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Evaluating the physical welfare of dogs in commercial breeding facilities in the United States

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EVALUATING THE PHYSICAL WELFARE OF DOGS IN COMMERCIAL BREEDING FACILITIES

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To my family and friends for helping me stay strong. Thank you! Your support has been precious to me.

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ABSTRACT

Hurt, Moriah J. M.S., Purdue University, August 2016. Evaluating the Physical Welfare of Dogs in Commercial Breeding Facilities in the United States. Major Professor: Candace Croney.

Despite high levels of public concern, the state of commercial breeding (CB) dog welfare is largely unknown. Therefore, this study aimed to characterize the physical welfare of dogs in CB facilities and their environment in Indiana. This study specifically aimed 1) to characterize dog foot health in CB facilities as a function of the length of time dogs were housed on a given flooring substrate, 2) to characterize visual dog body cleanliness and visual kennel cleanliness as a function of the flooring substrate, 3) to determine the efficacy of kennel cleaning procedures and 4) to characterize the dog dental and ear health in CB facilities.

With these aims in mind, physical examinations assessing foot, hock and elbow health; periodontal disease (PD) and ear health were performed on 118 dogs at five CB facilities in Odon, Indiana. Indoor flooring types were diamond-shaped coated expanded metal, polypropylene, or concrete. Dogs also had access to concrete outdoor runs and play yards containing natural surfaces. Time housed at the facility and body condition (BCS) were likely to influence foot health. Therefore, additional data collected included length of time housed at the facility and BCS. To characterize kennel and dog body cleanliness, visual cleanliness scores (scale 1-5; 1= clean) were recorded for both. To determine fecal contamination, kennel floors were swabbed after routine cleaning using electrostatic dry cloths, and later cultured for *E. coli*. Breed size and age likely influenced PD, so data was collected for both. PD (scale of 0-4; 0=normal), ear erythema as well as ear debris and excess hair (scale 1-4; 1= normal) were also visually scored.

Because of high variation between facilities and breeds, descriptive statistics were used for analysis and results were stratified by facility.

Most foot health problems observed were minor (e.g. matted foot hair n=50, or minor footpad fissures (cracks) n=6). Severe foot health conditions such as cutaneous lesions (n=6) or cysts (n=2) were rare. There was not a tendency to see increased foot health problems with increased time the dogs were housed at their respective facilities. BCS was ideal for most dogs assessed (3=ideal; mean BCS= 3.2). The most common elbow or hock health problem was alopecia (n=16). Both dogs and kennels were clean, as mean kennel and dog cleanliness scores were 1.2 and 1.0, respectively (1=clean). The percentage of individual kennels that were culture-positive for *E.coli* after routine cleaning ranged from 7% to 31% among facilities. Twenty-nine dogs showed evidence of PD after visual examination, which was more common in smaller sized dogs. Findings also showed that nine dogs examined had ear erythema. Additionally, 28 dogs examined had excess ear debris and 23 dogs had excess hair, which was more common in long haired breeds.

Results suggested that the flooring types assessed were not inherently detrimental to dog foot health, but management practices (e.g. access to multiple surfaces) likely had a large effect. Dogs and kennels were visually clean, indicating that current management procedures (e.g. grooming or cleaning regimen) were effective for maintenance of unsoiled conditions. The range in fecal contamination suggested that the cleaning products and protocols impacted fecal contamination to different degrees regardless of flooring type. Long hair breeds may need more ear care, while smaller sized dogs may require increased dental care. The preventive care likely contributed to the majority of dogs having low dental and ear health concerns. It is also possible that the visual scales missed signs of PD. Future studies should aim to understand the impacts of management on dog health and dog and kennel cleanliness by investigating in locations outside of southern Indiana. Future research should also assess different flooring substrates as a function of dog breed and size using larger sample sizes.

CHAPTER 1. INTRODUCTION

In the United States, there is a demand for purebred dogs for different purposes, such as biomedical research, dog showing or special working uses such as police dogs or service dogs. During the 2015 fiscal year, the United States Department of Agriculture (USDA) reported that 61,101 dogs were used for research purposes in the U.S. (USDA, 2016), most of which were likely purebred dogs. Another source of demand for purebred dogs comes from individuals seeking companions either through pet stores or directly from breeders. The commercial dog breeding industry satisfies a large portion of the purebred dog demand every year. Licensed breeders are defined by the USDA as anyone with at least four unaltered breeding females on their premises (USDA, 2015a) and are monitored by the USDA via unannounced inspections. State definitions also exist for commercial dog breeders, and these may vary between one another and from the USDA definition. For example, the state of Indiana defines a commercial dog breeder as anyone who maintains more than 20 unaltered females of at least 12 months of age (Board of Animal Health [BOAH], 2010) on their premises. In the U.S., there are an estimated 1,780 USDA licensed dog breeders, with 135 of those in the state of Indiana (USDA, 2015b).

Despite the demand for purebred dogs, the commercial breeding (CB) industry has become the subject of contentious public debates. This is partially due to the perceived poor welfare conditions of dogs in CB facilities, which are often described in the media using the derogatory term “puppy mills.” The CB industry is controversial because there is a perceived dog overpopulation issue in the U.S. Therefore, some individuals do not believe that dogs should be bred at all, especially with about four million dogs entering shelters or becoming strays each year (Woolf, 1997) and as many as 55% of those dogs being euthanized (Salman, 1998). Due to euthanasia rates, some groups believe that it is unethical to breed dogs and increase the number of dogs without guaranteed homes (American Humane Association, n.d.), especially with so many homeless dogs already in shelters. However, some experts do not agree that there is a dog overpopulation issue suggesting that the dog overpopulation statistics are improperly estimated and the consumer demand for purebred puppies is incorrectly assumed to be replaceable with shelter dogs (Fennell, 1999; Patronek and Glickman, 1994). The CB industry is also criticized for doing a poor job of self-regulation and being primarily interested in profit instead of dog well-being. Despite licensed breeders being regularly inspected by the USDA, and more frequently inspected if they have a record of compliance failures or if the USDA receives a complaint (USDA, 2014), some activist groups claim (e.g. Humane Society Veterinary Medical Association [HSVMA], 2013) that law enforcement of licensed breeder regulations are ineffective in ensuring that dog welfare is protected. Lastly, there is a lack of transparency about the practices utilized in CB operations resulting in greater suspicion of the CB industry.

This lack of transparency is partially due to the minimal research published on CB facility practices and the state of dog welfare in these facilities. Some research has been done on dogs that were reported, but not confirmed to have been part of the CB industry, such as studies done by McMillan et al. (2011; 2013) that reported on dogs suggested to be former breeding animals or dogs from pet stores. The findings indicated that dogs from CB facilities had more incidences of fear, nervousness, health problems and house soiling compared to matched controls from small hobby breeders (McMillan et al., 2013) or from the general pet population (McMillan et al., 2011). However, little research exists on dogs currently living in CB establishments. This could be due to lack of funding for research in this area, difficulty locating breeders, or reluctance of breeders to participate in research because they are cautious about harassment from activist groups. Such groups claim CB facilities have poor sanitation, dogs with poor physical welfare, minimal veterinary care or a lack of human contact and enrichment (American Society for the Prevention of Cruelty to Animals [ASPCA], n.d.; Humane Society of the United States [HSUS], 2010; HSVMA, 2013). However, there is little research to support these claims.

In the absence of sufficient science, some of the public perceptions have formed the basis of CB industry regulations. For example, few studies concerning the impacts of flooring substrate on dog foot health have been conducted, but some states, including Missouri and Pennsylvania, have outlawed certain flooring surfaces (Missouri Department of Agriculture; Penn State The Dickinson School of Law, 2008). If dogs do not have poor welfare in CB facilities but the public perception is the opposite, then regulations could be passed to address problems that do not exist and can potentially create new issues. Policy makers could be making under-informed decisions because they are being pushed to pass policy, even though current science is not available, forcing them to act without scientific evidence. In order for informed decisions to be made, an understanding of the current state of welfare of dogs in CB facilities is necessary. This is also important because the welfare of dogs in CB facilities affects humans and dogs both inside and outside the CB industry.

