EFFECTS OF PERCHES ON BEHAVIOR AND ACTIVITY OF BROILERS

by

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ABSTRACT

Increasing activity in broilers has become a key to improve their welfare in the commercial houses. Lameness occurs more in broilers under the commercial condition and it has been considered a welfare issue mainly due to the bird breed. The breed tends to have a high growth rate. Which in turn brings bone structure issues since birds don't exercise leg muscles in current houses. Some research suggests that adding perches can improve leg strength and mobility of broilers. The movement or action of perching behavior may exercise leg muscles and improve leg strength. Previous research showed that the use of perches by broilers has been low and suggested perch design played an important role to increase its use by broilers. It is hypothesized that improving perch design could increase the use of the perches by broilers.

A study with a series of experiments was designed and conducted to investigate proper perch design parameters for broilers, and their perching behaviors, and the effects of suitably designed perches on perching behaviors of broilers under commercial conditions. An experiment was performed to look at the features of perches to determine the perch design criteria based on the preferences of broilers for different perch shapes (round and. square) and heights (4 in. and 6 in.). A four-pen (each pen measured 2.25 ft x 5 ft) system with cameras and a video recorder was used to determine the preferred perch shape and height. A generalized linear model was formed to analyzing total perching duration and step on number on perch. The results showed broilers spent more time on square perches ($P = 0.02$). For height, birds preferred lower (4-in.) perches ($P < 0.0001$). The design of the perch affects the use of the perch by broilers. To achieve the health benefits of perches for broiler, perch design is an important aspect to consider.

Later experiment was looking for the strength of perching behavior. The system was modified for an experiment to assess the preference of broilers for perch enrichment. Bird perching activities and preferences on perch were monitored by load cells and a video recording system. Feed consumptions in each pen were measured and correlated to the bird preference for perch. A three-pen system with cameras and a video recorder was used to determine the preference of Cobb 500 broilers for an environment with a perch. Bird perching activities and preferences on perch were monitored by load cells and the video recording system. Feed consumptions in each pen were measured and correlated to the bird preference. The video data showed that broilers spent 26% more time in the perch area (P= 0.003). The results showed the feed consumptions in both perch and no-perch areas were the same which indicated that perch encouraged and increased the locomotion of the broilers. The results showed the preference of broilers for perch enrichment.

Three perch designs were further tested under field condition to verify the findings from the laboratory experiments. The first perch design was a single perch (Single) with square shape (0.5 in. side length) at 4 in. height from the ground. The second perch design was a double-perch structure (Double) with two perches at 4 in. high, set parallel 8.5 in. apart. The third design was a double-perch structure (Level) with two perches at 4 in. and 6 in. heights, respectively, in parallel 8.5 in. apart. The Double and Single perches recorded a similar perching activity due to the similarity of their designs. The low perching activities on the Level perch indicates that broilers lost the ability to jump

Key words: Welfare, Perch, Broiler, Preference, Activity

Chapter 1

LITERATURE REVIEW

1.1 Introduction

First a few ideas require clarification. The presented ideas focus on improving animal welfare in the poultry industry. It investigates how welfare is defined. By what means is welfare implemented in a commercial production. Although this study is on the poultry industry, these principles can be applied to other instances of animal husbandry. In the poultry industry, the main welfare issue relates to the behavior of broilers in a commercial house setting. Broilers are the type of chickens raised for meat production. The typical commercial setting houses thousands of broilers till they reach market weight. Meat birds grown for consumption gain weight quickly and undergo some physical strain. In order to discuss the improvement of conditions in the houses, this review highlights some important behaviors that broilers display in commercial houses. Significant areas of the house are discussed, as well as why birds cluster around the walls and what has been done to change their distribution. This review also investigates environmental complexity, which may be the solution to changing the environment in the house. It also proposes the use of enrichments in the house to improve welfare. Enrichments are features in the environment that allow broilers to perform interactive behaviors, ideally increasing activity and improving the well-being of the broilers in the house.

One example of enrichments for poultry are perches, defined as elevated structures used by birds to perform perching behaviors. Different perch designs are discussed in later chapters. In addition to investigating the types of perches used to improve activity, previous studies have also touched on a structure's variables that motivate birds to perch. In this context, it is important to note that if perching behavior is intrinsic in broilers, they will do so on certain structures. The right perch type will bring out the behavior and strengthen the instinct. Future studies set perches in commercial houses to determine the rate of perching. The scope of perch design is the focus of this literature review and informs the process of experiments into particular designs to improve welfare.

1.2 What constitutes good welfare?

When animals have poor welfare, productivity suffers. Therefore, improving the welfare of animal husbandry should be a concern for those who work closely with production animals. Welfare focuses on increasing an animal's state of being, including receiving appropriate care and having its needs protected. With regard to poultry, welfare has received more attention in the last decade due to the emergence of customer concerns over factory farming. Issues of animal treatment and what companies are willing to fix in the middle of this shift in attitude will determine how effectively welfare is implemented. For practical welfare evaluation, the concept of the five freedoms have been formulated (FAWC, 2009; Bergmann, 2017):

(1) freedom from hunger and thirst,

(2) freedom from discomfort,

(3) freedom from pain, injury and disease,

(4) freedom to express normal behavior,

(5) freedom from fear and distress.

This review discusses the fourth freedom. The freedom to express normal behavior is the concept that animals need to perform their natural behaviors. The wild animal species have a set of normal or natural behaviors due to their need for survival. The natural behavior of wild animals tends to be different than their captive counterparts (Savory et al.,1978). Over generations, the genetic structure of populations exposed to captive conditions shifts in favor of behaviors that fit in the environment of captivity. Production animals in farms and domestic animals in houses are exposed to different environmental pressures and genetic selection over time, changing the "normal behavior" and thus their welfare concerns have changed.

Welfare, according to Désiré and Veisser (2002), can be defined as the harmony between an individual and its environment. For most studies, welfare is measured through analysis of an animal's behavior or detected emotions. When looking at emotion as an indicator of welfare, animals are often put into experimental situations that test their emotional reactions. According to cognitive psychology, emotions arise from an appraisal process according to a series of criteria – namely, relevance, consequence, coping methods, and normative significance (Désiré and Veisser, 2002). Animal psychology has shown that farm animals have emotional states that form in the environment and in their genetic code. Désiré and Veisser suggest investigating the relevance of all criteria in order to assess situations in which farm animals are exposed to situations where only one criteria have been experimentally made more salient, as well as by measuring their gross reactions (e.g., locomotion, feeding behavior).

The definition of "natural behaviors," or even "normal behaviors," is not well understood for captive animals. Many of the physiological indicators used in welfare measurement, such as heart rate or respiratory rate, are autonomic responses that indicate activity or arousal rather than poor welfare. Those physiological changes are not consistent enough to serve as indicators for the kind of welfare to measure. Therefore, behavior as a measurement of welfare is often a better indication. These are measured by comparing wild birds to captive birds. Such experiments involve setting up captive birds to perform behaviors observed in wild birds. For example, wild Red junglefowl, the ancestors of laying hens, spend 60% of daylight hours performing active behaviors, such as walking, pecking, and scratching (Dawkins, 1989). However, those types of behaviors are difficult for caged laying hens to perform. Captive animals are not the same as their wild counterparts; their behaviors are different. Although being unable to perform those natural behaviors may lead to reduced welfare, laying hens may simply not need those behaviors.

Dawkins (2003) questioned how humans can recognize non-human animal suffering – that is, humans' ability to recognize the lack of animal's natural state. Injury, disease, and deformities are generally acknowledged to be major sources of suffering and thus make for poor welfare. Conditions that compromise an animal's health or put them at high risk of dying are universally understood as bad welfare. But to measure welfare without obvious outward signs becomes difficult. In her study, Dawkins proposes a means of measuring welfare to be used in the places where animals have the most impact, such as zoos, labs, and farms. She concluded that there is no clear litmus test to welfare. Animal captivity is different for each species and environments change with the setting and purpose depending on people. Indeed, nothing has been resolved about how to define welfare with such a limited understanding of an animal's welfare framework.

Dawkins poses a questions to help define welfare measures. The first question is “Are animals healthy?” Measures of health are the foundation of good welfare. Signs of growth, clean bodies, and no outward sign of disease are good signs that an animal’s environment promotes welfare. The second question is “Do the animals have what they want?” Animals in captive environments are potentially frustrated, bored, or experience discomfort in the environment. Often, these are situations in which animals are fearful or want to escape. The question about animals’ wants is also linked to animals’ needs and includes situations in which animals need resources to help them cope in the environment. An animal’s needs are not always able to be perceived by people. The focus of any welfare study should be measured in how it answers these important questions and in how well the proposed measures of a given study answers the final question: “does the animal show evidence of wanting to engage in the behavior?” A natural behavior observed in the animal or is present in their wild counterpart might not be encourage enough in the environment. If the behavior is linked to fulfilling a need or a want, the questions posed by Dawkins it can be considered a welfare measure. If the answer is negative, then the purposed behavior is not necessary to encourage.

To address the issue of animals seeking stimulation, a study evaluating welfare related to pigs and wallowing was analyzed. Here, Bracke and Spoolder (2013) examined the necessity of wallowing in mud among pigs in the pork production industry. By using an assessment similar to that previously proposed by Dawkins, here, welfare is determined by the animals’ behavior in the environment. “Has a pig that’s never seen a mud-hole ever imagined one, wanted one, or needed one?” Bracke and Spoolder sought to answer these questions to assess the necessity of a feature in the environment that performs a welfare function. As these questions are similar to those asked about poultry stimulation, this study is pertinent to my discussion and can yield valuable information.

Bracke and Spoolder's analysis identified the discrepancy between the way pigs perceive their environment under standard or poor conditions and how pigs would ideally like their environment. If the environment of wallowing facilities is absent or inadequate, that may have a negative impact on health and may negatively affect the pigs' healing, thermoregulation, and protection from the sun. Additionally, environments lacking a wallow may increase abnormal behavior e.g., pen soiling, stress, frustration, and avoidance.

The main objective of this study was to assess the overall importance of wallowing for pig welfare. The criteria formulated for the ideal mud hole for pigs based on available information about wallowing. The method used by the authors to assess the welfare importance of an attribute, such as wallowing in pigs, is based on scientific information describing the design parameters (e.g., presence/absence of a mud pool and an ambient temperature) and welfare-performance measures (e.g., panting, feed intake and mortality).

The importance of wallowing to a pig was assessed as a health demand. The formal assessment with other attributes was weighed as a function of the difference in relevance between the best and worst levels. To the end of determining the importance of wallowing, the characteristics of a wallow were studied to compare an ideal wallow to the current reality of wallows being used in practice. Bracke and Spoolder found that current facilities for pigs were characterized by the worst level wallowing, with little to no chance of wallowing. Ideal mud pools are described in the literature as having specific design features in the environment, such as the location and size of the pool being spacious enough to accommodate the swine, the type of substrate in the pool needed to keep pigs cool, the necessity of wallows being present at all times, and the importance of allowing pigs to wallow at their discretion.

The study concludes that wallowing is partially a body-care behavior that is partially internally motivated, i.e., it is a natural behavior. However, this conclusion does not imply that wallows should be provided; the uses of a wallow could be redundant if other features in the environment fulfilled the pig's needs (cool temperatures, other enclosures, and regular health care) reduce the pigs wanting to wallow in mud. In terms of the welfare consequences perceived by the animals, their natural inclinations are alleviated with the presence of certain attributes, perceived natural behavior is reduced due to the enviroment.

In line with those findings regarding pigs' wallowing behavior, the best way to increase welfare in the poultry industry is to enable the birds to engage in behaviors promoted by their environment or fulfill a behavioral need that is not getting an opportunity. The wallow study was able to isolate the type of wallow that was ideal for pigs and to discuss how wallowing affected pigs' health. For poultry, the major health concerns not related to disease or nutrition are the physical weakness of broilers' legs, the lesions on footpads, and hock burns, all of which are unfavorable states. The stress of living in commercial houses is attributed to the house conditions, which in turn have been attributed to causing some of the physical abnormalities. Stress-induced myopathies are associated with the genetic selection for high growth rates. Muscular dystrophies in broilers are genetic (Hudecki et al.,1995) but the environment cause the condition to worsen. When animals fail to cope with the conditions of the house, they face high rates of mortality, lesions on legs and footpads, and a reduced growth rate (Broom.,1986). The European Commission (2000) acknowledged that muscle abnormalities result in lame birds that do not see the end of production. Broilers die as a result of physical limitations, that reduces the flock numbers and affects the bottom line for producers.

One approach to welfare is designing a housing system allowing poultry to choose to perform semi-natural behaviors. Later this review will look at behaviors in the house that tend to cause low welfare. Once it's been established where the behavioral need for poultry can be improved a solution to satisfy poultry behavior and alleviate unfavorable conditions will be discussed. However, it is difficult to clearly identify the one variable in the house that causes low welfare conditions (Bradshaw et al., 2002). The factors that have the greatest negative impact on how welfare is implemented include genetic, nutritional., and management practices. Conditions of the house have been proven to affect the health of the flock, even more than the stocking density (Dawkins et al., 2004). For the sake of focus, the broilers behavior and the commercial house will be related causes of low welfare.

1.3 Behavior in the house

To illustrate the needs of birds in a commercial housing system, it is important to understand how they use the space available to them. If the commercial housing system fulfills the basic needs of food and water, it is also important to determine what additional requirements poultry need to improve their welfare. This entails looking for common behaviors demonstrated by the broilers who are using the space in a commercial house, including the social system of broilers observed in commercial houses.

Factors of the social environment affect the use of space in the house. The social systems of broiler chickens have been observed and defined in previous studies. Such studies have identified a set of behavioral interactions between animals that make up their complex social systems. Most social animals develop certain behaviors during social interactions. For domestic fowl under confined conditions, the traditional pecking order is the usual system, with certain birds ranking over other birds for resources. However, in a large house with 26,700–32,600 birds, it is possible that the pecking order is sufficiently dispersed that it does not affect broilers. The resources in the house are not restricted by other birds, and there is no interaction with predators.

