five days post-weaning. However, the results from this study demonstrated that all lambs, regardless of treatment, increased the percentage of time spent grazing on d 3 post-weaning. All lambs may have shown this trend as they adapted to new paddocks. The lack of a treatment difference also suggests that W and SF lambs have not yet rebounded to a level higher than lambs that remained with their dam by d 3.

We expected lambs placed with non-related adults (SF) would learn from the experienced animals, and this would increase their time spent grazing compared to those without social facilitators (W); however, this was not the case. Although lambs learn consumption preferences and strategies more efficiently in the presence of an experienced adult by mimicking their dietary choices, this process appears to be most effective in the presence of novel feedstuffs (reviewed by Baumont et al., 2000). The role of the social facilitator ewes in this study likely did not affect initial weaned lamb grazing behavior because these lambs spent their pre-weaning period on similar forages and pastures with their maternal dam. Ramos and Tennessen (1992) found that lambs exposed
to pasture with their dams more readily graze at weaning compared to inexperienced lambs; therefore the role of the non-lactating adult ewe for social facilitation in this study was likely limited. Using unfamiliar adults may have also interfered with social learning and grazing behavior in the lambs. For example, ewes kept with unfamiliar ewes will maintain a greater distance from the unfamiliar ewe and spend less time grazing and more time vocalizing compared to ewes with familiar conspecifics (Boissy and Dumont, 2002). In the SF treatment, we observed agonistic behavior of the adult ewes towards the lambs (e.g. displacing lambs from grazing, drinking, and mineral consumption through head-buttng and pushing), and adult ewes and lambs tended to stay on opposite ends of the paddock. The unfamiliarity of the adult ewes likely contributed an additional stressor of social mixing at time of weaning. The familiarity of a social facilitator ewe to weaned lambs would be an important consideration in future research with regard to the efficacy of social facilitation on behavior.

Although grazing time did not differ between treatments, lambs weaned early (W) spent the most amount of time standing idle (not grazing) compared to lambs in the other treatments. This behavior may be indicative of lambs searching for their dam. Similar findings have been demonstrated in weaned beef calves, where standing time increased post-weaning as an indicator of motivation to rejoin with their maternal dam (Enríquez et al., 2011). Lambs in the SF group spent the least amount of time standing idle, which may be additional evidence of poor social affinity within this group.
In the present study, non-lactating adult ewes were placed onto pasture with lambs weaned at 60 d of age to assess potential impacts that social facilitation has on long-term grazing behavior post-weaning. The SF treatment did not have an effect on percentage of time spent grazing over an eight-week period compared to lambs with (E) or without (W) their biological dam. The results from our study differed from Youssef et al. (1995), who found that lambs weaned at 90 d of age with non-lactating, non-related adult ewes increased time grazing, bite rate, and rumination time over a seven-week period. However, it should be noted that Youssef et al. (1995) identified that pre-weaning grazing experience has a greater effect on weaned lamb grazing behavior than social facilitation (i.e. incorporating experienced adult animals). All lambs in our study had pre-weaning grazing experience with their maternal dam. Additionally, lambs are sensitive to learning and developing forage preferences from their maternal dam around 28-56 d of age, close to the time of early weaning (Thorhallsdottir et al., 1990a). As lambs in our study were not weaned until 60 d of age, it is possible that they had already established forage preferences within this environment and therefore would not be influenced by the presence of a non-lactating adult ewe. These results may also be further exacerbated by the fact that the pre- and post-weaning grazing occurred on a non-diverse pasture (e.g. 90% dominant in tall fescue forage). A homogenous environment would diminish the likelihood of encountering novel forage species over time that require learned preferences and aversions (Provenza and Balph, 1987). Activity synchrony amongst flock mates is common amongst a cohesive flock (Gautrais et al., 2007). Considering that there were no
differences between W and SF treatments in grazing or lying behaviors, it can be concluded that the non-lactating adult ewes did not affect the long-term behavioral activity of lambs weaned at 60 d of age onto familiar pasture.