Millions of Americans are potentially impacted by the welfare of dogs in CB facilities for health and economic reasons. The physical health status of dogs has the potential to affect those responsible for their care. Zoonotic diseases that can spread from dogs to humans (Stull, 2011) may result in staff that are unable to work due to illness or further spread of diseases to other people and dogs when kennel workers leave the facilities. This is a public health concern for auditors, facility staff, or for animals that go to other facilities, such as when puppies arrive at commercial brokers or pet stores. If breeders sell directly to owners, then anyone receiving a new puppy or retired breeding animal is also at risk for disease. Additionally, animals that leave CB facilities in poor health and then go to other facilities or into homes can cost future owners or the next individual responsible for their care large sums of money and time in order to rehabilitate the animal. Lastly, animals with poor health often exhibit sickness behaviors, such as reduced appetite, water intake, activity level and interest in their environment (Dantzer et al., 2008; Hart, 1988). This prevents dogs from fully meeting the expectations of their new caretakers. For example, dogs that are physically unwell cannot be used for some research purposes, perform as service or working animals (Moore et al., 2001), or fully engage with owners to provide companionship.

The mental well-being of dogs in CB facilities can impact the health of the current and future caretakers. Animals may become distressed in novel situations and may become fearful or have an increased chance of illness (Moberg, 2000; von Borell, 1995). Fear aggression also increases the risk of caretakers, owners or strangers becoming bitten (Yin, 2009) making the behavioral health of dogs in CB facilities a concern, as puppies and retired breeding dogs may end up in homes. Also, dogs that are fearful may attempt to escape or become avoidant of people (Ogata and Dodman, 2011). Escape attempts can be a financial concern in addition to a dog welfare problem as some dogs may show destructive behaviors when attempting to escape that result in damage to property or self-injury (Lindell, 1997). Although dogs may do well living in CB facilities, if they are improperly or under-socialized, they may have difficulty adjusting to life in other environments (i.e. homes). Understanding the well-being of these dogs can benefit dogs and their caretakers. When conclusions are drawn on dog welfare outside the CB environment these conclusions may be inaccurate. For example, it is possible that breeding dogs could experience good welfare states while in CB facilities, but experience poor welfare when moved to a novel environment, such as a home, due to poor socialization to common household stimuli (e.g. vacuum cleaners). Evidence of poor socialization may not manifest as undesirable behavior while in the CB environment; therefore, dogs may not have poor welfare in CB facilities, but this has yet to be studied.

CHAPTER 2. LITERATURE REVIEW

2.1 Animal Welfare

The term ‘welfare’ is often used interchangeably with the term ‘well-being’, but ultimately welfare relates to the animal’s subjective experience of life (Stafford, 2006) and is to be evaluated from the animal’s perspective. Animal welfare has been defined in several different ways. For instance, Broom (1986) emphasized that animal welfare examines the quality of life of an animal by assessing the animal’s state when trying to cope with its environment. Wiepkema and Koolhaas (1992) defined animal welfare as the physical and mental health of an individual indicating it is living in harmony with its environment. There are other definitions, but whether it is the animal’s ‘state’ or its ‘physical and mental health’, which can be said to indicate the animal’s state, both definitions refer to the animal’s experience as a function of trying to adapt to its environment.

One of the earliest descriptions of ideal animal welfare, which has laid the framework for many animal welfare assessments and concepts today, came from the Brambell Report in 1965 (Mench, 1998; Veissier et al., 2008). The Brambell committee was formed in response to public outcry in Britain towards the possible poor welfare conditions of farm animals raised in intensive farming practices. Much of the public outcry came in response to the book *Animal Machines* by Ruth Harrison (1964) who stressed how farming had become primarily about efficiently converting animals into food resulting in what she termed ‘factory farms’. From the Brambell committee came what is now known as the five freedoms for animals. The five freedoms are actually ideal states of the animal that serve as guidelines for caretakers to constantly work towards. These include: 1) freedom from hunger and thirst; 2) freedom from pain, injury or disease; 3) freedom from discomfort; 4) freedom to express normal behaviors; and 5) freedom from distress and fear (Brambell Report, 1965).

Another concept of animal welfare describes the animal's biological functioning (e.g. physical health), affective state (e.g. fearfulness) and natural behavior (e.g. normal eating patterns) (Fraser et al., 1997). These three components of animal welfare encompass many of the ideal states listed in the Brambell report. For example, freedom from injury and disease are encompassed in proper biological functioning. Each of the three components is of equal importance and often overlap. For example, freedom from pain can encompass biological functioning in regards to the physical sensation (nociceptive) of pain, include affective state as pain is something that is perceived by the animal (Broom, 1991) and include natural behavior, as some animals exhibit changes in behavior when experiencing pain. For instance, dogs may display frequent changes in position when in pain (Hansen, 2003). Animal welfare exists on a continuum as well-being can range from very poor to very good (Broom, 2011) and can vary from moment-to-moment. When creating assessments to capture animal welfare, it is also important to understand what welfare science is not so that the appropriate factors are evaluated during assessments. For example, ethics is heavily integrated in the field of animal welfare, but is not part of the scientific assessment.

Ethics is an important part of welfare as it influences an individual's concept of welfare (Rollin, 2015). Unlike science, ethics must be considered when addressing value-based questions such as the acceptability of animal quality of life. Fraser (2008) suggested that two different individuals can look at the same group of animals and draw very different conclusions about the animal's welfare, but still agree on the facts. This is because both individuals may agree on the science, but not the values used to draw their conclusions. This can present a source of confusion for many individuals as the science of animal welfare is often expected to answer ethical questions (Broom, 1988), which is not possible. Some other terms and factors that may affect welfare, but are not the same as animal welfare science, are concepts such as animal protection or naturalness (Broom, 2011) and the treatment an animal receives. Treatment is covered by other terms such as animal care or husbandry (World Organisation for Animal Health [OIE], 2016). It is important to understand the complexity of animal welfare science and its components so that proper welfare assessments can be made. To assess welfare, both the psychological and physical state of the individual animal must be considered (Gonyou, 1986), while understanding the animal's nature (e.g. tendencies of prey animals versus predators).

2.1.1 Animal Nature and its Implications for Assessing Dog Welfare

Rollin (2007) argues that each animal has its own genetically encoded nature (telos) that is an important part of animal welfare as it influences how an animal may perceive its environment. Providing physical needs for dogs is largely accomplished by understanding nutrition, biological processes and treating various diseases. However, the natural behavior of dogs can sometimes be compromised in human care, such as when they are left alone without social interaction for long periods of time despite being a social species (Stafford, 2006). This can cause some dogs to develop separation anxiety and other attachment related issues (Lund and Jørgensen, 1999). The affective state of dogs can also be compromised as they are largely at the mercy of human caregivers who can impose experiences that result in undesirable mental states, such as fear during unexpected events (e.g. being surrendered to an animal shelter (Hennessy et al., 1997). When caretakers socially isolate animals motivated to live in groups or deprive highly intelligent animals of mental stimulation, undesirable mental states may result. In fact, Dawkins (1990; 2004), who stated that animal welfare can be assessed by determining if the animal was healthy and had what it wanted. The latter portion of this statement alludes to the notion that animals that want to perform a behavior and are thwarted can experience compromised welfare. This can impact an animal's affective state in a given environment (Mendl et al., 2010).

Emotions that arise in response to an environment that does not meet the animal's needs or motivations can lead to mental states such as frustration, boredom or fear (Dreschel, 2010; Jakovcevic et al., 2013; Wemelsfelder, 2005). Dogs are social animals that live in groups to varying degrees when unowned (Bonanni & Cafazzo, 2014) and have lived in proximity to humans since around 14-35,000 BP (before present) (Clutton-Brock, 1995; Bonanni & Cafazzo, 2014; Savolainen et al., 2002) and have co-evolved with humans. Once human attachments were formed, dogs left in unfamiliar rooms without their owner sought contact with their human companions (Topál et al., 1998) as it was in their nature to be with humans. Hennessey et al., (1997) found that in dogs entering an animal shelter where high levels of stress were common, plasma cortisol levels, as an indication of stress, were lower in dogs provided human contact compared to controls. In a study by Barrera et al. (2010), shelter dogs were found to remain in closer proximity to a stranger compared to pet dogs despite showing more fear and appeasement behaviors. This indicates the strong desire many dogs have to be with humans even in situations where there are high levels of stress or human contact is limited (i.e. confinement). Thwarting dogs' social needs may lead to negative affective states manifesting as undesirable behaviors, and ultimately compromising dog welfare.