There is a welfare concern about the stocking density affecting the social interaction of broilers. More birds in a confined area may contribute to aggression, fights, and the death of smaller broilers, who are trampled by larger broilers. A study investigating stocking density conducted by Febrer et al., (2006) was based on the previous research that the way birds distribute themselves in space furthest from other bird interactions. Their study examined the social parameters in commercial farms for a given stocking density and found that birds consider the proximity of other birds to not be aversive. The paper analyzed birds' social behavior of clustering, which birds perform by arranging themselves into clusters, thus leaving unused space. The study focused on ten major broiler producers in England, Scotland, Northern Ireland, and Denmark. The stocking density was adjusted by altering the number of chicks placed in the house. Within the limits of the data collected in over 100 commercial broiler chicken houses, they found no aversion between birds at high stocking densities. Strong flocking behavior means that birds choose to be near other birds. The problem with higher densities in the house is the increase of poor gait and reduction of growth rate, which is not necessarily due to the stocking density but rather can be due to the behavior of broilers in the house. Broilers often cluster, resulting in added heat, the jostling of other birds in close proximity, and, in turn, aversive health effects (Blokhuis, 1984).

Further analysis of individual distribution in the broiler house shows that, depending on certain behaviors, birds will change their distance from the birds around them. This study done by Keeling and Duncan (1991) was divided into two parts: the first investigated the effect of behavioral activity on the social spacing of birds, and the second looked at the change in activity associated with change in distance. This experiment demonstrated that when the behavior of broilers changes, there is a change in the inter-individual distance the furthest distance birds will sit from other birds. Thirteen females and two male bantams (ancestor strain) and medium hybrid laying strain (commercial layers) were released into an outdoor enclosure. There were no subgroups in either flock of the same type, but there was a difference in the two different groups -hybrids and bantams kept to their own type. The distance between neighboring bantams was much less than between the hybrids. This may be because bantams are more cohesive then the hybrids, which is attributed to an anti-predator behavior more common in the primitive bantam strain than in the more commercial strain. In its analysis of birds moving toward or away from each other, the hypothesis in this study focused on activity transition depending on behaviors. The same area used in the previous experiment was again used with a new group of medium hybrid strain birds. With the same pattern of behavior from the previous hybrid experiment, this flock featured greater distances between individual birds. The researchers made a distinction between ground pecking, which had the smallest neighbor distance, and foraging, which had the largest. They found a significant relationship between the movement of the individuals moving toward or away from each other. The results imply that behavioral activity is important in social spacing and that birds will react quickly to changes.

In confinement, animals are constrained by space; the enclosure limits the rate of dispersion and travel. Inter-individual position is the individual spacing between birds that informs a flock's behavior. Because flocking behavior is strong factor that causes birds to stay close each other, inter-individual spacing is a small distance. A series of studies done by Leone and Estevez (2008; 2010 look at the effect of enclosure size and number of individuals and their density. The first experiment in this study looked at the characteristics of the environment, such as enclosure size, group size and density, and their impact on movement and space use in domestic fowl. The researchers constructed three enclosure sizes, which were 16.04 ft^2 (small, 4 × 4 ft), 31.86 ft^2 (medium, 4 × 8 ft) and 48.11 ft^2 (large, 4 × 12 ft), and they increased enclosure size in only one direction to give all enclosures the same width (4 ft) (Leone and Estevez, 2008). The study wanted to investigate the dispersion of flocks in an area and how far they traveled.

The inter-individual distance showed a slight variation in the large enclosure, but the total distance travelled did not differ. Based on a previous study by Keeling and Duncan (1991), this is unsurprising because it is unreasonable to expect birds to distribute evenly. This study shows that the effect of enclosure size is independent of group size and density. The results concluded the limitation of movement was related to the presence of other individual birds in the path of movement, reducing the distance traveled by the group. Irrespective of density or group size, the net displacement followed a specific pattern, and inter-individual space was not different in the larger enclosures.

Removing group size and stocking density as factors, a study also looked at the impact of enclosure size on space use and movement patterns (Leone et al.,2010). The goal of the experiment in 2010 was to isolate the enclosure size. Using the same constructed enclosures instead of a rectangular pen, they used three square pens: 16.04 ft^2, 31.97 ft^2, and 48 ft^2. The increase in size from small to medium provided twice the amount of floor space. Again, similar results occurred, with inter-individual distance between neighbor birds not increasing with enclosure size. As for total distance traveled, it was not clear if the birds increased their travel distance when they were given more space. The researchers found that longer walls were used more by birds in the house as a means of cover because they perceived the walls as a secure area. At this point, it is clear that chickens spread out in their environment depending on the other chicken's spacing each other.

The commercial house is our main environment in which behavior occur from the broilers. These behaviors inform what happens in the house and where chickens spend their time. Since there is a strong flocking behavior and a social system in place. Chickens do tend to favor specific areas in the house. Broiler chickens limit their physical efforts and tend to stay and rest near drinkers and feeders as much as possible (Arnould and Faure, 2004) Other features in the house tend to attract the attention of the flock for other reasons. For example, birds could be crowding the walls in order to seek cover or avoid being disturbed by other birds. The term "crowding" implies an aversive experience due to high local density surrounding a chicken. When birds are in high local densities, they are more likely to be disturbed by the movement of other birds because they tend to push or climb over other individuals. An experiment by Buijs et al. (2010) looked at the behavior of wall-crowding. The researchers wanted to know if the distribution observed was the result of anti-predator tactics or from avoiding disturbances at rest. They studied spacing behavior at different stocking density of broilers in a confined space. The pen had inner, inner middle, outer middle, and outer (wall) areas labeled. Each focal bird was recorded in the area to link its location with the frequency of visiting that areas. Birds were present at the edges (rather than at the center of the pen) at treatment densities of more than 12.1 birds/m^2 for 6 weeks. In this experiment, the researchers could not find support for the predator hypothesis due to the increased number of birds along the wall with increasing group sizes. Thus, staying near the walls can be seen as an adaptation to crowding. High-density treatment group adjusted their posture twice as often as those at the lowest density. This means that the degree of density can disturb sleep or alternatively result in an increase in resting behavior. In conclusion, the wall hiding method develops in high-density populations as a result of broilers seeking more protection.

1.4 Environmental Complexity

From the behaviors shown in the house, it is clear that birds have distribution issues, crowding along walls, as well as a lack of environmental resources that encourage more natural behaviors. Good welfare is compromised due to broilers choosing to crowd because of their social instinct and because of environmental factors. Some previous studies have investigated this problem and have suggested adding new features to the house environment. That is, those studies tried to change the use of space with an additional structure. This idea of environmental complexity puts more value in the environment of captive animals. Adding more to the environment changes how birds use the space available.

Starting with, Cornetto and Estevez (2001) investigated the influence of artificial cover in changing birds' use of pen space. These researchers hypothesized that adding vertical panels to pen centers would increase complexity and change the distribution of the birds over the space. The experiment was designed as an incomplete factorial-treatments with different variables and a control treatment. There were three cover treatments and three group sizes with repeated measures. The first treatment was the panels, they were vertical stands, with openings of 0.01 x 0.03 cm. A mesh frame was attached to give the illusion of a wall. Next treatment just had the frame of the vertical panel and final treatment had no cover. The greatest use of the space occurred in the pens provided with the mesh treatment. No cover treatments had lowest use of center space. When group size increased the proportion of the birds using the pen center decreased for the frame treatment. Proportion of birds in the center increased for the lack of cover treatment only when density got higher. These panels were the main attraction for the birds. They gathered in the space for the panels' protection and cover.

In the case of the study with Cornetto et al. (2002) the same mesh panel treatment was used. they found that limited space along the walls increases aggression. Birds use aggression to control access to resources and social space, the researchers designed a solution based on that aggression. Although the use of a cover feature did not significantly reduce aggression in their study, aggression was observed more frequently in pens with no cover at all. That instead of maneuvering around other animals, birds simply took direct walking routes over other birds in no cover treatment. This is consistent with a previous study (Cornetto et al., 2001), which found that adding complexity to bird's structures reduced competitive behaviors and thus increased welfare. A change in environment impacted flock behavior and resulted in reduced aggression and levels of disturbances (Cornetto et al., 2002).

While the environment is an important feature for birds' welfare, commercial houses do not provide significant environmental complexity for birds to interact with beyond the feed lines and water lines that break up the space. In a study by Leone et al. (2007) researchers focused on the beneficial effects of cover panels, which were installed to increase environmental complexity and protection for broilers. They tested male birds between three and four weeks old, which were randomly divided into eight groups of 42 birds kept in 48.44 ft^2 pens. The researchers constructed three testing areas measuring 7.38 x 23.79 ft. All three group sizes were tested in three levels of environmental complexity—void, single panel, and quadruple panels. The void treatment was a control area that was empty and without any panels. The other areas had panels constructed from PVC pipe frames and mesh screens. The single cover was 13.12 ft long and 35.43 in. tall in the center area, and the quadruple panels provided cover with four different panels staggered 1 m apart in a broken line. The quadruple treatment had 129.17 ft^2 of protective cover, a greater cover than the single treatment, which had 96.87 ft^2 of cover. The researchers found that neither the group size nor the treatment affected the distribution of individuals' space use. Group size affect the way birds organized themselves in relation to each other and the collective use of space as a group. The results suggest that domestic fowl have the capacity to adapt to their social structure and assess their physical space. Birds in larger groups have the benefit of size to protect themselves and therefore lack strong social pressure to find cover.

1.4.1 Environmental Enrichment

Environmental enrichment is a non-specific term. Environmental enrichment is an improvement in the biological functioning of captive animals resulting from modifications to their environment (Newberry, 1995; Appleby, 1997). The phrase has generally been used to refer to the structure in an environment. An extra structure that encourages certain patterns of behavior (Wells, 2009). Often current aberrant behaviors such as pacing, pecking, or curb biting other objects to relieve boredom (Clarke and Jones, 2007; Skibiel et al., 2007) With environmental enrichments the stress related behavior is decreased, allowing for needs of the animal to be fulfilled. Those enrichments increase animals' ability to cope with challenges and increase positive use of the environment. Simultaneously enrichments present in the environment reduce aberrant behavior.

In order to evoke a response or to control the outcomes of performed behaviors, a stimulus must exist in the environment. An important discussion in this field centers around the relationship between the different factors that form the house environment and the animals' responses to such factors (Newberry and Estevez, 1997). One influential name in the study of welfare enrichment for zoos is Hal Markowitz (Markowitz and Woodworth, 1978; Markowtiz, 1982). His major contribution has been to highlight the importance of animals' choices within their environment, providing them with different features to interact with in their captive area. Using operant conditioning techniques, he was able to get animals to acquire food hidden in the environment- encouraging forging behavior. Markowitz developed devices and systems for zoos to increase the natural behaviors of captive animals. Animal caretakers in the 1980s were growing the idea of creating zoo environments specific for the species. Over the next two decades, the growing field of environmental enrichment changed the way caretakers and developers house zoo animals.

The environment of broiler birds is dependent on humans knowing how to enrich it. Evidence of improved biological functioning that comes as a result of environmental enrichment relate to reproduction, feed conversion, or improved health features that correlate to the environment. Enrichments investigated by past studies for broilers have improved foot pad lesions, reduced hock and pad burns (Kiyma et al.,2016), reduced leg deformity (Birgul et al.,2012), increased activity (Bizeray et al. 2002), they improved the well-being of birds in a commercial house.

This current study looks at perches as an enrichment for commercial houses and how to develop a perch as an enrichment for broilers. When developing an enrichment for a particular animal Mellen and MacPhee (2001) looked for a holistic approach in the terms of the animals' entire captive environment. That study added to the body of knowledge on welfare and clarified strategies for how to create an optimal environment for animals to feel comfortable with different stimulations. Using this knowledge of the animal's natural and individual history to rethink the way caretakers house, feed, train, and represent their animals. This important method of developing enrichments for particular animals depends on understanding the current environment and how the current behaviors in the poultry house affect the possibilities of a perch enrichment.

The environment of the broilers is important for their health because their behaviors are tied to the complexity available in the environment. Thus, how enrichments are designed within the environment directly affects broiler behavior, and an understanding of perching behavior must consider specific design elements.

Creating complexity in the environment by using enrichments like perches may improve broiler behavior. How to find a design to produce a desired effect requires an understanding of common broiler behaviors – that is, what features result in the behavior desired for improving welfare.

1.5 Understanding the design of perches

One environmental enrichment that has been placed in commercial housing in order to improve broiler behavior is a perch. Perches enable broilers to engage in natural behavior (one of the five freedoms). Currently, the American broiler industry does not have perches in the commercial houses. Some poultry house under organic settings have ramps or hay bales as their enrichments. Not enough has been done to bring perches into the commercial house. Problems of the past few years, such as crowded housing, indoor confinement, and rapid growth, have given the industry a poor image in the eyes of public consumers. The industry now needs to change the environment of commercial houses for their birds.

A series of perch studies has investigated similar designs and used them to study behaviors of interest. Those studies, however, did not design its interventions with the birds' ability in mind. If the design of a structure affects an animal's ability to use the structure, the animal will change its behavior toward the structure. This section below discusses the perches used in each study in order to determine if common features are important for broiler welfare as each experiment investigated different behaviors related to perching.

Recent studies are informed by the work of Dr. Inmaculada "Inma" Estévez, who works in poultry behavior, welfare, and precision farming. She has authored a number of studies with a focus on environmental enrichment. She used one type of perch design in multiple studies to investigate different aspects of the birds' behavior under observation. Her design started with a simple horizontal perch, an angled perch, and a steep perch. The perch design should improve the welfare of broilers' environment, increase their activity, and provide them with the means to easily perform natural behaviors.

The experiment done by LeVan et al. (2000) informed other experiments using the same set of perches. They performed an experiment designed to collect data on birds using different perches. The randomized block design had four (4) different treatments and three (3) perches set at different vertical angles. Additionally, the researchers wanted to identify what factors influenced perching behavior. Their main prediction was that angled perches were more easily accessible and would increase the frequency of perching from the broilers. Perches used in this experiment ranged from a 0-degree treatment (horizontal) with a height of 3.34 in a 10-degree angled perch that sloped from the floor to 6.69 in height, and a 20-degree angled perch that sloped from the floor to 13.97 in height. All the perches were designed with five equally spaced cross bars 11.02 in long, and each perch was 35.82 in length (LeVan et al., 2000).