Lambs that remained with their maternal dam spent less time grazing throughout the eight-week trial when compared to the W and SF treatments. Bojkovski et al. (2014) observed adult sheep to spend more than 65% of their time grazing in grassy paddocks, which is similar to the 62.5% and 62.3% values demonstrated for W and SF treatments in our study, respectively. However, lambs in the E treatment spent 10% less time grazing at 52.2%, which coincides with Alvarez-Rodriguez et al. (2007) study of ewes and nursing lambs grazing for 55.2% of daylight hours. Lambs alternate their ingestion behaviors based on the resources and nutrients available to them, particularly supplementing forage with milk intake (Alvarez-Rodriguez et al., 2007). Depending on ewe milk yield, lambs will continue to suckle up to 100-130 d of age (Arnold et al., 1979). In conjunction with this study, lamb performance was evaluated to determine overall productivity by treatment. Lambs in the E treatment gained more weight by the end of the eight-week trial compared to the W and SF treatments (Campbell et al, in press). Less grazing behavior performed by the E treatment lambs did not translate to less productivity, and the advantage in productivity is linked to milk access in addition to forage.

Grazing behavior progressively increased for all treatments over the eight-week trial period. The growth and development of lambs would necessitate increased intake over time to meet emerging energy demands. As body weight increases, feed intake as a percentage of body weight will also increase. Environmental characteristics may also
contribute to this trend, as our findings are similar to previous long-term grazing studies with adult ruminants. Previous research observed grazing behavior to increase from July to September, suggesting a relationship between decreased air temperatures, decreased daylight hours, and decreased forage availability/quality to increased grazing time (Hejcmanova et al., 2009; Lin et al., 2011). In the present study, grazing behavior increased on week 3, week 6, and week 8 specifically. This correlates with decreased forage dry matter availability between weeks 2 to 4 and weeks 6 to 7 (Campbell et al., in press), further supporting the relationship of decreased forage availability to increased grazing time.

This study also demonstrated that lying and standing idle behaviors had an inverse relationship to grazing behavior. The W and SF treatment spent a lesser percentage of time lying overall compared to the E treatment, and they also stood idle less than the E treatment during the second half of the trial. This coincides with results found in previous studies, such that the greater amount of time animals spend active inadvertently coincides with less time inactive (Lin et al., 2011; Chen et al., 2013).

*Short-term behavioral response in the feedlot (3 d post-weaning)*

Weaning lambs at 60 d of age and placing them into a feedlot involves not only the social stressors of disrupting the ewe-lamb bond and mixing with unfamiliar lambs, but also includes known environmental and nutritional stressors of novel flooring and feed, more prevalent human contact, competition for resources, and changes to environmental parameters such as temperature and ventilation (Rice et al., 2016). These
factors are important considerations for the welfare and management of feedlot lambs as they are initially at a greater risk for suppressed productivity and immunity due to neophobia, physiological adjustments, and characterizations of shy-feeders (Jolly and Wallace, 2007; Savage et al., 2008).

In the present study, lamb feeding behavior increased on d 3 post-weaning. This is similar to previous findings of newly weaned lambs placed into a feedlot, where the percentage of lambs not feeding decreased from 70% on d 1 to less than 5% on d 3 (Savage et al., 2008). Increased feeding behavior on d 3 is also similar to the grazing timeline for lambs housed on pasture. This data suggests that lamb feeding behavior increases on d 3 post-weaning, regardless of environment.

There are likely additional factors influencing feeding behaviors in feedlot lambs given differences noted in the behavioral time budgets between the pasture and feedlot environments. During the first day post-weaning, lambs on pasture appeared to spend 39.2% more time consuming nutrients compared to lambs in the feedlot, although this was not statistically compared. Lambs in this study did have pre-weaning grazing experience but no prior exposure to concentrate feed. Neophobia is considered a survival mechanism for domestic ruminants to avoid toxicities, where new feedstuffs are cautiously sampled and intake is initially low (Launchbaugh et al., 1997). Neophobia is an influential factor for the time budget variation between environments in this study. The first three to four days of exposure to novel feed is a time when smelling and tasting are greatest in order to adjust to the feedstuffs (Hinch et al., 2004; Savage et al., 2008). Neophobia is even further exacerbated when novel feed is provided in an unfamiliar environment.
environment, such was the case for the feedlot lambs in this study (Burritt and Provenza, 1997). The observed rebound on d 3 for feedlot lambs may be multifaceted in that it is associated with gradually overcoming neophobia in an unfamiliar environment in addition to weaning stress.