As the welfare of animals comes to the forefront of public and scientific concern, it becomes increasingly important to be able to measure welfare appropriately. Welfare is a dynamic state and constantly changes with the animal's internal and external environment. Assessments of welfare are further complicated when considering animals in a group, as each animal can perceive the same macro-environment differently, as well as the micro environmental factors such as social hierarchy, which differ for each animal. This intra-group variation has presented an interesting challenge to animal welfare scientists, who are increasingly asked to assess welfare on a group or farm level (Fraser, 2003). While assessment of animal welfare in the field is common in livestock species (e.g. Welfare Quality® 2009), it is less common, but increasingly important, in companion animals. Practical welfare assessment tools are needed for kennel environments (e.g. Barnard et al., 2014) as dogs are also kept in large groups such as shelters, research facilities, boarding kennels and CB facilities. Therefore, when assessing the welfare of dogs in CB facilities, addressing welfare at the group level is equally as important as at the individual level.

2.2 Metrics of Welfare

There is no single metric that can be used to measure animal welfare. This is not surprising considering the different components of welfare (i.e. biological functioning, natural behavior and affective state). Currently, science cannot directly measure affective state in most species because, unlike humans, animals cannot self-report. Instead, behavior and physical measures are used to indirectly indicate affective state (Dawkins, 2004; Gonyou, 1986). For example, 75.6% of dogs exhibited tucked tails when experiencing fear on the examination table at a veterinary clinic (Döring et al., 2009). This shows a change in behavior, but additionally indicates the dog's affective state (i.e. fear). When measuring welfare, investigators are often looking for signs of stress. Stress is defined as any threat to homeostasis (Mills and Marchant-Forde, 2010) and is divided into two categories. The first category is eustress, normally referred to as positive stress, and can occur during play or mating behavior (Mills and Marchant-Forde, 2010). The second category is distress, normally referred to as negative stress, and can occur during physical discomfort (Mills and Marchant-Forde, 2010; Ridner, 2004). Stress can also be either acute (temporary) or chronic (prolonged) (Moberg et al., 2000), which can affect the animal's response to the stressor. Many welfare assessments tend to focus on distress, but identifying signs of eustress can be equally as important, especially when establishing practices that promote good welfare. Assessments usually gauge animals' stress levels through physical or behavioral metrics.

2.2.1 Physical Metrics

Physical metrics refer to internal or external changes that occur in the body as it attempts to cope with environmental challenges. This encompasses physical damage (e.g. injury) or physiological activity (e.g. hypothalamic-pituitary-adrenal (HPA) axis activity or growth). Physical metrics such as injury or disease are readily accepted as a means to interpret poor welfare as they result in an immediate threat to homeostasis (e.g. blood loss from injuries), but also cause suffering. However, other physical metrics such as cortisol levels, catecholamines, increased disease rate, or decreased growth can also indicate poor welfare. Interpretation of some physiologic metrics can be more difficult because they can occur both in situations of eustress (e.g. mating) or distress (e.g. being threatened) (Broom and Fraser, 2007). When physical metrics are ambiguous, behavioral metrics can often provide clarity.

Every physiological metric available may not be appropriate for every species, however some metrics are fairly conserved. Changes in an animal's hypothalamic-pituitary-adrenal (HPA) axis, sympathetic adrenal medullary (SAM) system, immune function, decreased reproduction or growth can all indicate poor welfare.

Hypothalamic Pituitary Adrenal (HPA) Axis

Hormones indicative of HPA activity are frequently used to measure distress. The major events of the HPA axis when a stressor is perceived, are the release of corticotropin-releasing hormone (CRH) and vasopressin (VP) from the hypothalamus to the anterior pituitary, which releases adrenocorticotropic hormone (ACTH) to the adrenal cortex where glucocorticoids are released into the blood stream (Matteri et al., 2000). In primates, Carnivora, Ungulata, some fish and other animals, cortisol is the glucocorticoid produced (Broom and Fraser, 2007; Wasser et al., 2000). Cortisol can be measured using plasma, saliva, urine (i.e. cortisol: creatinine ratios), feces or hair (Beerda et al., 1996; Davenport et al., 2006; Rehbinder and Hau, 2005; Schatz and Palme, 2001) depending on the type of information of interest. For example, plasma or salivary cortisol may indicate a stress response to specific events whereas naturally voided fecal or urinary cortisol may reflect general stress levels over the course of a several hours to a day due to collection time (Schatz and Palme, 2001; Vincent and Michell, 1992). Increased cortisol concentrations have been observed during situations known to be stressful such as restraint, introduction to a novel environment or for some species, social isolation (Hennessy et al., 1997; Minton and Blecha, 1990). Another system that also activates during distress is the sympathetic adrenal medullary (SAM) system.

Sympathetic Adrenal Medullary (SAM) System

During a stress response, the SAM system, part of the autonomic nervous system, is responsible for the release of catecholamines from the adrenal medulla, which impacts various tissues and organs to manifest some of the commonly known features of the stress response, such as increased heart rate or blood pressure (Moberg, 2000). Some of the hormones that are part of the SAM system are also used to measure stress much like hormones of the HPA axis. During a stress response, the body switches to sympathetic from parasympathetic activation (Gaines, *dissertation*, 2008) indicated by various hormonal changes. For example, catecholamines like epinephrine (adrenaline), norepinephrine (noradrenaline) and dopamine are released from the adrenal medulla as hormones (Matteri et al., 2000) and epinephrine and norepinephrine can also be released as neurotransmitters (Maule and VanderKooi, 1999) during stress. The stressor and the individual can influence the ratio of sympathetic to parasympathetic activation that occur, but generally increased sympathetic activity causes affects such as increased heart rate and blood pressure (Abelson et al., 1996; Fell et al., 1985). Because of the varying degrees of activation between sympathetic and parasympathetic systems, increased heart rate or heart rate variability can also be an indication of SAM activity (von Borell et al., 2007; Zupan et al., 2016). For example, in dogs heart rate has been noted to increase in response to startling stimuli (Beerda et al., 1998) and there was more heart rate variability in lame dairy cattle than sound cattle (Kovács et al., 2015). Changes in heart rate, blood pressure, or catecholamine concentrations can indicate SAM activity during distress. However, immune system function can also change during challenges to homeostasis.

Immunocompetence

Some of the observed responses of the immune system towards distress are secondary effects from other systems (i.e. the HPA axis), but the immune system can also initiate responses as well (Blecha, 2000). During stress the body can become either immunocompromised or hyper-reactive resulting in increased disease incidence especially if stress is prolonged. The increased disease incidence may be due to suppressive effects of glucocorticoids on various immune functions during the stress responses (Roth and Kaeberle, 1982). For example, cattle are known to be more susceptible to bovine respiratory disease after transport stress (Blecha, 2000) and a study looking at feeder calves transported long distances showed an increased risk for leukocytosis (Blecha et al., 1984). Other factors such as current immunity may also contribute toward disease, but distress (e.g. from transport) may also cause higher disease rates in animals (Roth and Kaeberle, 1982).

Another immune response to stress is changes in cytokine production resulting in increased inflammatory response (Raison et al., 2006). Although inflammatory responses were not measured, medical students experiencing psychological distress from an upcoming exam had higher levels of T-helper 2 cytokines, responsible for humoral immunity, compared to after the exam (Marshall et al., 1998). Metrics such as increased disease incidence may be useful outside of laboratory settings for CB facility owners or anyone assessing dog welfare. Other impacts of distress include changes in the reproductive system.