They found that broilers used the angled perches the least. In experiments using both one perch type and mixed types of perch, birds chose the lowest angle perch (horizontal). Until the birds were six-weeks old they perched on the horizontal perch. The influence that most impacted the birds' ability to perch was age: birds exhibited the greatest frequency of perching between week 3 and week 5 of age. Angled perches may have been used least due to birds' limited mobility, especially later in life; broilers' weight gain would deter them from using perches. Similar results from the study on perch provisions found horizontal perches received more attention from broilers (Bailie et al.,2018).

With the same type of perches, Estevez moved on to another aspect of welfare: how the density of birds affects perching behavior (Pettit-Riley and Estevez, 2001). The goal of this study was to look at stocking density as a factor in perching. Estevez hypothesized that birds would perch more if they had no room on the floor. Pens were assigned to the perches used in the previous study. The previous experiment with this set of perches was only set at one stocking density (LeVan et al., 2000). While this experiment included 36 groups divided by a 4 x 3 factorial randomized block design. The results show a low frequency of perching, with significant changes over time. Birds slow their rate of perching on different perches ($F10,89 = 4.07$, $P < 0.0001$). Significant effects occurred as density increased. Birds climbed to higher sections of the angled perches more than sections of the horizontal perches. Within the mixed treatment, the horizontal and 10-degree angled perches were used more than the highest angle perch. The birds perched at higher densities but did not continue to perch as they grew larger.

The next experiment used to analyze the use of perches by Estevez looked at activity. This time Bizeray et al. (2002) attempted to increase general locomotion and activity by adding complexity to the broiler pen, which they achieved by placing barriers in the path of important resources. They had two methods to stimulate birds to change their behavior: (a) making barriers to the essential resources and (b) projecting moving colored light onto the floor to increase forging behavior. The barrier treatment in the experiment had a 4.92 ft long x 0.49 ft high x 0.13 ft wide wood barrier that was placed between the drinker and feeders. This required the birds to interact with the structure or move around it from feeders to drinkers and vice versa. The researchers looked at the effect of age for walking frequency. Maximal perching happened at 4 weeks of age, 17% of the time. Age did not affect the frequency of birds crossing the barrier. The experiment results show that behavior can be affected by increasing the complexity of the environment. In that regard, it is effective at diversifying behavior patterns, but there are some limits to the improvement, such as the fact that age reduces activity. Forcing animals to exercise by navigating barriers was more effective in increasing activity than in stimulating foraging activity, which indicates that birds perform more activity toward a goal and that food motivation is more influential than performing an empty task. The results also show that birds tend to walk over barriers rather than walking around them.

The next study by Rodriguez-Aurrekoetxea et al. (2015) investigated the benefits of panels and perches on birds with slow growth rates. A randomized block design consisting of three treatments—panels, perches, and control—were assigned randomly to each house. Wooden perches were 9.68 in long, 9.84 in high, 1.57 in wide and attached to a base (two 7.87 in × 1.97 in × 0.20 in perpendicular bases) that was hidden in the litter. The design of the perches in the treatment were the same as in Bizeray et al. (2002a) and Ventura et al. (2012) but were a little higher and the experiment allowed the birds to have access in outdoor areas. The results of this study conflicted with other studies that involved this method (Rodriguez-Aurrekoetxea et al., 2014). Age still affected the frequency of perching by reducing the behavior. Under commercial conditions, researchers found only mild effects of the enrichment treatments on behavior. The study by the Estevez team, however, was limited by the availability of the perches and panels. This suggests that if complexities were more stable and more available in the houses, different results would have been recorded.

Now to look at behavior around the perching area, the interaction of the birds intending to use the perch. The study by Pettit-Riley et al. (2002) looked at the effects of aggressive behaviors in areas of interaction. Crowding (stocking density combined with group size) has been shown to affect levels of aggression in domestic fowl. The disturbance of rest or sudden movement may result in aggressive tendencies. The objective was to have perches or other devices set in the open area to reduce aggressive interactions and to determine the impact of crowding and perch availability on aggressive behavior in broiler chickens. Treatments were in a 4 x 3 factorial randomized block design. Four different perches from the previously described studies against 3 density levels. The analysis looked at aggression as a key behavioral factor around the perch. The crowding level had a significant impact on the frequency of threatening behaviors. The least crowded treatment had the highest frequency of threats and aggressive interactions, while the most crowded treatment had the lowest aggression level. Aggression near or around the perch was different depending on the type of perch. Contrary to the expectation of lowering aggression with perches, the threats tended to happen in angled and horizontal perch treatments. An explanation for this increased aggression could come from a similar result from the previous study, where the horizontal perch was the most frequently used (Pettit Riley and Estevez, 2001), resulting in birds having a higher chance of interacting with aggression. The conclusion was that perches in this experiment might not diminish aggression in broilers. However, this finding largely depended on perch design, which is a common problem in studies of perches for broilers.

Norring et al. (2016) developed a different perching design from previous experiments and compared it to a platform. The main result was that birds used the platform more than the perch. Perches were designed to be 78.74 in. long and 47.24 in. wide, with only two heights (11.81 in. and 3.94 in. from the floor) and two thicknesses (22 x 22 mm and 50 x 50 mm with rounded edges). Platforms are a type of enrichment that induces the same perching behavior but with a different design. The main hypothesis was to compare the use of platforms and perches. The platform was built to be 47.24 in. long and 23.62in. wide and was elevated 11.81 in. from the floor, with both ends forming a ramp from the floor. Analysis of the different types of perches was performed using the Friedman test is used to detect differences in treatments across multiple test attempts. One possible explanation for the high use of platforms is that the ease of access for broilers to get on platforms.

Current studies on commercial broilers have found that broilers engage in a low use of perches (LeVan et al.,2000; Pettit Riley and Estevez, 2001; Norring et al., 2016), although some research shows that broilers have also been able to perch as much as 10–25% of their time (Bizeray et al., 2002, Ventura et al., 2012). Low perching attempts could be due to the fact that broilers are unable to reach perches after a certain age. In all the studies there is more perching done by younger birds on low angles, the horizontal perch (LeVan and Estevez, 2001; Pettit-Riley et al., 2002) had a height of 3.34 in and got the highest number of birds perching. The lowest rung was 3.93 in from the ground in Norring et al. (2016) and the added platform took birds away from the perches in the experiment compared to platforms. The physical challenge of using the perch limited broilers' motivation to choose to perch over the platform. There is no mention of how the shape of the perch affected broilers perching.

The designs from a welfare standpoint did not consider the broilers specific needs when it comes to perches.

Based on the above studies, the most popular type of perching for broilers is a horizontal design. The ramps and platforms are partially used when access to the perch is easy for the broilers, while angled ramps are the least used, according to the body of work. Therefore, ease of access is important for perching behavior because the broilers did not continue to climb up inclines as they aged. Therefore, it is clear that design factors change the way broilers interact with the structure. The experiments in the present study looked at how to design a perch to meet broilers' behavioral needs and to increase perching activity.

1.6 Objective

The objective of this study is to improve broiler perching behavior by designing an effective perch. If broilers need to engage in perching behavior, then fulfilling that need should increase welfare.

- The first goal is to understand how the design, height, and shape of a perch impacts the perching behavior of broilers. If the design is based on the birds' ability to perch, the rate of perching will increase.
- The second goal of this experiment is to investigate broilers' motivation to perch. Having perches in the environment inherently changes birds' use of the environment. Birds may use the perch but not with the same frequency discussed in previous studies. In light of previous studies, perching patterns depend on a few variables that require understanding before moving the enrichment into a larger house.
- The third goal of this experiment is to further study the perching frequency of a flock in a large commercial house. The number of birds that frequent

the perches are the ones using the enrichment. Those numbers indicate if the type of design is fit for the environment.

Our understanding of the use of perches and how perches were previously designed informs our means of measuring the activity of focus. Specifically, the perches used in our experiments could track perching activity. One measuring method has been to observe the number of birds using perches or performing certain behaviors (Pettit Riley and Estevez, 2001; Ventura et al.,2012). In this series of experiments, the design incorporates measurement devices to track the perching duration and the number of steps taken by broilers.

This type of study is important to clarify behavior that is attributed to birds, namely, perching. Similar to wallowing behavior in pigs, however, perching in birds may also be a misunderstanding or a behavior that can be reduced simply through the lack of opportunity. For example, for Red junglefowl, perching serves as a protective behavior, allowing them to escape predators and forage for food. Broilers have the same behavioral instinct, but the opportunity for perching is lacking from their environment. Environmental complexity is lacking in commercial houses, but improving the use of the environment through the addition of enrichments can encourage different and necessary behaviors.

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Chapter 2

PREFERENCE OF BROILERS ON DIFFERENT PERCH CONFIGURATIONS

2.1 Abstract

In commercial houses, broilers have limited active behaviors, which can cause leg development problems. It was suggested that adding perches in production houses could improve leg strength and mobility of broilers. The use of perches in broilers has been low and there was limited information on designing perches for broilers. A properly designed perch may increase perching activity and consequently a number of health benefits can be resulted. Therefore, a study was conducted to investigate specific perch characteristics (shape and height) using perching behaviors as a measurement. An experiment was designed to focus on two shapes of perches (round and square) mixed with two heights (4-in. and 6-in.) by comparing the perching times affected by the features of the perch structures. The use of perches was tracked by recording weight changes on perches via load sensors. A generalized linear model was formed to analyzing total perching duration and step on number on perch. The results showed broilers spent more time on square perches ($P = 0.02$). For height, birds preferred lower (4-in.) perches ($P < 0.0001$). The design of the perch affects the use of the perch by broilers. To achieve the health benefits of perches for broiler, perch design is an important aspect to consider.

Key words: Perch, Behavior, Broiler, Shape, Height

2.2 Introduction

There is a welfare concern in commercial broiler houses about low activity levels. The environment of the commercial house dose not encourage activity. The motivation to walk or exercise decreases with the increasing age and body weight. Broilers tend to spend 70-80% of their time resting (Bailie et al., 2014; Weeks et al., 2000), which can result in underdeveloped leg muscles and early culling by farmers. Broiler birds, like their wild counterparts Red Junglefowl (*Gallus gallus*), are prey animals, and they seek protection in their environment from potential threats. In the wild, these instincts result in roosting on higher structures to avoid predators. The current commercial houses reduce the need for protection since predators are not a factor in broiler life. However, these birds still have an instinctive need and motivation to use their environment to satisfy their innate behaviors. Thus, the use of perches or similar structures would allow broilers to express their natural behavior.

Motivation to perch has been demonstrated in laying hens which use elevated structures during the night (Olsson and Keeling, 2000). Layer perching behaviors have been studied to characterize perch materials, which best fit the layer's special needs (Pickel et al., 2010; Chen et al., 2014;). What birds need in commercial houses is a complex environment that induces their instincts for survival. Without the means to express normal activities, broiler birds exhibit coping behaviors, such as feather pecking, aggression, and a general fear (Pettit-Riley et al., 2001). Additionally, leg deformities may be reduced with perches, as they allow the animals to strengthen their leg muscles (Kestin et al., 1992; Birgul et al., 2012).

Perches improve welfare in commercial housing and have been demonstrated to be a key to diversifying behaviors. For instance, some researchers have previously suggested that perch-like structures or platforms helped improve broilers' activity

(LeVan et al., 2000; Norring et al., 2016). While adding additional complexity to the environment changed the distribution of the birds and allows them to perform more active behaviors, the structures have only been used sparingly in broilers (Bizeray et al., 2002). In some studies, birds had difficulty climbing onto the structures and did not interact with the perches throughout the growing period (LeVan et al., 2000; Rodriguez-Aurrekoetxea et al., 2015). Other structures such as platforms used like perches, may serve as a sufficient perch, but did not improve perching rates for older, heavier birds (Norring et al., 2016). Most structures used for perching did not consider the broiler bird's ability to climb or stay perched. With an understanding of the physical limitations of broilers, more enrichments could be introduced into the houses and improve welfare of the birds (Leone et al., 2008; Kaukonen et al., 2017). The hypothesis is that improving perch design could increase the use of the perches by broilers. Therefore, a study was conducted to investigate the effects of perch shape and height on overall use by broilers.

2.3 Materials and Methods

A four-pen system measured 5 ft x 9 ft was used to conduct the experiment. The frame of the system was made of (2 in. x 4 in.) wood and divided into four identical pens by plywood (0.125 in. thick and 2 ft high) wall (Figure 2.1). The floor of the pens was 0.5 in. plywood. A twin-nipple drinker (VB150, Val-co, New Holland, PA) was used in each pen and located at the same end of the pens. A hanging feeder with 2 kg capacity was hanged under a hanging load cell (RB-Phi-123, RobotShop, Mirabel, Canada) in each pen and located at the opposite side of the drinker. The center of each pen was installed with a 60 cm long wood perch along the centerline of each pen. The cross-section shapes of the perch tested were square with a 1.5 in. side length and round with a 1.5 in. diameter. The wood with 1.5 in. side length and 1.5 in. diameter were the most available building materials in the US. A pair of micro load cell sensors (RB-Phi-119, RobotShop, Mirabel, Canada) was used on each perch to measure the perching activities when birds perched on it (Figure 2.1). The top heights of the perches were set to 4 or 6 in. by adjusting the heights of the adjustable base under the load cells. The bases of the perches were secured to the floor with screws.