Lambs in the feedlot spent on average 7.8% of their 15-h day feeding on d 1, then increased to 14.4% on d 3 – nearly a two-fold increase. This is similar to previous findings of feedlot lambs with no prior exposure to concentrates that spend about 8% of their time feeding on d 1 and increase to approximately 18% by d 7 (Savage et al., 2008). Additionally, results of newly weaned beef calves placed into a feedlot demonstrated that the number of calves observed feeding increased by 10% when comparing the first two days to d 4, 5, and 6 (Gibb et al., 2000).

*Long-term behavioral response in the feedlot (8 wk post-weaning)*

In the current study, the percentage of time lambs spent feeding was highest during the second week post-weaning and then decreased to a relatively consistent percentage for the remainder of the trial. Similarly, newly received feedlot calves do not achieve normal intake levels until two to four weeks after arrival (Loerch and Fluharty, 1999), and weaned dairy goat kids achieve the highest concentrate feed intake during the second week post-weaning (Atasoglu et al., 2008). Newly received feedlot animals demonstrate physiological responses to stress (Loerch and Fluharty, 1999), and the initial weeks are considered a transition period from a high forage diet to a high concentrate diet where monitoring behavior and health is imperative. Ruminants are at high risk for
acidosis and bloat during adaptation as the new diet is more rapidly fermentable (Galyean and Rivera, 2003). Large, infrequent meals and less time ruminating are two behavioral feeding patterns that can contribute to low ruminal pH (González et al., 2012). Less lying time coupled with greater standing behavior are indicators of discomfort and potential acidosis in sheep (Commun et al., 2012). Lying behavior in this study increased between weeks 2 and 3, similar to when feeding peaked on week 2 and then decrease between weeks 2 and 3. Lying facilitates saliva production during rumination and rest in order to buffer acids produced by high-concentrate diets, and thus may be an integral behavior for promoting gut health during the transition period (González et al., 2012).

Feeding behavior as a proportion of the general time budget was also largely different between pasture and feedlot environments (62.5% grazing and 14.7% feeding). The two types of available nourishment (i.e. forages versus concentrates) provide different nutrient profiles, which will yield modifications in consumption patterns to meet energy demands. Lambs grazed on forages typically have lower average daily gain (ADG), longer timelines to reach targeted slaughter weight, and lighter carcasses when compared to concentrate-fed lambs in a feedlot management system (McClure et al., 1994; McCutcheon, 2014). Variations in chemical composition of forages (e.g. lower crude protein and higher neutral detergent fiber) and additional energy expenditure by grazing animals (e.g. locomotion to search for food in an extensive system) will impact available maintenance energy and decrease nutrient efficiency when compared to confined animals (McClure et al., 1994; Hejcmanova et al., 2009; Lin et al., 2011; McCutcheon, 2014). Additionally, lambs fed high protein diets have greater feed
efficiency (Fluharty and McClure, 1997). Similarly, lamb performance data of W lambs demonstrated less average daily gain compared to FL lambs (Campbell et al., in press). Forage quality samples in this study averaged 13.5% crude protein (CP) and 57.1% neutral detergent fiber (NDF), while the concentrate diet included 17.5% CP and 13.3% NDF (Campbell et al., in press). Feedlot lambs also engaged in substantially more inactive behaviors than pastured lambs (i.e. standing idle and lying, 80.6% for feedlot and 35.1% for pasture), which would result in less energy expenditure and thus less maintenance energy requirements. Pastured lambs engaged in feeding behaviors for a larger portion of their time budget when compared to feedlot lambs likely due to inefficient energy conversion from the availability and quality of forage-based nutrition.