Reproduction

Distress can also produce changes in the reproductive system, which is typically inhibited as reproduction has a lower priority when homeostasis is threatened in most animals (Fuzzen et al., 2011; Uphouse, 2011). This occurs primarily as a result of the interaction between the HPA and hypothalamic pituitary gonadal (HPG) axis. Gonadotropin-releasing hormone (GnRH) from the hypothalamus is a major hormone that controls the release of lutenizing hormone (LH) and follicle stimulating hormone (FSH) (Ferin, 1993), which impact ovulation cycles, gametogenesis and steroid hormone release (Uphouse, 2011). In rats, GnRH shows decreased levels during distress consequently reducing levels of plasma LH and FSH (López-Calderón et al., 1991). This could cause a decrease in reproductive ability manifesting as delays in ovulation (Abbott, 1984) spermatogenesis, or decreased testosterone levels (Johnson et al., 1992; Semple et al., 1987). Psychological distress can also decrease the animal's willingness to mate and manifest as a decrease in reproductive success (Uphouse, 2011). For instance, males subjected to psychological distress, such as social or combat distress, may have lower testosterone levels, which can lead to decreased libido or fertility if prolonged (McGrady, 1984; Sapolsky, 1994). Acute distress may not have lasting effects on the reproduction system, but chronic stress could result in decreased reproductive success and/or ability in some animals. However, for some animals that are not mature enough to breed or that are sterile (e.g. companion animals) other welfare metrics must be considered.

Growth

A final indication of distress is decreased growth rate. This may be more notable in younger animals that are not growing and developing as expected, but adult animals may have decreased average daily gain or lose weight when distressed. This is due to nutrient and energy reserves being diverted to other systems and an increase in anorexia while distressed (Elsasser et al., 2000; Gregory, 2004). During distress, animals experience decreased fat accumulation, cartilage production and bone elongation (Elsasser et al., 2000; Moberg, 2000). An extreme case can be seen in some children that are victims of abuse that show delayed growth, referred to as psychological dwarfism (Skuse, 1989). Metrics such as increased weight loss or decreased growth and development, can prove useful when measuring distress over time.

Physical metrics provide an objective way to measure animal welfare and several metrics may manifest at once due to interactions between body systems. For instance, the immune system can also activate or influence the HPA axis (Maule and VanderKooi, 1999). However, some physical metrics can be misinterpreted. Elevated cortisol levels can be observed in situations of both distress and eustress. For example, exercise, mating and excitement can all result in increased cortisol (Yeates and Main, 2008). Disease is a good indicator of distress, but it is not always a result of psychological distress. It could also be due to increased challenge to the immune system from the environment or decreased natural immunity. An increase in disease incidence could also affect growth and reproduction, which can additionally be affected by a number of other physical metrics, and not necessarily a result of mental distress, but still a sign of poor welfare. Other factors such as genetics play a role in growth and development and there may not be any compromise to welfare if animals are not growing as expected. For these reasons physical metrics can be misinterpreted, but sometimes pairing them with behavioral welfare metrics can provide clarity.

Behavioral indicators or poor welfare can help interpret an animal's welfare by providing a more holistic picture. For example, a dog with elevated cortisol levels and displaying signs of fear such as low body posture or aggression is likely experiencing poor welfare, while a dog that has elevated cortisol levels and is displaying play bows or willingly exercising likely has good welfare. Therefore, both physical and behavioral metrics can better indicate the animal's state of welfare.

2.2.2 Behavioral Metrics

Assessing animal behavior goes beyond observing its presence, but includes the behavior's frequency and duration (Broom and Fraser, 2007). When assessing behavior, observing (or not observing) sickness, pain, fear, stereotypic (see Lawrence and Rushen, 1993 for more detail) or other abnormal behaviors (Broom and Fraser, 2007; Dawkins, 1990; Hellebrekers, 2000; Stephen and Ledger, 2005) can all indicate the animal's state of welfare. However, behavior metrics can be ambiguous; therefore, multiple behavioral metrics, physical metrics and environmental contexts can all provide a clearer interpretation of animal well-being.

Sickness behaviors

Sickness behaviors are a group of adaptive behaviors that occur in response to illness to promote survival by conserving the body's resources (Dantzer et al., 2008), and can provide valuable insight on animal welfare. These behaviors are fairly conserved across species and can manifest in response to either infection or psychological distress (Aubert, 1999; Dantzer et al., 2008; Hart, 1988; Hennessy et al., 2001). For example, dogs may appear lethargic when experiencing high levels of fear or from contracting influenza (American Veterinary Medical Association [AVMA], 2016; Yin, 2009). Some of the most common sickness behaviors are decreased food and water consumption, activity and concentration or memory (Aubert, 1999; Broom, 2006; Hart, 1988; Gregory, 2004). Changes in activity, appetite, and attention can be signs of physical or psychological distress in addition to behaviors that indicate pain in animals.

Pain Behavior

Animals may alter their behavior when they perceive pain. The type of behavior, its intensity and duration can vary between animals because pain is an individual experience (Hardie, 2000). Common behavioral signs of pain are favoring injured areas, increased attention towards the area (i.e. licking or pawing), aggression, limb retraction, attempt to create distance between the animal and the painful stimulus, changes in normal behavior patterns, or changes in position (Camps et al., 2012; Epstein et al., 2015; Gregory, 2004; Hansen, 2003; Hardie, 2000). For instance, cattle that experienced freeze branding or hot-iron branding showed more tail-flicking and kicking behavior than controls (Lay et al., 1992; Schwartzkopf-Genswein et al., 1997). During these procedures animals are normally restrained; therefore, kicking could be an attempt to create some distance between the animal and the source of pain, but increases in both tail flicking and kicking are changes in normal behavior. Each species may show different behaviors when experiencing pain. For example, prey species are more adapted to concealing pain as revealing ill-health to predators could make them a target (Hansen, 2003). Signs of pain are an indication of compromised physical and/or psychological welfare as the physical sensation by the nervous system (nociceptive) and the perception by the animal both influence how the animal responds (Epstein et al., 2015). Perception is key to every source of distress particularly when fear or anxiety is involved.

Fear or anxious behavior

Mental states of fear or anxiety activate the HPA axis and the SAM system, as both are responses of worry or dread, with fear being in response to specific stimuli and anxiety being more non-specific (Gregory, 2004). How an individual responds to stress can depend on the source of stress and if the individual has a proactive or reactive coping style (i.e. method of handling stress). An example of fear behavior has been observed in pigs 20 weeks of age that were aversively handled (i.e. briefly slapping or shocking if the pig came in close proximity to the experimenter), which showed more avoidance behavior compared to pigs subjected to pleasant handling (i.e. briefly petting when pigs came in close to the experimenter) (Hemsworth and Barnett, 1991). In this study animals showed avoidance in response to fear, but other animals could show aggression (Gregory, 2004; Yin, 2009). Behavioral indications of fear can be towards specific stimuli (e.g. people, sounds, objects or another animal) or towards the environment (e.g. novel rooms or facilities), while anxiety can be in anticipation of a potential stimulus (Boissy, 1998) that does not exist, but both can compromise welfare.

Stereotypies

A common category of behaviors that are often linked to poor welfare are stereotypies, which are repeated unvarying behaviors that serve no obvious function (Hubrecht, 1995; Broom, 1988). Examples include, swaying in elephants, pacing in polar bears, circling in dogs or sham chewing in pigs (Haspeslagh et al., 2013; Hubrecht, 1995; Terlouw et al., 1991; Wechsler, 1991). They typically develop as a coping mechanism for an environment that does not meet the animal's needs in some way (Hubrecht, 1995). Stereotypies can become life-long behaviors that may show little sign of decreasing after development regardless of the environment. Therefore, stereotypies can develop as a means to cope with a poor environment and still manifest in a more sufficient environment. Since stereotypies develop as a coping mechanism they can act as a way to calm the animal. Danzter and Mormede (1983) found that pigs prevented from stereotypic chain pulling had higher corticosteroid levels compared to pigs allowed to engage in chain pulling. Preventing an animal from performing stereotypic behavior can cause distress, but some behaviors can conversely cause injury to the animal, such as uneven foot wear from swaying in elephants (Veasy, 2006). Thus, stereotypies are good signals of where more investigation is required, and may be associated with poor welfare.