Four (2 x 2 design) different perches with two shapes (round and square) and two heights (4 in. and 6 in.) were randomly assigned into the four pens for each flock. Two flocks of birds were raised with four female Cobb 500 broilers in each pen from day-old to 42 days of age. Fresh pine shavings were used as beddings with 10 cm depth. Feed and water were provided ad libitum. Birds were fed a two-phase commercial diet: a starter ration (3,100 kcal/kg, 22.00% crude protein) from 0 to 13 day of age and a grower ration (3,200 kcal/kg, 20.00% crude protein) from 14 to 42 day of age, the end of the experimental period. Feed was checked daily and added as needed. The four-pen system was housed in an environmental controlled room. An artificial lighting program and a standard temperature program were followed (Table 1). Hanging brooder lamps were used to provide supplementary heat during the brooding period via until seven days. The birds were weighed weekly and growth curves were developed for the pens. A PC program was developed to continuously collect the weights of birds on perches and feed consumption in the pens through a data acquisition module (USB-2416, Measurement

Computing, Norton, MA) with one-minute sampling and recording interval. For each day perching activities were identified via a Microsoft (MS) Excel program by coupling the weight changes of the perches and average body weight. An infrared camera (PRO-T845, Swann, Santa Fe Springs, CA) was mounted at 8 ft above each pen and connected to a recorder (DVR4-4350, Swann, Santa Fe Springs, CA) and video files were recorded consciously for each pen. Five video clips (5 min per clip) for every day were randomly selected to verify the perching activities identified by the MS program. At the end of each flock all birds were examined for gait score by using three-score system and feed conversation ratios of the pens were derived using recorded feed consumptions and body weights.

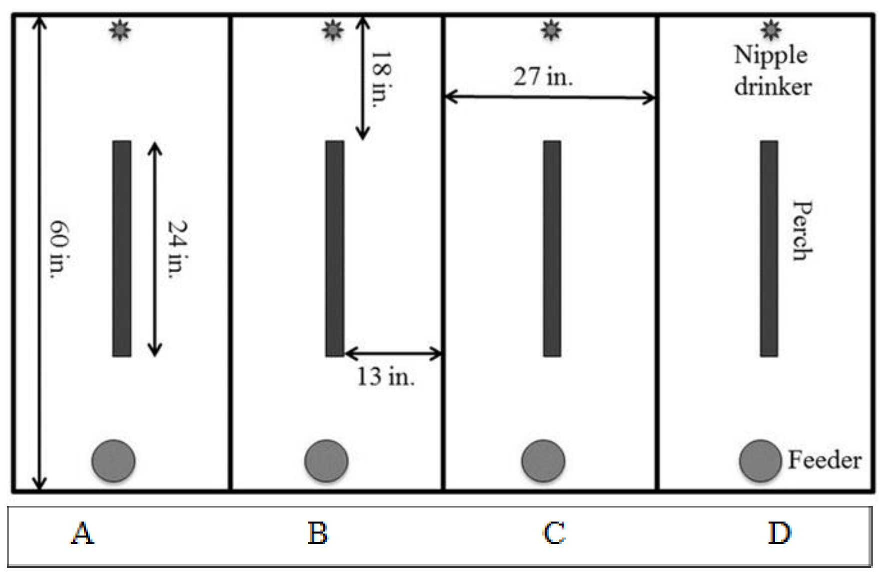

Figure 2.1: Pen layout- Four test areas with four perches, (A) Round 6", (B) Round 4", (C) Square 4" (D) Square 6".

Table 2.1: Light schedule

Age	Light: Dark (hr)	Temperature (°F)
0 – 6	24:0	86.0
7 – 14	24:0	86.0
14 – 20	20:4	80.1
21 – 27	16:8	73.9
28 – 42	18:6	68.0

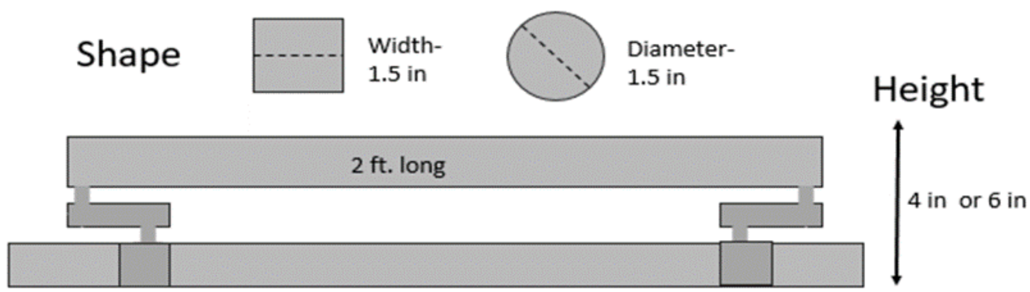

Figure 2.2: Perch Design, different perch design with a round or square perch on a base attached on Single Load Sensor

Based on the daily body weight and weight changes of the perches, the number of the birds on a perch was determined in Eq (1).

$$n = Round(W/W_i) \qquad (1)$$

where n is number of birds on perch; W is change of perch weight, g; and W_i is average body weight at age of i day, g.

Daily perching time (the duration of perching) on each perch was derived by integrating the perching times of all birds in Eq (2).

$$T_i = (\sum_{n=1}^{4} nT_{n,i})/4 \qquad (2)$$

where T_i is daily perching time at age of i day, hr/bird; n is number of birds on perch; and $T_{n,i}$ is total time when n birds on perch at age of i day, hr. Daily perching step-on times (Steps) also was derived when the change of perch weigh increase by one bird body weight. Mean perching bout per step-on (Bout) was calculated in Eq (3).

$$B = T_i / S_i \quad (3)$$

where B is mean perching bout, min; T_i is daily perching time at age of i day, min; and S_i is step-on times at age of i day.

Data were analyzed using JMP Pro (V12.0). Mean daily values per pen over a flock was calculated for the perching time, step-on time, perching bout, gait score, body weight, and feed conversion ratio (FCR). The log transferred weekly mean values of perching time and step-on time were compared using ANOVA with 'shape x height' as treatment factors after testing for homogeneity of variance and normality.

2.4 Results

2.4.1 Daily perching time

The birds with different perches demonstrated different perching behaviors over the two-flock trial (Figure 2.3). There was very minimum perching activity for the round 6-in. (R6) perch compared to the others on daily perching time. The perching activities started as early as 3-day of age for square 4-in. perch while the other birds did not perch until 9- to 11-day of age. The daily perching time significantly increased during the first two weeks and reached peaks round 15-day of age. The daily perching time of the birds with S4 perch remained high over another 24 days while the rest of the birds with different perches had low perching time after 20-day of age. There was a trend that the birds perched more on the S4 perch than the other perches. The highest daily perching time was 6.5 hr/bird (26.7% of the daily time) on S4 perch on age of 25-day. The overall daily perching times were 1.19 and 0.15 hr/bird at 4-in. and 6-in. height while those were 1.04 and 0.1 hr/bird on the square and round perches, respectively.

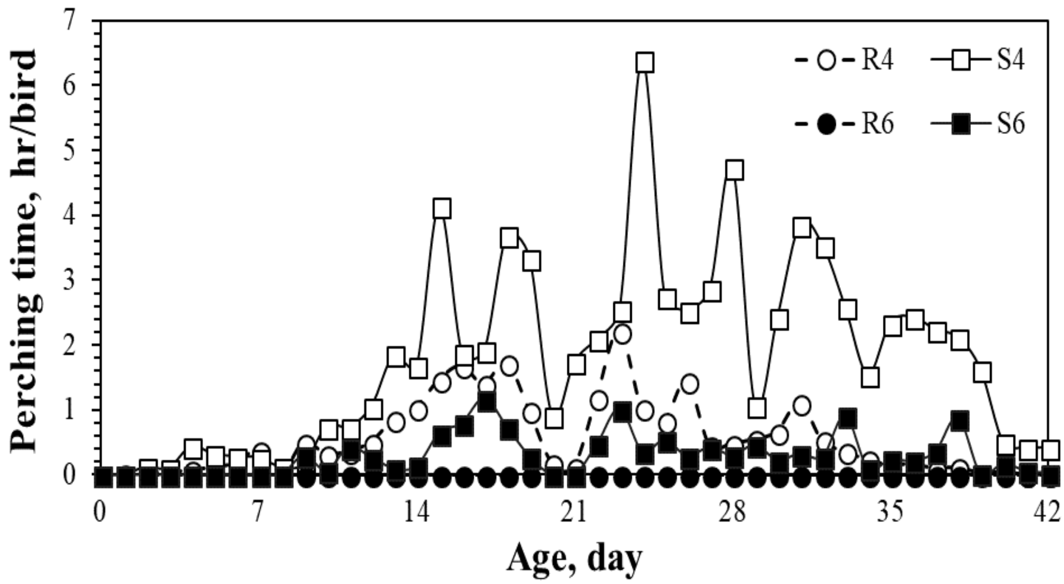

Figure 2.3 Daily perching time of broilers in pens (4 birds per pen) with different perches over 2 flocks (S: square, R: round; 4:4-in. and 6:6-in.).

2.4.2 Daily step-on time

The recorded daily step-on time for the birds show a pattern of rising steps with lower height. The highest step-on time throughout a day was 104 steps on the round 4-in. (R4) perch (Figure 2.4). The two 4-in. perches showed a similar step-on pattern while the two 6-in. perches had different patterns. The R6 perch had a negligible amount of perching which illustrated that birds barely perched on it. The step-on times were also affected by the age of the birds. The birds younger than 25-day of age showed more variations on step-on times while the older birds slowly reduced the steps-on time. In general, the birds stepped on 4-in. perches much more that the 6-in. perches.

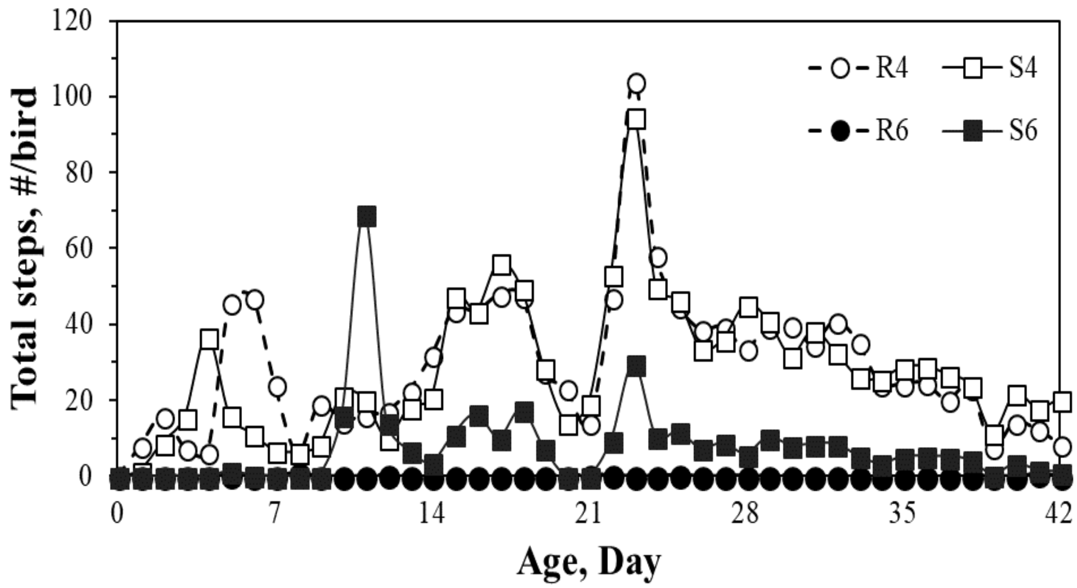

Figure 2.4: Daily perching step-on per bird over age.

2.4.3 Daily mean perching bout (Bout) per step-on

The mean Bout varies with bird age and perch types (Figure 2.5). During the first 11 days, birds spent less than 150 secs when they were on perches. Birds perched longest on S4 perch that was followed by square 6-in. (S6) perch. Similar to daily perching and step-on times, birds did not perch long R6 perch. It seems that the birds had a difficult time staying on the round and high perches. The highest Bout were 500 and 730 secs per step on S4 and S6 perches.

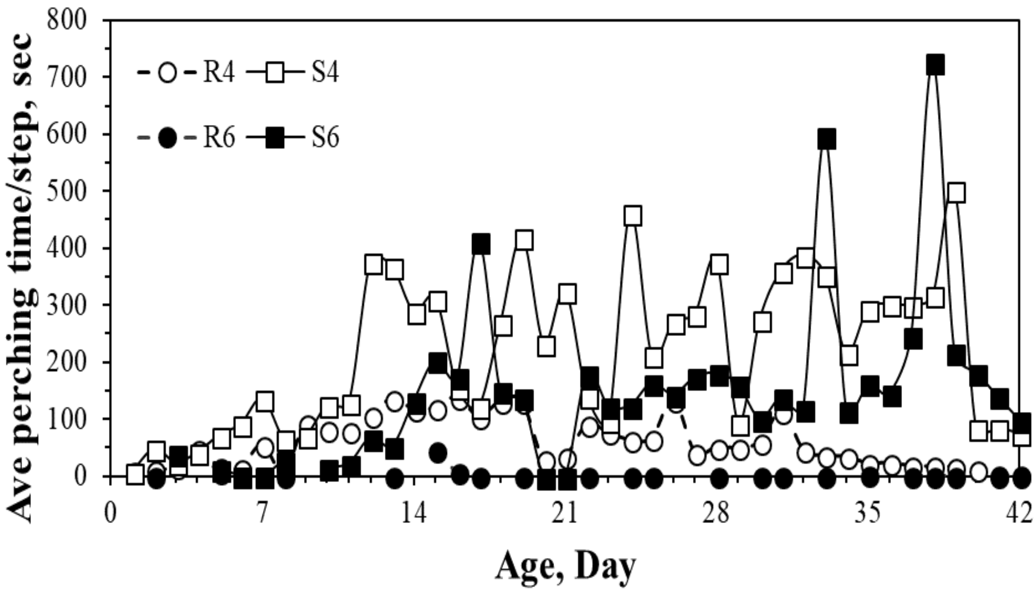

Figure 2.5: The daily average bout over age.

2.4.4 Effects of Shape and Height

The interaction between birds and the perches varied depending on the trial and perch configuration. The highest average daily step-on time was found on R4 treatment with 178.59 steps followed by S4 treatment with 168.08 steps in trial 1. The highest average daily perching time was 8.31 hr. on the S4 treatment in trial 1, and the second highest treatment was 5.73 hr. on the same treatment in trial 2 (Table 2.2). Among the four perches, birds tended to have highest perching duration with the S4 treatment and lowest one with R6 treatment (Table 2.3).