CONCLUSION

The social dynamics and environment for lambs weaned at 60 d of age are critical considerations for welfare and management strategies. For all lambs in this study, weaning decreased feeding behavior for the first two days and a rebound effect was observed on d 3. Weaning lambs onto a familiar, non-diverse pasture with non-related adult ewes did not influence the percentage of time lambs spent grazing. Social facilitation is likely more effective in unfamiliar environments with novel foods, and the familiarity of the selected social facilitator animal to the lambs may be an important factor to consider in future studies. However, lambs that remain with their dam (E) sustain lower amounts of grazing behavior than weaned lambs (W and SF) until 116 d of age. This is indicative that lambs continue to rely on their dam’s milk supply as a
nutritional source during this time, and delayed weaning offers an optimal strategy for lamb welfare in terms of sustaining the ewe-lamb bond both socially and nutritionally. Weaned lambs in an unfamiliar feedlot environment with novel feed demonstrate feeding behavior fluctuations within the first two weeks, and lambs should be monitored closely during this time for health concerns. This study demonstrates that environmental and social factors play a critical role in the long-term feeding behavior of lambs weaned at 60 d of age.
<table>
<thead>
<tr>
<th>Environment</th>
<th>Behavior</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pasture</td>
<td>Grazing</td>
<td>Standing or walking with muzzle close to the grass (i.e. head is below shoulders).</td>
</tr>
<tr>
<td></td>
<td>Lying</td>
<td>At least 50% of the stomach or side in contact with ground; body not supported by all four legs.</td>
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<tr>
<td></td>
<td>Other</td>
<td>Lamb is performing other behavior, such as mineral consumption, locomotion, or drinking.</td>
</tr>
<tr>
<td></td>
<td>Standing</td>
<td>Body supported by all four legs, not in motion. Head is above shoulders.</td>
</tr>
<tr>
<td>Feedlot</td>
<td>Feeding</td>
<td>Head is within the feed bunk and no longer visible.</td>
</tr>
<tr>
<td></td>
<td>Lying</td>
<td>At least 50% of the stomach or side in contact with ground; body not supported by all four legs.</td>
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<td></td>
<td>Other</td>
<td>Lamb is performing other behavior, such as locomotion or drinking.</td>
</tr>
<tr>
<td></td>
<td>Standing</td>
<td>Body supported by all four legs, not in motion. Head is above shoulders.</td>
</tr>
</tbody>
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Table 3.1. Behavioral ethogram for lambs housed on pasture and in a feedlot.
Table 3.2. Behavior performance percentages (%) ± standard error means (SEM) of feedlot in a 15-h day (06:00-21:00) for the first three days post-weaning (06:00-21:00 h/d).

Feedlot lambs were weaned at 60 d of age and placed into an indoor feedlot facility. There was an effect of day on feeding behavior (P=0.04), and pair-wise comparisons were made to determine differences between consecutive days. \(^{a,b}\) Within a row, means without a common superscript differ from the preceding day (P<0.05).
<table>
<thead>
<tr>
<th>Weeks Post-Weaning</th>
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<tr>
<td>Behavior</td>
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<td>Feeding</td>
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<td>Standing</td>
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Table 3.3. Behavior performance percentages (%) ± standard error means (SEM) of feedlot lambs in a 15-h day (06:00-21:00) for eight weeks post-weaning.

Feedlot lambs were weaned at 60 d of age and placed into an indoor feedlot facility. There was an effect of week on all behaviors (P<0.0001), and pair-wise comparisons were made to determine differences between consecutive weeks. Within a row, means without a common superscript differ from the preceding week (P<0.05).
Figure 3.1. The percentage of time (%) lambs performed standing behavior ± standard error means in a 15-h day (06:00-21:00) during the first three days post-weaning on pasture for weaned (W), social facilitator (SF), and ewe (E) treatments.

There was an effect of treatment across all days, with W lambs standing more than SF lambs overall (P<0.05). A day effect was also found (P<0.05).

Weaned (W) indicates weaned lambs housed with similar-aged lambs. Social facilitator (SF) indicates weaned lambs housed with similar-aged lambs and non-lactating adult ewes. Ewe (E) indicates lambs not weaned from their dams.
Figure 3.2. The percentage of time (%) lambs performed grazing behavior ± standard error means in a 15-h day (06:00-21:00) for eight weeks post-weaning on pasture for weaned (W), social facilitator (SF), and ewe (E) treatments.

There was an effect of treatment (P<0.05) and week (P<0.05). Lambs in W and SF treatments spent more time grazing overall than lambs in E treatment.

Weaned (W) indicates weaned lambs housed with similar-aged lambs. Social facilitator (SF) indicates weaned lambs housed with similar-aged lambs and non-lactating adult ewes. Ewe (E) indicates lambs not weaned from their dams.
There was an effect of treatment (P<0.05) and week (P<0.05). Lambs in W and SF treatments spent less time lying overall than lambs in E treatment.

Weaned (W) indicates weaned lambs housed with similar-aged lambs. Social facilitator (SF) indicates weaned lambs housed with similar-aged lambs and non-lactating adult ewes. Ewe (E) indicates lambs not weaned from their dams.
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