Abnormal behavior

Lastly, abnormal behavior can encompass novel behaviors or changes in the frequency, duration or intensity of normal behaviors. For example, drinking is a normal maintenance behavior that most animals must do to survive; however, some animals display polydipsia (excessive consumption of water) in response to distress (Casey, 2002). Grooming is also a normal behavior, but some animals that excessively groom can develop lick granulomas (Stein et al., 1994) or alopecia. Some animals may begin to self-mutilate during prolong distressed such as feather plucking observed in birds that have been separated from a human attachment for variable amounts of time(Jayson et al., 2014). The development of abnormal behaviors can indicate that the environment is not sufficient to maintain animal well-being. However, witnessing one abnormal behavior may not be enough to draw conclusions about animal welfare.

Behavioral metrics, like physical metrics, can be misinterpreted if taken alone. Observing other factors like the context and the environmental situation can provide insight to the causes of behavioral changes and what they may mean. Behavioral metrics are further complicated by the fact that one behavior may hold different meaning for an animal's welfare depending on the situation. For example, an animal with decreased activity levels could be psychologically distressed, suffering from an illness or just beginning to show signs of aging (Bush, 1993; Gregory, 2004). Therefore, it is important to establish a relative normal for each animal (Bayne, 2012). In this case, physical metrics could parse out any illness or injury and potentially shed light on signs of psychological distress, while considering the individual and the context could help deduce if the decreased activity is from age. Collecting multiple behavioral and physical metrics, and recording the context can help determine the state of an animal's welfare and provide robust animal welfare assessments.

2.3 Welfare Concepts as Applied to Dogs

Some metrics for welfare cannot be utilized in dogs. For example, decreased reproductive success may not be a good welfare metric for most dogs in the U.S., as many are sterile and few dog breeds may be unable to breed successfully on their own due to breed conformation or health issues (e.g. English Bulldogs) (Rooney, 2009).

There are some exceptions such as breeding dogs, but in general reproductive success may not be a useful welfare metric for many dogs. Additionally, the absence of grooming behavior may not be a good indicator of welfare as some dogs may not groom regularly. Good welfare indicators for dogs include positive welfare metrics such as the presence of good health, hormone (e.g. oxytocin) levels, HPA axis activation, normal behavior and pro-social behavior. Indicators of negative welfare can include HPA axis and SAM system activation, compromised immune system, pain or sickness behaviors, appeasement behaviors, fear behaviors, behaviors indicative of low mental stimulation and abnormal or repetitive behavior. Welfare metrics for dogs include many of the welfare metrics previously mentioned for measuring welfare for animals in general. However, each species has its own unique considerations. Additionally, capturing both positive and negative signs of welfare for dogs is important, as practices that promote positive welfare can be continued and practices that do not can be altered or discontinued.

2.3.1 Indicators of Positive Well-beng in Dogs

Indicators of good welfare can be indicators of good physical health, hormones associated with positive affect, HPA axis activation, normal behavior and pro-social behavior. Ideal health, such as good body condition, the absence of illness or proper coat condition can all indicate the animal is free from hunger, thirst, disease, discomfort or pain. These signs may not attest to the mental state of dogs, but they do give a good indication of the biological functioning of the dog. Also, elevations in hormones indicative of positive mental states such as oxytocin can point towards positive emotions (Handlin et al., 2012). Oxytocin is released during offspring-maternal bonding or during physical contact (see Carter, 1998 review). Social contact with humans, may be important for some dogs as centuries of co-evolution have likely lead to dogs viewing humans as important attachments. In fact, dogs and their owners that participated in a three minute petting session, showed both increased oxytocin levels and decreased heart rate (Handlin et al., 2012). Increased oxytocin levels can indicate good welfare as it can occur during positive experiences in dogs such as social interaction.

HPA axis activation can also happen during states of eustress as it is likely an indicator of arousal and not necessarily valence (Yeates and Main, 2008). Additionally, during physical activity other indicators that could be related to distress such as increases in heart rate, respiration rate and blood pressure can occur during eustress. If dogs desire to perform any type of activity such as play or exercise, increases in HPA axis activation (e.g. increased cortisol) can be signs of positive welfare (Broom and Fraser, 2007; Moberg, 2000). However, lower cortisol levels can also indicate positive welfare. In a study, after at least 30 minutes of exercise and human interaction dogs had significantly lower salivary cortisol concentrations compared to a control group with minimal interaction (Menor-Campos et al., 2011). Other studies have shown lower cortisol levels with the addition of human contact (Hennessey et al., 2002; Shiverdecker et al., 2013). This suggests that human interaction, a known valuable resource to dogs, may cause positive or more relaxed mental states resulting in lower cortisol levels. Overall, the context of behavior combined with elevated or depressed HPA activation can be used to indicate positive welfare.

There are several behavior signals of positive well-being in dogs. Normal behavior (e.g. regular elimination and food consumption) is a sign of at least fair well-being in many animals and dogs are no exception. However, pro-social and other behaviors such as relaxed body posture and facial expression (ears to the side or forward if anticipating a positive event), taking food when offered, playing, positively approaching people, soliciting attention or leaning against a caretaker (Boissy et al., 2007; Yin, 2009) can indicate a positive emotional state in dogs. When considering dog welfare, indications of positive well-being are just as important as signs of poor well-being. Some hormonal signals (while considering the context) such as oxytocin, cortisol, or catecholamines can be indicators of positive welfare. Some behavioral signs that appear only after basic needs have been met such as play can also be indicators of good welfare. Identifying positive welfare can also provide a reference point when looking for signs of poor welfare.

2.3.2 Indicators of Poor Dog Welfare

Physical metrics such as injury and disease are relatively universal across species, but collection methods for metrics such as hormonal levels may differ between species. Glucocorticoids are commonly used to indicate HPA axis activation across species (Beerda et al., 1997). Cortisol has been collected from dogs using plasma, feces, urine and saliva (Beerda et al., 1996; Schatz and Palme, 2001; Stephen and Ledger, 2006; Vincent and Michell, 1992), but the method used depends on the type of information of interest. Also, more invasive metrics like plasma cortisol can further complicate readings as measurements collected may be in response to the sample collection technique instead of or in addition to the stressor. In dogs, cortisol is mainly excreted in the urine likely making urinary cortisol a more useful metric in dogs compared to fecal cortisol (Schatz and Palme, 2001). Additionally, Beerda et al. (1999b) found salivary and urinary cortisol to be good indicators of chronic stress in Beagles subjected to social and spatial restriction, which showed higher cortisol: creatinine ratios compared to when they were group housed in outdoor yards. HPA activation is a good indicator of welfare in dogs, as in other species, but depending on the goal different methods of measurement may be more useful.

Measurements of SAM activity and the immune system are also used, especially in response to acute stressors (Beerda et al., 1997). SAM activity may lead to elevated catecholamines (e.g. epinephrine), which may then cause cardiovascular changes (Beerda et al., 1997). Chronic distress has also been known to decrease immunocompetence (Roth and Kaeberle, 1982), which may lead to increased disease incidences due to decreased ability to fight off infection. Dogs with increased fear or anxiety towards strangers were found to have shorter lifespans compared to dogs without fear or anxiety towards strangers (Dreschel, 2010). Dogs with separation anxiety and non-social fears were found to have increased severity and frequency of skin disorders (Dreschel, 2010). This indicates that states of heightened distress can not only compromise mental health, but also physical health. Overall, dogs with poor welfare may experience changes in the HPA axis and SAM system activation and immunocompetence, but these changes may differ during acute and chronic stress and can be used in addition to signs of injury or disease.

As in other species, dogs display behaviors indicative of pain or sickness that can be utilized by caretakers to assess welfare. Behaviors such as rate of position changes, adopting new postures, limb retraction upon touch, aggressive reactions upon touch or vocalizations (i.e. yelping) can all indicate pain (Camps et al., 2012; Epstein et al., 2015; Gregory, 2004; Hansen, 2003; Hardie, 2000). For example, dogs with osteoarthritis were reported by owners to have difficulty moving (Rialland et al., 2013). Indications of disease may be simply noticing a change in the dog's normal activity such as lethargy, mood changes or decreased appetite (Gregory, 2004). These behaviors can indicate that the dog's physical state is affecting its natural behavior and affective state and compromising its welfare. However, properly assessing dog behavior is necessary to understand when welfare is compromised.