Table 2.2 Daily perching duration and step-on among four perch treatments over the two trials.

		Duration, hr.	Step-on
Trial	Treatment	Mean (SE)	Mean (SE)
1	R4	3.89 (0.60)	178 (8.0)
	R6	0.00 (0.00)	1.03 (0.26)
	S4	5.73 (0.86)	168 (17.15)
	S6	2.32 (0.36)	64.9 (14.48)
2	R4	0.43 (0.12)	59.7 (5.61)
	R6	0.00 (0.00)	0.60 (0.18)
	S4	8.31 (1.41)	58.0 (3.93)
	S6	0.00 (0.00)	0.20 (0.06)

Table 2.3 Mean daily perching duration and step-on time among the four treatments with different shapes and heights. (N =2)

Treatment	Duration, hr. Mean (SE)	Step-on Mean (SE)
R4	2.16 (0.36) [b]	118.38 (11.44) [a]
S4	7.02 (0.84) [a]	112.32 (10.66) [a]
R6	0.00 (0.00) [c]	0.81 (0.16) [c]
S6	1.16 (0.22) [b]	32.13 (7.99) [b]

[*] *Significant different based on P < 0.05.*

Table 2.4 Effects of daily perch height and shape on perching duration and step-on (N=2)

	Height, in.		Shape				
	4	6	Square	Round	R.M.S.E	P(Height)	P(Shape)
Perching time, hr.	4.76	0.60	4.16	0.40	3.08	<0.001	0.002
Step-on, #	115	16.5	72.2	59.6	55.8	<0.001	0.38
Bout, sec	170	44	191	22.2	153	0.01	<0.001

Table 2.4 shows the effects of the perch characteristics on the perching behaviors of the birds. The results showed that significant higher perching activities,

including perching duration and step-on time, with the square perch at 4 in. height, and indicated that perch with square shape and low profile should be provided to broilers.

2.5 Discussion

The results show that the height affected birds' perching activities than the shape. In other research, the height of the structure was also cited as the main factor that broiler birds had when trying to mount perches (Norring et al., 2016). It has proved to be difficult for birds to manage the height after they gained significant weights. The perch can only be useful when the motivation of using it by birds overcomes the height. The least used perches were the 6-in. with both shapes while birds preferred lower (4-in.) perches ($P < 0.0001$). The square perches received the most attentions in both perching time and step-on count. Different breeds may have different preferences for the perch shapes. The square perch was ranked first in the groups of New Hampshire hens which had been previously exposed to square roosts only, while the round-shaped roost was ranked first in the Columbian Plymouth Rock groups which had no previous experience (Muiruri et al., 1990). In this study, the square shape allowed Cobb 500 broilers to balance on the perch, putting their full weight on the structure for longer periods of time.

During the first three weeks, broilers undergo much weight gain and growth simultaneously: bone structure is established for the birds' ability to walk to resources, and muscles are converted from the feed at a rapid rate due to nutritional availability. After the 4th week in the later periods of growth, birds are accompanied by a change in activity levels. From that time on in our study, birds spent more time on the perch but did not increase their step-on time. Height was an early indication of the birds' motivation to perch. The most step-on received by a 6-in treatment was in the first week. The time spent on the 6-in treatment was dependent on shape. The round shape was too unstable for broilers to maintain balance. The broilers would lose motivation to attempt perching on a high structure with an unsustainable balance. The birds could not be motivated to mount a high structure. Their perching from 4- to 6-weeks of age was reduced, in contrast to the earlier weeks when perching time and step-on instances increased. To understand the behaviors of these animals, it was worth noting that these birds were only as natural as their bodies allow them (Bergmann et al., 2017). Physical traits that are valued in these animals shape their behavior, which in turn results in their levels of welfare.

Broilers have similar perching patterns to layers, and perch height and shape are both significant factors for layers. Unlike broilers, layers prefer to reach higher perches (Pickel et al., 2010; Chen et al., 2014), but also use square perches more than round perch frames (Chen et al., 2014). Layers tend to perch more than broilers. Layers with no previous experience spent 54% of their time on perches and continued to perch at night (Muiruri et al., 1990). Due to their light body frames, they can reach high perches easily and maintain this behavior pattern throughout their lives.

The frequency of bird perching activity was also recorded as perch step-on count. The low perches were used more frequently which indicated that broilers did not step on high perches as often. The 6-inch perches were too difficult for the birds to reach comfortably, and so they did not spend time on these perches that they could not access. Keeping perches low would attract more birds and thereby increase the frequency of the perching activity. The square shape allowed the broilers to grip the structure more comfortably and rest their full body weight on the perch. While the broilers may have been able to grip the rounded perches, they may not be able to balance their full weight on these structures.

2.6 Conclusions

The results of this study indicated that broilers were motivated to use a perch for roosting, and this motivation depended on the broilers' ability to use the perch. The perching behavior of broilers tended to be more frequent on lower and square-shaped structures which encouraged more resting behaviors. For the assessment of welfare, it would be valuable to extend the study of perching motivation with more tests that quantifies the motivation under different condition, such as in commercial houses.

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Chapter 3

ASSESSMENT OF BROILER PREFERENCE FOR PERCH ENVIRONMENTAL ENRICHMENT

3.1 Abstract

When looking at the environment of the commercial house there is a distinct lack of complexity. Complexity of an environment helps change the behavior in the environment. Changing environment by increasing environmental complexity may increase broiler activities and improve the well-being of the birds. A perch is an enrichment to increase roosting behavior while it may also increase locomotion by giving them a structure to climb. More importantly it adds to the complexity of the environment specifically for broilers. The objective is to find what would attract birds to a perching area and how often would broilers use the perch. A preference test was conducted to assess the perching motivation of broilers when they were provided a perch. A three-pen system with cameras and a video recorder was used to determine the preference of Cobb 500 broilers for an environment with a perch. Bird perching activities and preferences on perch were monitored by load cells and the video recording system. Feed consumptions in each pen were measured and correlated to the bird preference for perch. The video data showed that broilers spent 26% more time in the perch area (P= 0.003). The results showed the feed consumptions in both perch and no-perch areas were the same which indicated that perch encouraged and increased the locomotion of the broilers. The results showed the preference of broilers for perch enrichment.

Key words: Perching, Behavior, Motivation, Choice, Environment

3.2 Introduction

The value of an environment to broilers depends on its attraction. Food and water availability are obvious attractions for birds to satisfy their needs of hunger and thirst to survive. In commercial houses, the water and feed lines are the most prominent features in the birds' search for survival. Another environment available in commercial houses is generally the rest of empty space. The distribution of birds seems highly related to the location of food and water (Arnould and Faure, 2004). As a distribution factor, birds clustered around areas with important features. Areas with attractive features tended to draw more birds and changed the distribution pattern (Leone and Estevez, 2008). Physical constraints of the broiler are another factor in broiler distribution. The rapid weight gain and lack of physical demands on broilers reduces motivation to walk and to perch (Bokkers et al., 2007). Broilers' walking in the house is limited due to the crowding of other birds. Aggressive birds trample over other birds to get to other areas or resources. It has been shown that birds spend about 80% of their time resting before they searched for optimal area to rest (Weeks et al., 2000; Arnould and Faure, 2004). When birds were in high local densities, the chance of disturbances by the movement of other birds was lowered, allowing more chance for longer rest periods (Buijs et al., 2010).

Environmental enrichments have been used in the empty space of the houses to improve the welfare of the birds. The motivations and behaviors of birds on food and water may change when birds are provided with an enriched environment and given the freedom from space choice in their environment. Perch is one of the enrichments and adopted in some of the modern commercial practices. The placement and location of perches in commercial houses needs to be investigated while the placement depends on the perching motivation of the birds over food and water or empty space. The objective of this study was to look at the use of space by broilers when they were given a choice of perch. Perch may add an attraction to an area that would help improve the special awareness of broilers and increase their perching and locomotion activities.

3.3 Materials and Methods

A three-pen system measured 5 ft x 9 ft was used to conduct the experiment. The frame of the system was made of 1.5 x 3.5 in. (2 x 4) wood and divided into four identical pens (Figure 3.1). The two plywood-dividing walls of the two end pens were replaced by wire mesh (0.5 x 0.5 in. hole). The center of the central dividing wall was cut for a 12 x 12 in. opening that allowed birds to have free access to both center pens. The floor of the pens was 0.5 in. plywood. The two end pens were served as control pens: one with perch and the other without perch. The two center pens were treated as choice pens for broilers. The perches with square cross-section shape and 4 in. height was placed in one of the end pens and the adjacent pen. The center of the two pens was installed with a 2-ft long wood perch along the centerline of each pen. The cross-section shape of the perch tested was square with a 1.5-in side length. A pair of micro load cell sensors (RB-Phi-119, RobotShop, Mirabel, Canada) was used on each perch to measure the perching activities when birds perched on it. The top heights of the perches were set to 4 in. by adjusting the heights of the adjustable base under the load cells. The bases of the perches were secured to the floor with screws. A twin-nipple drinker (VB150, Val-co, New Holland, PA) was used in each pen and located at the same end of the pens. A hanging feeder with 4.5 Ib capacity was hanged under a hanging load cell (RB-Phi-123, RobotShop, Mirabel, Canada) in each pen and located at the opposite side of the drinker.

Two flocks (replicates) of birds were raised with four female Cobb 500 broilers in each end pen and six broilers in the two center pens from day-old to 42 days. Fresh pine shavings were used as beddings with 4 in. depth. Feed and water were provided ad libitum. Birds were fed a two-phase commercial diet: a starter ration (3,100 kcal/kg, 22.00% crude protein) from 0 to 13 day and a grower ration (3,200 kcal/kg, 20.00% crude protein) from 14 to 42 day, the end of the experimental period. Feed was checked daily and added as needed. The four-pen system was housed in an environmental controlled room. Hanging brooder lamps were used to provide supplementary heat during the brooding period via until seven d. The birds were weighed weekly and growth curves were developed for the pens. A PC program was developed to continuously collect the weights of birds on perches and feed consumption in the pens through a data acquisition module (USB-2416, Measurement Computing, Norton, MA) with one-minute sampling and recording interval. For each day perching activities were identified via a Microsoft (MS) Excel program by coupling the weight changes of the perches and average body weight. An infrared camera (PRO-T845, Swann, Santa Fe Springs, CA) was mounted at 2.4 m height above each pen and connected to a recorder (DVR4-4350, Swann, Santa Fe Springs, CA) and video files were recorded consciously for each pen. Five video clips (5 min per clip) for every day were randomly selected to verify the perching activities identified by the MS program. At the end of each flock all birds were examined for gait score by using three-score system (Li et al., 2017) and feed conversation ratios of the pens were derived using recorded feed consumptions and body weights.

During each day three light (at 1000, 1400, and 1800) and one dark (at 0200) period (30 min) observations were performed to determine the numbers of birds in each pen. A program was developed to analyze the location and movement of the birds in the choice pens using a software (Solomon Coder, Version beta 16.06.26). The video was scanned and the durations and locations over each observation period were determined for each individual chick. The preference of broiler for perch is calculated here in Eq (1).

$$P_{Perch} = \frac{\sum_{N=1}^{6} N_{perch} T_{perch,N}}{3T} \times 100\% \qquad (1)$$

where P_{perch} is daily preference for perch area, %; T is the daily total observation, 120 min;

N_{perch} is number of birds in the pen with perch; and $T_{perch,\,N}$ is duration of N birds in the pen with perch.

Based the daily body weight and weight changes of the perches, the number of the birds on a perch was determined in Eq (2).

$$n = Round\left(W/W_i\right) \qquad (2)$$

where n is number of birds on perch; W is change of perch weight, g; and Wi is average body weight at age of i day, g.

Daily perching time (the duration of perching) on each perch was derived by integrating the perching times of all birds in Eq (3).

$$T_i = \left(\sum_{n=1}^{4} nT_{n,i}\right)/4 \qquad (3)$$

where T_i is daily perching time at age of i day, hr/bird; n is number of birds on perch; and $T_{n,i}$ is total time when n birds on perch at age of i day, hr. Daily perching step-on times (Steps) also was derived when the change of perch weigh increase by one bird body weight. Mean perching bout per step-on (Bout) was calculated in Eq (4).

$$B = T_i/S_i \qquad (4)$$

where B is mean perching bout, min; T_i is daily perching time at age of i day, min; and S_i is step-on times at age of i day.

Data were analyzed using JMP Pro (V12.0). Mean daily values of preference for the perch and non-perch areas and feed consumption in the two areas over each week were compared using Student's t test.

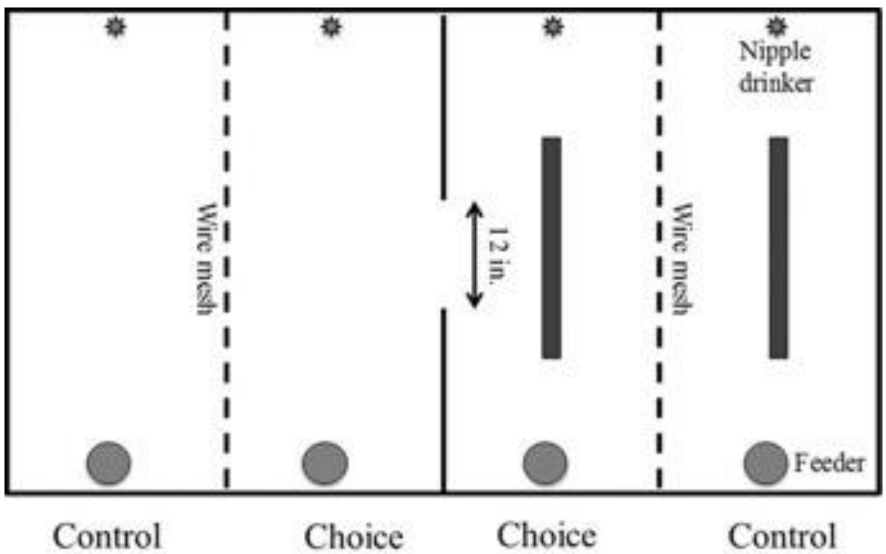

Figure 3.1 Diagram of the perch treatment pens for perch preference.