Dog behavior, in addition to physical metrics, is important when assessing dog well-being, but understanding how dogs signal is necessary for accurate assessment. Dogs communicate primarily through body language, which can include subtle and relatively quick signals (Rugaas, 2006). This makes it difficult for untrained individuals to spot some signs of distress in dogs. Sometimes, a behavior may commence and conclude while the individual is not watching and will ultimately go unnoticed, leading to possible inaccurate conclusions on dog welfare. Lip licking is a behavior believed to occur when a dog is nervous about a situation and may be trying to prevent conflict with another dog or person (Rugaas, 2006), but the behavior is often very quick and may be missed by observers. It is also possible for people to misinterpret behaviors due to subtle but important characteristics. For example, tail wagging is typically perceived to indicate that a dog is in a positive mental state. However, the height of the tail, the direction it is wagging and the arc of the tail wag can all indicate different levels of arousal and affective states that vary from aggression to excitement (Bradshaw and

Nott, 1995). Additionally, some dogs may only display particular signs of distress in certain situations. Beerda et al. (1999a) found that dogs subjected to chronic stress using social and spatial restrictions did not show significant amounts of copropaghy, paw lifting or vocalizations. This may stem from paw lifting being a calming signal in social situations (Rugaas, 2006). In addition, there was likely individual variation in the expression of copropaghy in the dogs assessed. During different types of psychological distress, a dog may respond with different behaviors. For example, during social interactions a dog may show appeasement behaviors such as lip licking, yawning, paw lifting, acting 'sleepy' or 'smiling' and averting gaze (Pastore et al., 2011; Yin, 2009). Dogs may also show fear behaviors such as low body posture and tail position or ears in a pulled back position (Beerda et al., 1999b; Casey, 2002; Pastore et al., 2011; Serpell, 1995; Yin, 2009). The same dog could show abnormal behaviors such as pacing while in an inadequate environment. As with physical indicators of welfare, behavioral indicators need to be put into context and individual variation considered.

Paying attention to the amount of time dogs spend performing these types of behaviors and the different situations can help in identifying how a dog expresses distress. For example, Mariti et al. (2015) found that 82% of dogs displayed nose licking (or lip licking) behavior, 13% attempted to exit (escape behavior) and no dogs showed hypersalivation or urination/defecation when visiting a veterinary clinic. If every dog showed the same behavior, then the percentage of dogs showing any given behavior would be the same. Important signs of distress include: shaking, panting, muscle tension, food refusal, furrowed brow, hypervigilance, increased or decreased vocalizations, displacement behaviors (i.e. scratching when not pruritic, sniffing the ground, eating or drinking in the absence of hunger or thirst), salivating, urinating or defecating, or shedding (Barrera et al., 2010; Casey, 2002; Hiby et al., 2006; Pastore et al., 2011; Serpell, 1995; Yin, 2009). Some dogs may also seek contact with familiar caretakers, owners or conspecifics (Barrera et al., 2010; Casey, 2002). Many of these behaviors may only be observed in response to specific events or in individual dogs (i.e. going to the veterinary clinic, strangers or arriving at a shelter). Certain behaviors are signs of psychological distress and are meant to create distance between the dog and the source of the perceived threat such as aggression, avoidance, hiding or escape attempts (e.g. digging) (Barrera et al., 2010; Casey, 2002; Mariti et al., 2015; Pastore et al., 2011; Serpell, 1995; Yin, 2009). Unfortunately, for dogs many of the challenges to their welfare result from human imposed environments.

Compromises in dog welfare can result from their living environment, primarily controlled by humans, which may contradict their nature. For example, free ranging dogs have been reported to spend the majority of their active time searching for food (Fox et al., 1975). However, many of the pets in the U.S. are free fed or provided with regular meals to ensure nutrient requirements are met, but this manner of feeding also reduces the amount of time dogs engage in food finding behavior. This can reduce mental stimulation and, as a result, may eventually lead to abnormal behavior (Wemelsfelder, 2005). Many of the previously mentioned behavior signs appear during acute distress, but when chronic distress arises other behaviors may manifest.

When distress is prolonged and the dog has failed to cope with its environment dogs may display additional behaviors as coping mechanisms. Abnormal or repetitive behaviors include: excessive licking, flank sucking, circling, wall bouncing, whirling, tail chasing or pacing (Casey, 2002; Denham et al., 2014). This can be seen in dogs that are housed in consistently inadequate environments, such as one that is under-stimulating or that has consistent sources of distress. For example, Beerda et al. (1999b) found that Beagles increased the amount of time spent circling when transferred from group housing to single housing conditions for seven weeks. Circling was also performed when Beagles were walked down an unfamiliar corridor or exposed to restraint or escape tests (dog given the opportunity to escape their kennel) (Beerda et al., 1999b). These events may be particularly distressing for dogs that are adapted to social living, neophobic, not typically restrained or rarely leave their home kennel. Some behaviors related to abnormal consumption have also been reported, such as copropaghy, polydipsia (excessive drinking) and polyphagia (excessive appetite) (Beerda et al., 1999b; Casey, 2002; Serpell, 1995). Compulsive behaviors such as staring or 'fly chasing' (Casey,

2002) are also possible. Identifying behavioral signs of psychological distress or a poor mental state can aid in assessing dog welfare, especially when physical welfare appears intact.

Most species experience distress when they have a reduced ability to predict or control their environment or relevant events (Wiepkema and Koolhaas, 1993). A stimulus is considered controllable if the animal can change its behavior to influence its occurrence, while predictability is the animal's ability to anticipate an outcome based on the regularity of its environment or an event (Bassett and Buchanan-Smith, 2007; Sambrook and Buchanan-Smith, 1997). Both control and predictability work together and can impact the welfare of dogs in any environment. Many dogs in the U.S. have a limited amount of control over their environment as it is primarily decided by their human caretakers. In environments where consistency is low, such as dogs with varying caretakers, the predictability of the environment is reduced and can cause further distress. Dogs need to be able to predict their environment and have some degree of control over it to decrease the amount of distress they experience. For instance, dogs provided with platforms were reported to be more confident compared to before the platform was added (Hubrecht, 1993). The option to elevate provides more control over the environment and likely increases the welfare of the dogs. The predictability, even of negative events, has also been suggested to reduce detrimental effects to animal welfare. In fact, Weiss (1971) found that rats that could predict the occurrence of an electric shock had reduced stomach ulcers compared to rats that could not predict the shock. In general, predictability may reduce the severity of negative effects seen and control may also improve welfare. In addition to considering the importance of control and predictability, understanding how dogs exhibit their state of welfare can help in understanding and assessing unique welfare issues affecting breeding dogs.

2.4 Welfare Issues in Breeding Dogs

Assessing dog welfare, especially on larger scales, is becoming increasingly important as animal protection organizations push for more regulation of commercial dog breeding facilities (e.g. West, 2015). Dog welfare is important to understand if commercial breeding (CB) dog welfare is going to be assessed, particularly in terms of investigating the areas of concern for dog breeding, such as genetics, behavior, socialization and similar welfare concerns found in other kenneled dogs. As previously mentioned, some individuals do not believe that dogs should be bred in the U.S. due to a perceived dog overpopulation issue, although this is debatable. Additionally, there is controversy surrounding purebred dog breeding for welfare reasons with one of the most prominent reasons relating to genetics.

Genetics

The controversy behind purebred dogs primarily stems from the welfare concerns associated with meeting breed standards. For example, the breed standards for the Bulldog state that the dog's head should be very large and the circumference should be at least the height of the dog at the shoulders (American Kennel Club [AKC], 1976). This standard may be detrimental to welfare as dogs with very large heads can experience dystocia if they also have small pelvises (Rooney and Sargan, 2010). Several breed characteristics such as back length in Dachshunds contributes to intervertebral disc disease, large eyes in Pugs leading to exposure keratosis, or excess skin folds prone to skin infection and eye conditions in the Chinese Shar Pei may put the individual animal at risk (Priester, 1976; Stanford, 2006). Additionally, a review of the top 50 breeds of the UK Kennel Club, of which most are also popular breeds in the U.S., revealed a total of 396 inherited disorders related to conformation or disease (Asher et al., 2009). Therefore, the standards under which breeding is performed could be negatively affecting the health of purebred dogs. The same amount of genetic disorders are not seen in mixed breed dogs as cross breeding increases genetic diversity and decreases negative affects seen in closely related purebred dogs (Leroy, 2011). Therefore, the health of purebred dogs may be in jeopardy due to the desires of humans.

There is additional concern that many purebred dogs, particularly those with small founder populations, have a very small gene pool increasing the number of homozygous individuals, which can increase the likelihood of genetic disorders in offspring (Crispin, 2011; McGreevy and Nicholas, 1999; Rooney and Sargan, 2010). What is still unclear is how common these genetic disorders are found in dogs housed in CB facilities. Therefore, it is likely that the CB industry faces many of the genetic diseases that all purebred dog breeders must face. There is additional concerns for the behavior of purebred dogs.

Behavior

Breed standards can also influence the behavior of dogs by affecting their ability to communicate, by accidentally selecting for abnormal behaviors, or housing dogs in environments outside of their original purpose. Body language is an important mode of communication in dogs and some breeds that have been heavily modified can only perform a small portion of the visual communication signals of wolves or less modified conspecifics (Bradshaw and Nott, 1995). For example, tail position can communicate the affective state of a dog (e.g. tucked tails indicating fear) but breeds with bobbed tails (e.g. Corgis or Old English Sheepdogs) cannot utilize this form of communication. Additionally, breeds with long hair cannot raise their hackles (Bradshaw and Nott, 1995; McGreevy and Nicholas, 1999). Also, breeds with short limbs may have difficulty adjusting their posture for appropriate signaling (Rooney, 2009). These conformations, among others, can prevent dogs from normally communicating with conspecifics and human caretakers from accurately interpreting dog body language. Overbreeding for desirable traits may inadvertently select for undesirable traits. For example, the ‘eye stalk’ is a desirable trait in Border Collies for herding purposes, but some dogs may develop the tendency for compulsively staring (McGreevy and Nicholas, 1999). Therefore breeding dogs specifically for phenotypic traits as opposed to their function as pets can create welfare concerns.

During domestication dogs were likely selected based on their ability to favorably interact with humans and to perform certain tasks that benefited humans (e.g. pulling sleds or livestock guarding) (Coppinger and Schneider, 1995; McGreevy and Nicholas, 1999; Stanford, 2006). However, today many breeds of dogs are primarily companions. This can create conflict between what the dog wants to do and what the dog is allowed to do. Dogs living in busy households bred primarily for companionship may be left alone for long periods of time or dogs bred for their working ability may develop behavioral problems in the home, with no task to perform (Stanford 2006). In other words, some dogs are living in an environment that does not support their nature. This creates welfare concerns as a large portion of the dogs relinquished to animal shelters, a high stress environment with relatively low control and predictability, are due to behavioral issues (Mondelli et al., 2004; Salman et al., 1998). These same concerns can exist in the CB industry, particularly if they are motivated to perform tasks that cannot be done in kennel environments for practical and safety reasons. The CB industry must contend with these concerns and the additional limitations of CB facilities that can impact their proper socialization.

Socialization

Socialization is a process were animals adapt to their social environment by learning certain behavior patterns that allow them to at least coexist (Mills and Marchant-Forde, 2010). Dogs housed in CB facilities are particularly criticized for having poor mental health, which is suggested to be due to poor socialization (McMillan et al., 2011). In these environments, dogs may not be exposed to stimuli common in households, which can be an issue when retired breeding dogs are adopted out to homes. For example, a dog from a CB facility may not have experience with many flooring surfaces, stairs, sounds or experiences associated with living in a home (i.e. carpet, household appliances or riding in a car). CB facilities that are not near urban areas may result in dogs experiencing fear from sounds common in urban areas if the move to cities. Additionally, due to biosecurity concerns dogs may not have much experience with strangers. These factors may indicate that dogs are socialized to the CB environment, but may not cope well should this environment change.

There is additional criticism that CB facilities may impose a large amount of emotional distress on puppies as they are weaned, separated from the bitch, eventually separated from littermates, and transported to new facilities (e.g. brokers, other breeders, or for sale in pet stores) between six to twelve weeks of age. During this period puppies may be more motivated to create new social contacts, but it is also a time period when they are susceptible to psychological distress (Fox and Stelzner, 1966). Puppies also learn a substantial amount about their environment and how to socially interact during this period (Lindsay, 2000). Therefore, it is likely that puppies may have large amounts of psychological distress that may result in negative impacts such as, impaired learning or ability to interact with their environment or conspecifics (Lindsay, 2000).

Kennel environment issues

Any breeder that keeps dogs in a kennel environment, likely encounters welfare issues found in other kennels (i.e. shelters, laboratory animals, working dog kennels or boarding facilities) that can be detrimental to dog welfare such the lack of human contact, elevated noise levels, confinement, and relatively barren environments.

As previously mentioned, dogs are a social species that form particular attachments towards humans. Although dogs are closely monitored by humans, there can be difficulty in providing individual attention to dogs in large facilities (Hubrecht, 2002). A lack of human interaction can also be a concern for housed in commercial breeding facilities, particularly if there are a large volume of dogs relative to the amount of staff available to provide human contact. This can create frustration in dogs that continuously solicit for attention and do not receive it.

In other kennel environments when there is human activity an increase in barking is also noted (Sales et al., 1997). In fact, damaging noise levels to human hearing (e.g. over 85dB) have been reported in dog kennels (Coppola et al., 2006). Dogs, who have more sensitive hearing compared to humans (Hubrecht, 2002), likely suffer from hearing damage as well. This could be of particular concern in CB facilities where breeding stock may be housed for years. The noise levels may also impose maternal stress to gestating bitches, which may alter the development of offspring as found in other species (e.g. rats, Sobrian et al., 1992). Much of the excess noise is caused by the dogs themselves and may only occur during times of high arousal such as routine husbandry, but noise pollution can cause detrimental welfare in kenneled dogs.

The kennel environment by default puts dogs in a form of confinement, which dogs have not been selected for. This suggests that it contradicts some of the natural motivations of dogs. As naturally inquisitive animals, dogs can develop behavioral abnormalities while in environments with low mental stimulation (Hubrecht, 2002). Barren housing is a common characteristic of kennel environments. Low environmental complexity can lead to boredom and reduce the amount of control the dog has over its environment. The lack of control and increased boredom can create chronic distress and compromised welfare.

The CB industry has the unique challenge of addressing potential welfare problems identified in all purebred dogs and those that are found in kennel environments. This can create welfare problems that stem from genetics, behavior, proper socialization or inadequate environments. Therefore, the welfare of dogs in CB facilities require special consideration and investigation in order to truly understand the welfare problems present.

2.5 Areas that Require Further Study on Dogs Housed in Commercial Breeding Facilities

Commercial breeding (CB) facilities are faced with public scrutiny and accusations concerning the state of the environment and the dog's physical health. However, there has been minimal research in CB facilities to truly know the current welfare state of the dogs housed in them. There are studies done on dogs believed to be originally from CB facilities, but in order to accurately assess welfare it must be done in the environment of interest using a combination of behavioral and physical metrics that are appropriate for dogs. There are some welfare concerns that are likely to impact dogs in CB facilities that face all purebred dogs and dogs living in other kennel environments, but the degree to which these problems exist is unknown. The welfare of dogs in CB facilities is important to understand as it likely affects other aspects of society, such as the economy and public health. Additionally, the public perception of the welfare of dogs in CB facilities can influence regulations. There are several layers of dog welfare in CB facilities that require further investigation, but the first step is to identify the current state of dog welfare and to understand some of the practices of the CB industry.