3.4 Results

3.4.1 Perching activities

In the choice pens with the six birds, the enrichment area included a perch that recorded the interaction of the birds. The average daily perching times in both choice and control pens were presented in Figure 3.2. There was a growing interest in the perch after day 9. After day 35, birds reduced their perching activities. The usage of the perch increased over the first three weeks when the highest perching time occurred during the 3rd week for both pens. The control pen had the higher daily perching time than the choice pen, which could be due to the different stocking densities.

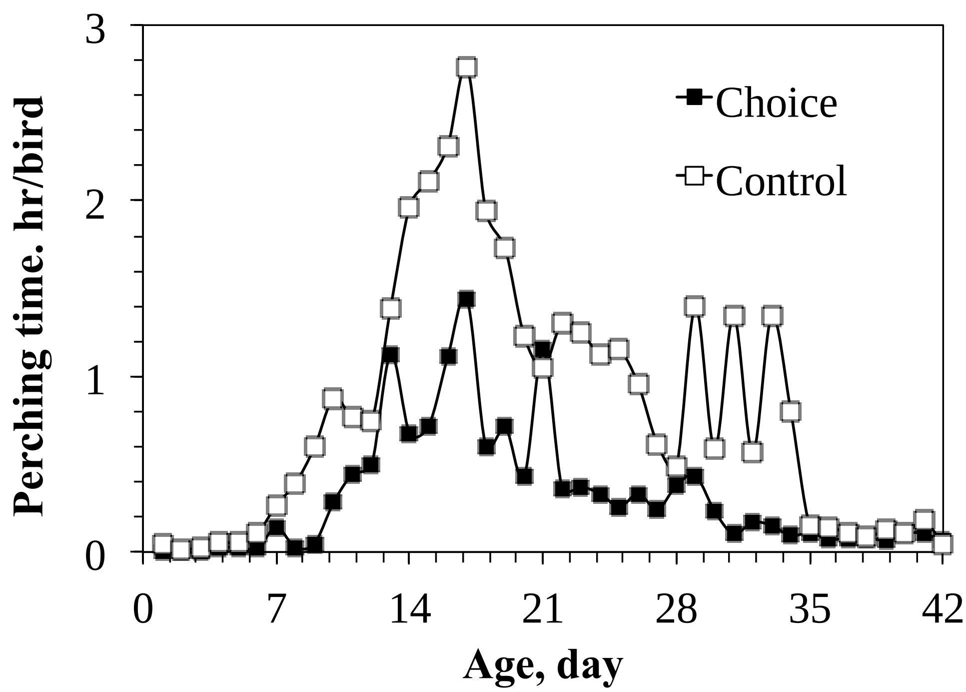

Figure 3.2: Daily total perching time, by hour per bird

The trend in perching time for the two pens shows the birds' motivation for perching decreased significantly with age. Different numbers of birds existed in the perching pens: the choice area featured 6 birds, while the control pen had 4 birds. The control pen had a higher stocking density. The highest perching time occurred during the third week (Table 3.1). The control pen had an average of 1.88 hr/bird while the choice pen showed 0.88 hr/bird. The stocking density in the control pen increased the likelihood of perching and enhanced birds to perch. The choice area, with 33% more space for each bird, showed a reduced perching time when birds were given more choice over space. The highest perching time in the choice pen still happened during the third week. Between the two pens, the choice pen had significantly lower perching time due to the lower stocking density (P< 0.0001).

Table 3.1: The average daily perching times (hr/bird) of choice and control pens.

	Choice	Control
Week	Mean (SE)	Mean (SE)
1	0.03 (0.02)	0.08 (0.03)
2	0.44 (0.14)	0.96 (0.20)
3	0.88 (0.14)	1.88 (0.23)
4	0.33 (0.02)	0.98 (0.12)
5	0.19 (0.05)	0.88 (0.18)
6	0.08 (0.01)	0.11 (0.02)

The average daily step-on showed that the perching activities started as early as day-old and significantly climbed after day 4. The highest step-on took place on day 14 in the control pen and on day 29 in the choice pen. In general, the perching activities occurred throughout the whole flock.

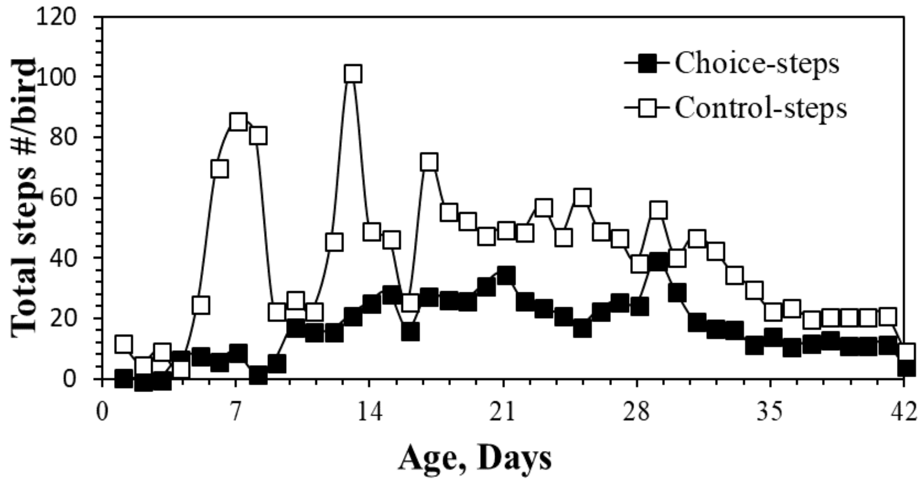

Figure 3.3 Daily average step-on (#/bird) of choice and control pens

The weekly pattern of step-on the perches shows a growing number of step-on for the first 3 weeks (Table 3.2). Both pens had their highest step-on in week 3. The changing step-on could indicate that the first 3 weeks show a growing increase in step-on because birds finally grow large enough to step onto the perch. It was similar to the perching time that the control pen had higher step-on than the choice pen ($P < 0.0001$).

Table 3.2: The average daily step-on of choice and control pens.

	Choice	Control
Week	Mean (SE)	Mean (SE)
1	4.62 (1.52)	30.39 (12.75)
2	15.01 (3.12)	50.25 (11.70)
3	27.56 (2.19)	50.48 (5.28)
4	23.38 (1.16)	50.16 (2.73)
5	21.35 (3.72)	39.52 (4.26)
6	11.00 (1.08)	19.95 (1.74)

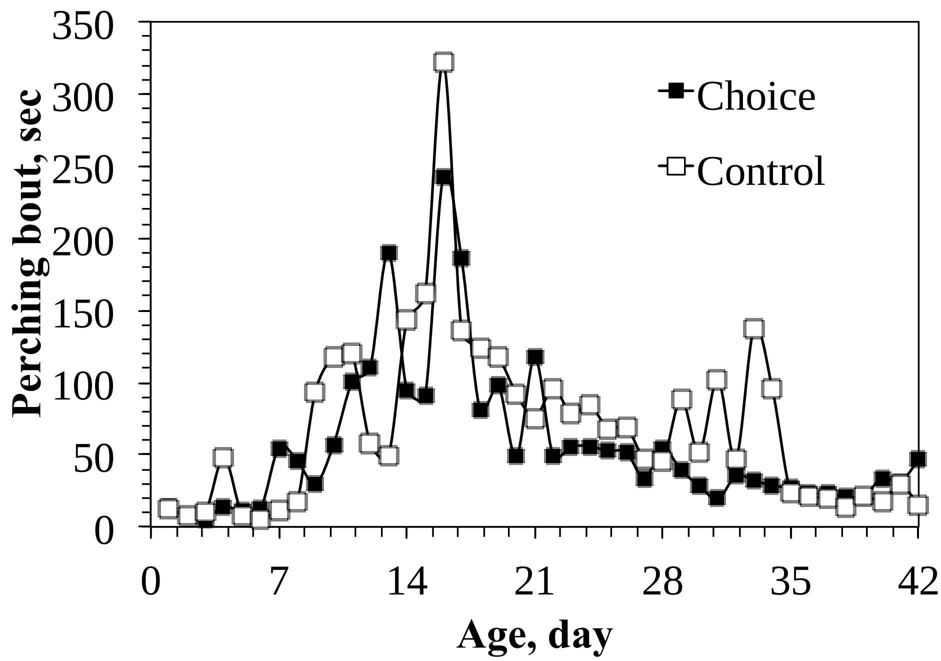

Figure 3.4 Daily perching bout of choice and control pens

The daily perching bouts of the two pens had a same pattern and there was no difference between the two pens on perching bout (P = 0.5). The average bouts were 58 and 59 secs for the choice and control pens, respectively. This indicated that the perching bout was not affected by stocking density although it affected perching-time and step-on in the choice pen with low stocking density.

3.4.2 Area preference

The no perch area (NP) in the choice pen had an open floor while the perch area (P) had a perch in the center. The 6 birds were tracked, and the time of the birds spent and feed consumptions in the two areas were calculated and compared (Figures 3.4 and 3.5). The weekly feed consumptions of the two center pens were compared and no significant difference was found (P = 0.45). The space preference data showed that broilers spent 26% more time (113% vs. 87%) in the pen with perch than that without perch (Table 3). It indicated that the birds equally used the feeders in both areas while they spent more time in the perch area. They might increase their locomotion and activities to the feeder when they sought feed in the non-perch area.

Table 3.3 Effects of perch on space preference and feed consumption

	Perch	Non-Perch	R.S.M.E.	P
Feed consumption, g/week	2,432	2,649	632	0.45
Preference, %	113	87	12	<0.001

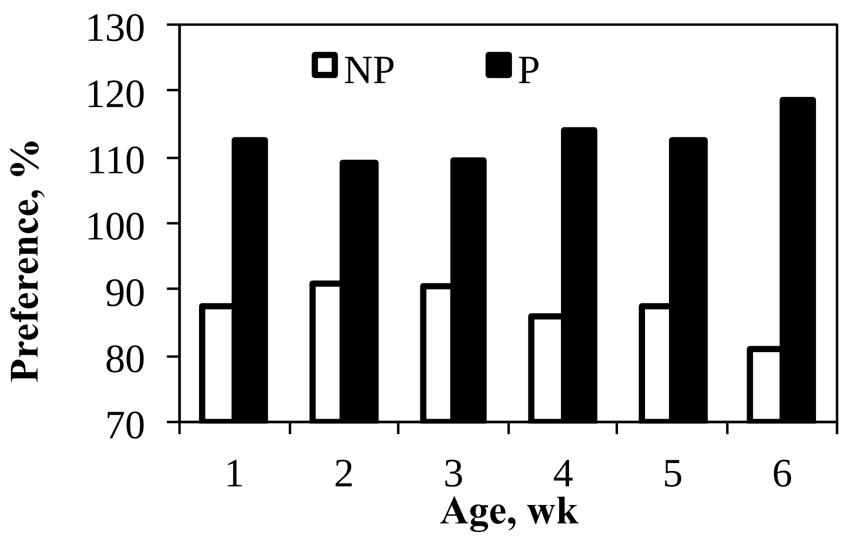

Figure 3.5 Weekly area preference in the two pens with (P) and without perch (NP)

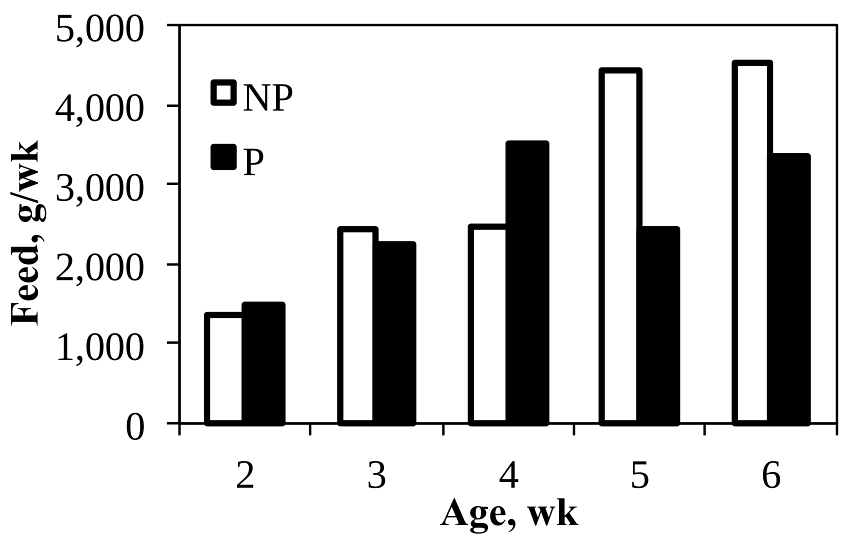

Figure 3.6 Weekly area preference in the two pens with (P) and without perch (NP)

3.5 Discussion

This study was designed to understand the influence of perches on the use of space by broiler chickens. The presence of a perch would result in a change in the distribution of birds within the choice pen. The results show that the presence of a perch increased the use of the area by the birds within the available space. When perches were present, more birds were attracted to the enrichment areas of the pen. This finding agreed with the results obtained from other research that demonstrated how vertical panels in the center area increased dispersion of the birds to the center (Cornetto and Estevez, 2001).

Since all areas were identical and contained no enrichment other than perch, it can be assumed that the perch was the only subject attracting the birds to the area. The consumption of feed in the P area should be higher if it was assumed that the birds used the same time on feeding in the same area. However, the results showed that the

NP area had slightly more feed consumed. The birds would have to travel more to the feeder in the NP area pass the opening from the P area when they spent more time in the P area. Although the birds in the choice pen preferred the P area to rest or perch, limited space around the feeders and drinkers created the competition of obtaining food and water and forced the birds to travel to other areas with these resources.

Boilers activities was motivated by the desire to reach areas with resources, such as food, water, and enrichments. Space for rest and sleep is important to broilers as it is strongly associated with energy conservation and tissue growth (Blokhuis, 1984). Thus, being close to the perch but not putting in the effort to climb the structure may be how the broilers use the structure. The perch is for security and safety rather than its intended purpose to cause activity. Broilers may view the perch enrichment as a resting resource, giving them security in the area similar to grouping near walls in commercial houses.

The grouping behavior of broilers was dependent on social interaction between individuals (Febrer et al., 2013). In this experiment the control areas to the side of the choice pen was divided by a mesh wall allowing birds to see each other, the control birds provided a social attraction for individuals in the NP choice area. Therefore, the bias of grouping behavior on the preference for the perch was minimized by providing the two control pens.

Broiler locomotion and perching decreased with age. The weight of broilers impacted the active behaviors of the birds, the pattern of low activity later in life was related to the increasing bird size and weight, reducing free area to inhabit. But enrichments can turn some of the resting behavior into active behavior. The resting behavior associated with laying down was slightly reduced when enrichments were used for broilers (Bailie et al., 2013). Slightly increasing feeding activities in the NP area showed perch promoted the locomotion activities of the birds, such as walking reducing the resting time as a result. This suggested that perch in commercial houses should be placed away from feeder and water lines to promote locomotion behaviors.

3.6 Conclusions

Boilers activities was motivated by the desire to reach areas with resources, such as food, water, and enrichments. Broilers may view the perch enrichment as a resting resource, giving them security in the area similar to crowding near walls in commercial houses. The motivation to be near a perch was higher than that to be on a perch. Broiler spent more time in the area near a perch and showed a preference for a perch while they traveled more for food and water. The perching activities of broilers was affected by stocking density. Perching time and step-on increased with stocking density while the perch bout remained unchanged.

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Chapter 4

ASSESSMENT OF DIFFERENT PERCH DESIGNS FOR BROILERS UNDER COMMERCIAL CONDITION

4.1 Abstract

Lameness in broilers have become an emerging welfare issue due to the fast growth rate. Research suggested that adding perches could improve leg strength and increase mobility in broilers. However, perching by broilers has been low due to the design of perches. A perch with a certain design may impose physical limitations on broilers and reduce the use of the perch. A properly designed perch can increase perching behaviors. This study was conducted to investigate perch configurations under field conditions with two different stocking densities by measuring perching behaviors. Three perches were designed and evaluated in a research facility. The first perch design was a single perch (Single) with square shape (0.5 in. side length) at 4 in. height from the ground. The second perch design was a double-perch structure (Double) with two perches at 4 in. high, set parallel 8.5 in. apart. The third design was a double-perch structure (Level) with two perches at 4 in. and 6 in. heights, respectively, in parallel 8.5 in. apart. Birds had more perching activities on the Single and Double perches before they reached 35 day of age. The perching activities peaked between 7 to 14 days of age and decreased over time. The results indicated much higher perching activities under higher stocking density. Birds might be forced to use perch more often due to the space competition. There was no difference on the perching activities between the Single and Double designs. Perching activities of birds with high stocking density was three times of those with lower stocking density. Increasing the complexity of perch design may not necessarily increase the motivation of perching and perching activities.

Key words: Perch, Design, Commercial, Stocking density, Broilers

4.2 Introduction

In recent decades, growing concerns over animal welfare have changed the pace of broiler industry. The addition of organic and free-range practices has been implemented to address welfare concerns. There is a concern that birds do not get enough exercise, resulting in poor leg health and losing the ability to walk. Broilers have to be culled due to lameness. Also evidences in houses show that broilers are lacking the ability and space to perform natural behaviors, such as preening, dust-bathing, walking, investigating, and perching.

In organic and some animal-welfare driven certified practices, environmental enrichments were adopted to encourage the natural behaviors, such as perching, although some researchers asserted that the enrichment has not encouraged enough behavioral changes in the flock (Pettit-Riley and Estévez, 2001). Birgul et al. (2012) reported that perch induced active behaviors in birds and could increase leg strength in broilers. The addition of a perching structure would also reduce hock burns and foot dermatitis (Ventura et al., 2010). Other research has shown that the use of perches by broilers was low and did not increase health benefits for birds (Su et al., 2000). Research also investigated ramps and raised platforms with mesh covers and reported some improvement in perching frequency on platforms, walking behaviors did not increase (Faure et al., 1981; Birgul et al., 2012; Bailie et al., 2018).

While these results were not conclusive, perch design needs to be addressed before perches are used under commercial conditions. Determine the fundamental design criteria for perches used under commercial conditions, where the cost of the construction and maintenance of a perch structure should be considered. The objective of this study was to determine broiler perch configurations and understand the perching activities of broiler under field conditions. The finding of this study provided baseline data for perch design.

4.3 Materials and Methods

Three perches were designed and evaluated under field condition in a research facility at the University of Delaware (Figure 4.1). The first perch design was a single 3-ft long perch (Single) with square shape (1.5 in. side length) at 4 in. height. The second perch design was a double-perch structure (Double) with two 3-ft single perches at 4 in. height in parallel 8.5 in apart. The third design was a double-perch structure (Level) with two 3-ft single perches at 4 in. and 6 in. heights, respectively, in parallel 8.5 in. apart.

The research facility had two identical partitions (each measured 37 ft x 57 ft). The two partitions were symmetrical and shared the same end wall and control room. Each partition had insulated drop ceilings, static-pressure controlled box air inlets along the sidewalls, two radiant tube heaters, two 24 in. and two 36 in. diameter fans located at each end of the building. An integrated environmental controller coordinated control of air temperature, ventilation fan and heater operation, and lighting programs. The houses were equipped with foggers for cooling, as needed. East partition was equipped four weight scales, two feed weighing scales, and two water meters. The two partitions were managed separately, but had the same setup, bird genetics and production stage. Each partition used half house brooding (0 to 7 day) with a center brood curtain and divided into two pens with a center fence (Figure 4.2).

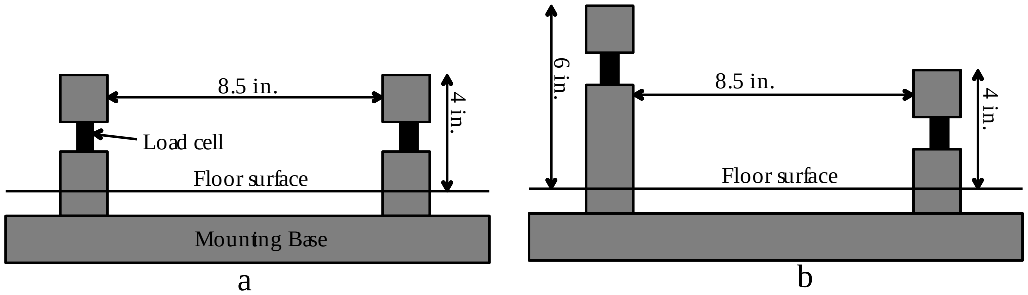

Figure 4.1 Diagram of the perch designs evaluated under field conditions. (a) Double-perch design with two perches at same height; and (b) Level-perch design with two perches at two different heights.

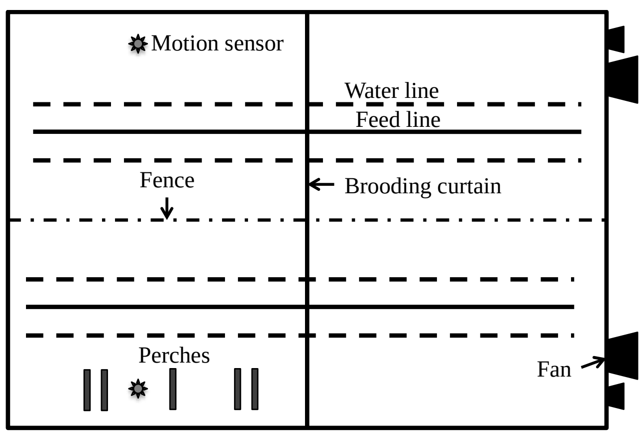

Figure 4.2 Diagram of the perch placement under field conditions.

Each of the three types of perches was installed 7 ft apart and perpendicular to the sidewall (2 ft from the sidewall) in the brooding area of each partition. The locations of the perches were evenly distributed along the sidewall and randomly assigned to the three perches. The perches were having the same micro load cell sensors that were connected to two data acquisition modules and recorded to a PC by a Labview program. The same infrared camera in the Chapters 2 and 3 was mounted 7 ft above each perch to monitor the bird acidities. The video of each camera was recorded continuously. A passive motion sensor (SRN-2000, Visonic, Bloomfield, CT) with a standard lens (NO-100) was mounted horizontally 7 ft above the single perch to detect the bird activities around the single perch. Another motion sensor was mounted at the same location in the non-perch pen (opposite side) to measure the activities of birds without access to perch. The weight changes of perches and motion signals were measured and recorded with a 1-min interval. Two flocks of broilers were raised in the two partitions. The flock 1 had 2,400 straight-run Cobb 500 broilers in each partition over a 7-week grow out and the flock 2 was with 3,500 straight-run Cobb 500 broilers in each partition over a 5-week grow out. The light schedule was set to 23:1 hr. (light: dark) throughout the two grow outs. One-hour dark period was Bird body weight in each partition was determined daily by the bird scales and used to calculate the perching activities of the birds.

Based the daily body weight and weight changes of the perches, the number of the birds on a perch was determined in Eq (1).

$$n = Round(W/Wi) \qquad (1)$$

where n is number of birds on perch; W is change of perch weight, g; and Wi is average body weight at age of i day, g.

Daily perching time (the duration of perching) on each perch was derived by integrating the perching times of all birds in Eq (2).

$$T_i = (\sum_{n=1}^{4} nT_{n,i})/4 \qquad (2)$$

where T_i is daily perching time at age of i day, hr/bird; n is number of birds on perch; and $T_{n,i}$ is total time when n birds on perch at age of i day, hr. Daily perching step-on times (Steps) also was derived when the change of perch weigh increase by one bird body weight. Mean perching bout per step-on (Bout) was calculated in Eq (3).

$$B = T_i / S_i \qquad (3)$$

where *B* is mean perching bout, min; T_i is daily perching time at age of *i* day, min; and S_i is step-on times at age of *i* day.

Bird activity over a 30-min interval was calculated as relative standard deviation (RSD) or coefficient of variance (CV) of the original signal of the motion sensor in Eq (4).

$$A = \sigma / \mu \qquad (4)$$

where *A* is activity; σ is standard deviation of signals, voltage; and μ is mean of signal, voltage. Daily mean bird activity was calculated from the 30-min bird activities over a given 20-hr period.

Data were analyzed using JMP Pro (V12.0). Mean daily values of perching time, step-on time, and activity over each week were compared using Tukey HSD test.

4.4 Results

The perching activities of the three perches were compared base on cumulative perching time and step-on time per linear perching space (m). Figures 4.3 and 4.4 show daily perching time over each week for the two flocks with two stocking densities. Figures 4.5 and 4.6 show daily step-on time over each week for the two flocks with two stocking densities. Birds had more perching activities on the Single and Double 4-in. perch before they reached 35 days of age ($P < 0.001$). The perching activities peaked between 7 to 14 day of age and decreased over the rest grow outs. After 42 day of age, the perching activities on any perch were the lowest. The results indicated much higher perching activities under higher stocking density. Bird might be forced to use perch more often due to the space competition. There was no different on the perching activities between the Single and Double designs (P = 0.33). The perch design also did not affect the perching bout and bird spent similar time on each perch for each bout. Perching activities of birds with high stocking density (1.66 bird/ft^2) was three times of those with lower stocking density (1.13 bird/ft^2) from 14 to 35 days of age. The design of square shape and single perch at 4-in. height would promote the perching activates and boiler welfare. Increasing the complexity of perch design may not necessarily increase the motivation of perching and perching activities. It suggested that a simple single perch would offer a better return by its low cost. Figure 4.7 shows that there were higher locomotion related activities in the area with perch enrichment than those in the non-perch area during the first two weeks. It indicated that perches were attractive to young birds and induced more locomotion of the broilers. The attraction of the perches to birds diminished when birds were older, and the floor space was crowded. Birds may not be able to reach a perch even they have the desire and want to be around the perch due to high-density surround birds.

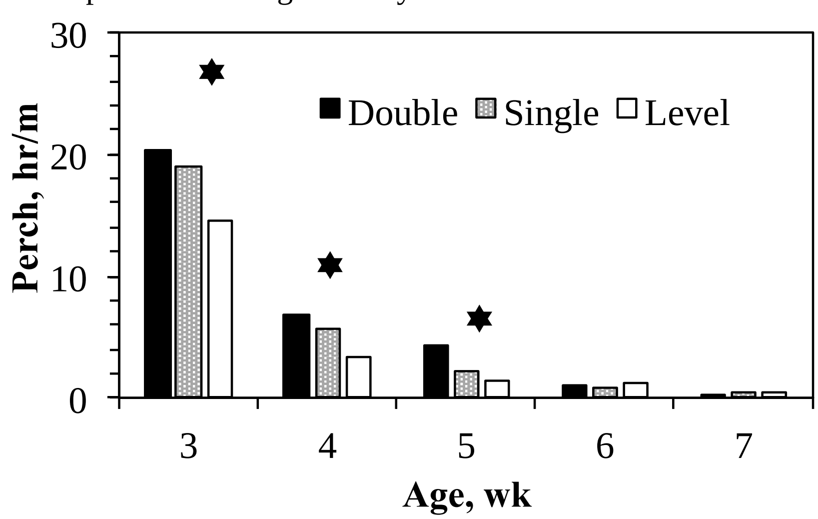

Figure 4.3 Perching time of broilers on three perches during a 7-week grow out (Data for the 7-week grow out over the first two weeks were missing due to system malfunction). * represents significant difference among the three perches at P = 0.05.

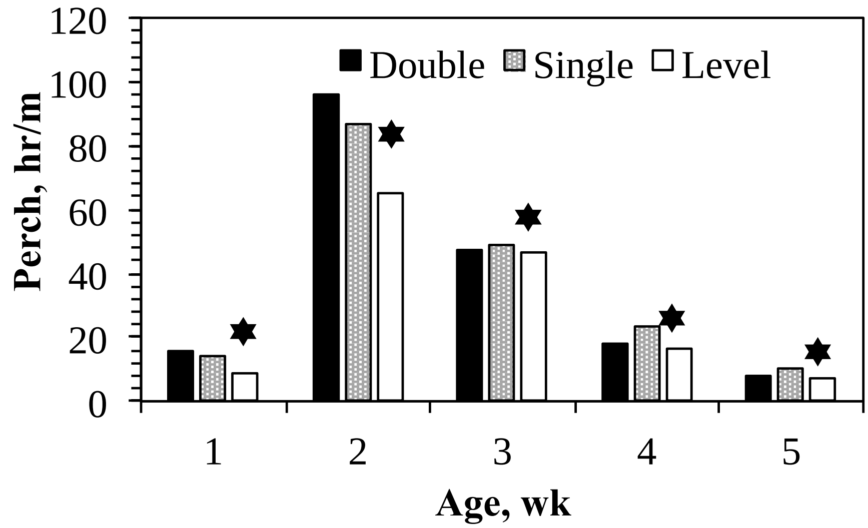

Figure 4.4 Perching time of broilers on three perches during a 5-week grow out. * represents significant difference among the three perches at P = 0.05.

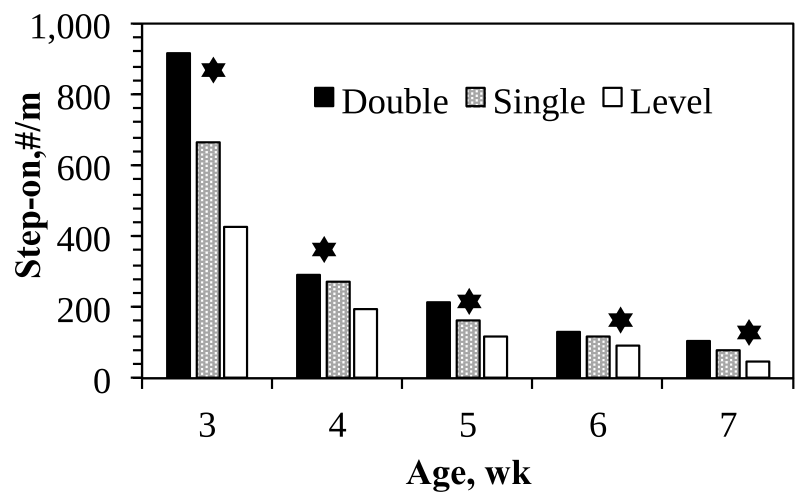

Figure 4.5 Step-on time of broilers on three perches during a 7-week grow out, (Data for the 7-week grow out over the first two weeks were missing due to system malfunction). * represents significant difference among the three perches at P = 0.05.

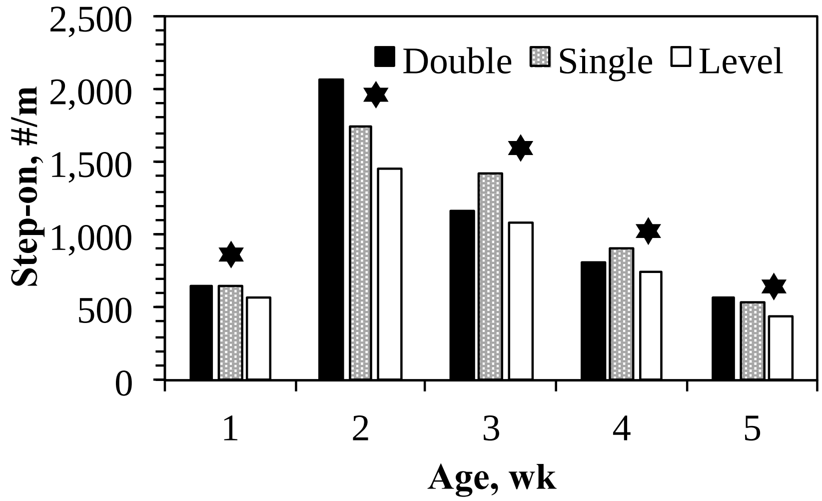

Figure 4.6 Step-on time of broilers on three perches during a 5-week grow out. * represents significant difference among the three perches at P = 0.05.

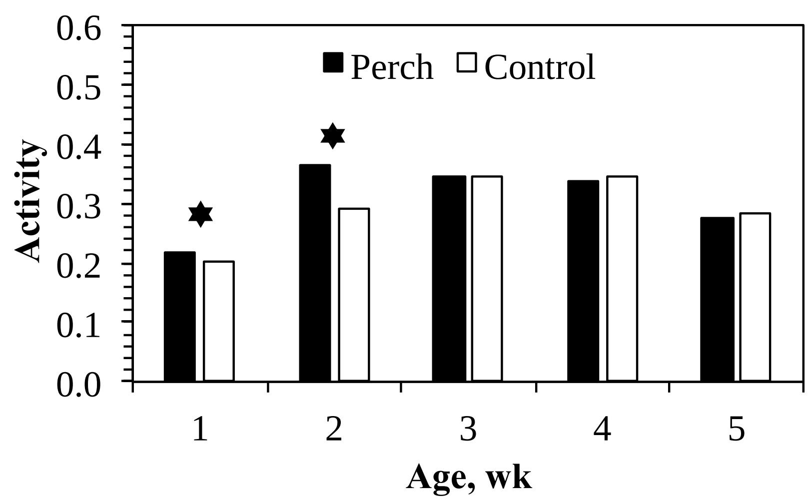

Figure 4.7 Mean daily activity measured by passive motion sensor over the five-week grow out. * represents significant difference among the three perches at P = 0.05

Besides daily perching time, step-on, and bout, the distribution of number of birds perching was also investigated. Due to the different stocking densities, the results of the two flocks of birds were presented separately. The number of perching birds varied with age for all three perch designs.

For the higher stocking density flock with 5-week grow out, the most frequent perching bird number on the Double perch was 6 or more during the 1^{st} and 2^{nd} weeks and its frequencies were 21.8% and 33.2%, respectively. Chicks showed more perching behaviors in a bigger group. When birds were getting older and heavier, the peak perching bird number shifted down towards lower number. By 3^{rd} week, the predominant peak perching bird number was around 3. By the end of the 5-week grow out, more than 60% of the perching activities happened by one single bird. Among the three perch designs, the distribution patterns were similar. The number of birds on perches more evenly distributed when they were 2 weeks of age or younger. When birds were 4 week of age or older, the perching seems more to be an individual behavior.

For the lower stocking density with 7-week grow out, it was clearer that the most frequent perching bird number on the perches decreased regardless the perch design. It directly indicated that perching became an individual behavior among the birds. It also showed that the perching frequency and group perching behavior was affected by stocking density. The most frequent perching bird number deceased from 3 during 1^{st} and 2^{nd} week to 2 during the 3^{rd} week while only one or two birds used perch simultaneously for most of the times after 4^{th} week.

Table 4.1 Distribution of number of perching birds on Double perch during 5-week grow out (n = 2)

Double	1	2	3	4	5	≥6
Week 1	14.7%	16.6%	18.2%	15.6%	13.1%	21.8%[a]
Week 2	2.5%	8.6%	16.0%	19.7%	20.0%	33.2%[a]
Week 3	15.2%	26.6%	27.5%[a]	18.8%	8.8%	3.2%
Week 4	34.2%[a]	23.8%	26.5%	11.2%	3.0%	1.3%
Week 5	60.8%[a]	25.2%	11.7%	1.9%	0.3%	0.0%

Note: [a] Highest % of birds perching for the week recorded ($P < 0.0222$)

Table 4.2 Distribution of number of perching birds on Single perch during 5-week grow out (n = 2)

Single	1	2	3	4	5	≥6
Week 1	19.8%	22.2%[a]	17.5%	15.7%	11.3%	13.5%
Week 2	3.5%	12.9%	19.1%	23.5%[a]	18.4%	22.7%
Week 3	14.0%	26.4%	27.7%[a]	19.9%	8.6%	3.4%
Week 4	29.1%[a]	25.4%	24.0%	15.1%	4.2%	2.1%
Week 5	60.2%[a]	26.6%	10.8%	2.2%	0.2%	0.0%

Note: [a] Highest % of birds perching for the week recorded ($P < 0.021$)

Table 4.3 Distribution of number of perching birds on Level perch during 5-week grow out (n = 2)

Level	1	2	3	4	5	≥6
Week 1	27.0%[a]	21.2%	19.2%	14.1%	12.7%	5.8%
Week 2	6.5%	15.5%	22.9%	23.9%[a]	20.4%	10.8%
Week 3	15.8%	29.3%[a]	29.2%	16.6%	7.5%	1.6%
Week 4	37.4%[a]	23.5%	24.6%	10.7%	2.3%	1.5%
Week 5	70.4%[a]	20.4%	7.9%	1.3%	0.1%	0.0%

Note: [a] Highest % of birds perching for the week recorded ($P < 0.001$)

Table 4.4 Distribution of number of perching birds on Double perch during 5-week grow out (n= 2)

Double	1	2	3	4	5	≥6
Week 3	42.0%[a]	36.0%	16.1%	4.6%	0.8%	0.4%
Week 4	76.9%[a]	20.7%	2.2%	0.2%	0.0%	0.0%
Week 5	85.1%[a]	13.8%	1.1%	0.0%	0.0%	0.0%
Week 6	93.6%[a]	6.4%	0.0%	0.0%	0.0%	0.0%
Week 7	95.7%[a]	4.3%	0.0%	0.0%	0.0%	0.0%

Note: [a] Highest % of birds perching for the week recorded ($P < 0.0001$)

Table 4.5 Distribution of number of perching birds on Single perch during 7-week grow out (n=2)

Single	1	2	3	4	5	≥6
Week 3	43.6%[a]	35.1%	14.7%	5.0%	1.4%	0.2%
Week 4	79.1%[a]	19.1%	1.8%	0.0%	0.0%	0.0%
Week 5	81.8%[a]	17.6%	0.7%	0.0%	0.0%	0.0%
Week 6	97.4%[a]	2.6%	0.0%	0.0%	0.0%	0.0%
Week 7	98.7%[a]	1.3%	0.0%	0.0%	0.0%	0.0%

Note: [a] Highest % of birds perching for the week recorded ($P < 0.0001$)

Table 4.6 Distribution of number of perching birds on Level perch during 7-week grow out (n=2)

Level	1	2	3	4	5	≥6
Week 3	41.8%[a]	31.8%	17.8%	6.2%	1.8%	0.4%
Week 4	84.8%[a]	13.5%	1.7%	0.0%	0.0%	0.0%
Week 5	92.0%[a]	7.8%	0.3%	0.0%	0.0%	0.0%
Week 6	98.6%[a]	1.4%	0.0%	0.0%	0.0%	0.0%
Week 7	100%[a]	0.0%	0.0%	0.0%	0.0%	0.0%

Note: [a] Highest % of birds perching for the week recorded ($P < 0.0001$)

4.5 Discussion

Previous studies indicated that 4-in. perch with a square shape were preferable for broilers, and that they were attracted to perches with simple designs that allows the birds to perch at a comfortable height. The maximum number of birds allowed to be perching on a perch depends the minimum perching space that varies with bird age and size. The minimum perching spaces were 3, 4, 5, 6, 8, and 9 in. for ages of 2, 3, 4, 5, 6, and 7 weeks. After the birds turned 3-weeks old, there was a significant drop in perching activity, which is attributed to the rapid weight gain, less available perching space, and lack of interest. This contradicts a previous study, that reported that more perching happened after 3 weeks on similar type of perch (LeVan et al., 2000; Pettit-Riley and Estevez, 2001; Kiyma et al., 2016). But the other experiments used a different method to measure perching behavior. It may suggest that reducing perching space is not the main reason of lower perching activities when birds are older.

The low perching activities on the Level perch indicates that broilers lost the ability to jump or interest in jumping on higher perches. In contrast, layer hens prefer higher perches as they are conditioned to sit high off the ground as an anti-predatory response (Pickel et al., 2010) and perform comforting behaviors and resting at night on high perches (Schrader et al., 2009). The purpose of perches to broilers after the behavior decrease with age, are to use the perch area as a place of security wherein they can perform preening or resting behaviors. The Double and Single perches recorded a similar perching activity due to the similarity of their designs. The birds distributed themselves on the Double perch by taking over the inner area as a secure place to rest. The lack of jostling disruption in the inner area made it an ideal location for resting activity. If perches are not used as intended, they still provide a functional place in the environment for other natural behaviors.

4.6 Conclusions

Broiler demonstrated different perching activities on the three purposely designed perches under field conditions. Birds had more perching activities on the Single and Double 4 in. perch. There was no difference on the perching activities between the Single and Double designs. The perching activities peaked between 7 to 14 days of age and decreased over the rest of the time. The results also showed much higher perching activities under higher stocking density. Birds might be forced to use perch more often due to the space competition. Increasing the complexity of perch design may not necessarily increase the motivation of perching and perching activities. It suggested that a simple single perch would offer a better return by its low cost.

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Appendix

INSTITUTIONAL ANIMAL CARE AND USE COMMITTEE LETTER

University of Delaware
Institutional Animal Care and Use Committee
Application to Use Animals in Research and Teaching

RECEIVED
JUN 17 2016
IACUC

Title of Protocol: Analyzing the Behavior of Day Old Chicks Under Foam Vaccination Administration Method

AUP Number: 61R-2016-0	**← (4 digits only — if new, leave blank)**

Principal Investigator: Hong Li

Common Name: Broiler chicken

Genus Species: *Gallus gallus domesticus*

Pain Category: ***(please mark one)***

USDA PAIN CATEGORY: *(Note change of categories from previous form)*	
Category	**Description**
☐ B	Breeding or holding where NO research is conducted
☒ C	Procedure involving momentary or no pain or distress
☐ D	Procedure where pain or distress is alleviated by appropriate means (analgesics, tranquilizers, euthanasia etc.)
☐ E	Procedure where pain or distress cannot be alleviated, as this would adversely affect the procedures, results or interpretation

Official Use Only

IACUC Approval Signature: [illegible], DVM

Date of Approval: 7/26/2016