To begin understanding the welfare of dogs in CB facilities this project started with some areas that are lacking in the scientific literature and sources of public concern that are fundamental to good welfare such as the physical environment and the dog's physical health. The initial goal of this study was to characterize the physical welfare of dogs and their environment in Indiana CB facilities. Since flooring substrate is a contentious social issue that can also impact dog health, the first portion of this study assessed foot health, dog body cleanliness and kennel cleanliness as a function of flooring substrate. There are other aspects that should be considered when deciding appropriate flooring, but health and cleanliness are two important areas to begin with. The second portion of this study sought to further understand the physical health of dogs in CB facilities by characterizing their dental and ear health as a function of preventive care provided. Understanding the current state of dog welfare in CB facilities is important when deciding what areas of welfare are important for future research. This study provides important preliminary data concerning environmental cleanliness, dog cleanliness and dog health in order for future research to build on and ultimately provide an accurate description of the welfare of dogs housed in CB facilities.

CHAPTER 3. THE IMPACTS OF KENNEL FLOORING ON ENVIRONMENTAL AND DOG CLEANLINESS AND BREEDING DOG HEALTH

Interests in improving the welfare of dogs in commercial breeding (CB) facilities has resulted in efforts to change policies or regulations surrounding the CB industry, but the scientific basis for current and new regulations is often questioned. An area that is of particular concern is the housing conditions in CB facilities. Research assessing the impacts of spatial parameters, living conditions (Beerda et al., 1999a, 1999b; Hetts et al., 1992; Hubrecht et al., 1992) and environmental enrichment (Eisele, 2001; Hubrecht, 1993; Pullen et al., 2010) on dog welfare have been conducted in kenneled dogs (Taylor and Mills, 2007), but minimal research exists on housing aspects like flooring type, despite increased concerns about the impacts of flooring substrate on dog welfare. Dogs maintained on non-solid flooring surfaces is a major source of contention. Additionally, various organizations claim that surfaces such as grid, wire, slats or mesh are detrimental to dog foot health and are more difficult to clean (Canadian Veterinary Medical Association [CVMA], 2007; HSUS, 2010). Such groups further suggest that solid surfaces promote dog welfare (HSVMA, 2013). How flooring impacts foot health or other aspects of dog well-being (i.e. comfort, cleanliness or behavior) has not been investigated. However, there is ample research concerning the effect of flooring substrate on health, comfort, cleanliness and behavioral well-being in other species (e.g. Bergsten et al., 2015; Bøe et al., 2007; Dawkins, 1981; Elmore et al., 2015; Korhonen et al., 2003; Weeks et al., 2000), indicating its importance to animal well-being. It is likely that flooring type similarly influences dog welfare. Therefore, understanding the impacts of flooring on dog welfare may help to inform policy and promote positive dog welfare in a kennel environment.

Flooring Choice and Its Impacts on Animal Welfare

Despite the lack of research concerning flooring and dog well-being, research in other species has found flooring to impact animal health by influencing the risks of injuries, disease, lameness, and the animal's body cleanliness. For example, turkeys housed on damp litter developed foot ulcers faster than birds housed on dry litter (Martland, 1984), and the risk for foot and limb injuries tended to be higher in piglets housed indoors compared to piglets housed outdoors on more natural surfaces (Kilbride et al., 2009). Flooring can impact an animal's ability to develop a normal gait and move around without slipping (Fjeldaas et al., 2010). For instance, dairy cattle were found to display different stride lengths on solid rubber flooring compared to slatted rubber flooring types. This indicates that cows change/shorten their stride in order to avoid slipping depending on the particular surfaces they walk on (Telezhenko and Bergsten, 2005). This is supported by other studies suggesting that both the friction and softness of a flooring surface can affect animal gait with softer floors with greater friction having lower risks for slipping (Applegate et al., 1988; Flower et al., 2007).

The abrasiveness of a flooring substrate can also impact the health of the animal. For example, animals that do not feel comfortable standing on a flooring surface may reduce their eating behavior. In beef cattle, average daily gain was found to be higher in cattle housed on rubber slatted flooring compared to cattle housed on concrete slatted flooring (Brscic et al., 2015). This could be because cattle housed on rubber were more comfortable standing and therefore spent more time eating. Elephants housed on sand and concrete were found more likely to have foot health problems than those housed on other substrates (Haspeslagh et al., 2013). Also in dairy cattle, (Hultgren and Bergsten, 2001; Kremer et al., 2007) beef cattle, (Brscic et al., 2015) sows, (Díaz et al., 2013; Elmore et al., 2010) and humans (Wahlström et al., 2012), the risk of lameness, foot or body cutaneous lesions and pain can increase on certain flooring surfaces that are more abrasive. The flooring surface's abrasiveness, friction or design can also impact the animal's health and well-being and are important considerations when determining flooring surfaces for dogs. Flooring can also impact the cleanliness and health of the animal. Beef cattle housed on slatted flooring were found to be cleaner than cows housed on solid flooring (Elmore et al., 2015) and farmed foxes housed in cages with mesh flooring had cleaner coats during pelting compared to foxes with access to sand flooring (Korhonen et al., 2003). This is likely due to the openings in the flooring allowing waste to fall underneath the pen and away from the animal. The ability to clean and disinfect a flooring type and its impacts on the animal's body cleanliness are important factors when considering flooring type in addition to the animal's comfort and risk for injuries.

Observations in various species indicate that behavioral well-being of the animal can also be impacted by flooring. Factors such as where the animals decide to spend their time, the range of behaviors expressed (dust bathing, digging, being active or resting) or the amount of time animals spend performing different behaviors (beef cattle, Brscic et al., 2015; hens, Dawkins, 1981; foxes, Koistinen et al., 2008; dairy cattle, Kremer et al., 2007; rats, Manser et al., 1995; and elephants, Meller et al., 2007) can all be influenced by the flooring surface. For example, foxes housed in cages with access to sand flooring exhibited digging behavior, which they could not perform when housed on mesh flooring surfaces (Koistinen et al., 2008). In addition, the preferences that animals show for various flooring types can be influenced by the condition of the flooring (e.g. wet, dry, or soiled), the season, and the ability of the animal to thermoregulate on the flooring type (dairy goats, Bøe et al., 2007; sheep, Faerevik et al., 2005; and foxes, Harri et al., 2000). Dairy goats showed a preference for lying on expanded metal in moderate temperatures, but preferred solid wood in colder temperatures (Bøe et al., 2007) likely due to the difference in thermal conductivity between the two flooring types. The manner in which flooring affects behavior is also an important consideration when choosing dog flooring surfaces despite minimal research in this area.

Influences on Flooring Choice in Commercial Breeding Kennels

An important consideration for breeders in selecting a flooring surface for their dogs is their ability to comply with the USDA requirement to remove waste from the kennel on a daily basis (USDA, 2013). Facility owners may find it easier to remove waste on flooring types with holes or slats compared to solid flooring. Perforated flooring may also aid in helping the dog's body and feet remain visually clean and dry. In other species housed on flooring with openings animals have remained cleaner (Elmore et al., 2015; Korhonen et al., 2003). Dog breeders may select flooring surfaces with openings because they find it easier to keep dogs clean as they allow excrement to fall underneath the kennel, and help the dogs to avoid contact with urine and feces.

In addition to promoting health, flooring surfaces should be easy to clean, sanitize and easily drain moisture. Määttä et al. (2010) found that some flooring surfaces were more difficult to clean from organic debris typically found on dairy farms (e.g. manure or feed) using radiochemical cleaning methods. Therefore, the flooring types that breeders chose must be readily cleaned with current methods and requirements. Flooring in USDA licensed CB facilities are cleaned on a daily basis and sanitized on a bi-weekly basis at minimum as required by the Animal Welfare Act and Animal Welfare Regulations (USDA, 2013), but knowing if kennels are sanitizable in addition to being visibly clean can indicate whether dogs are exposed to any serious health risks on a routine basis. If the flooring is visually clean and the majority of kennels have no evidence of fecal contamination, then the flooring is able to be properly cleaned and successfully sanitized. Dogs housed on clean, sanitizable flooring are also likely to have fewer health risks.

Flooring should also be easily rid of excess moisture, which is essential to dog foot health, as feet that are in contact with constant moisture can be at increased risk for health concerns. For example, foot rot in sheep has been associated with moist pasture conditions (Graham and Egerton, 1968). Moist skin can also exhibit altered pH levels as excess moisture can promote bacterial growth and alter the microflora of the skin (Ruedisueli et al., 1998). Skin pH is believed to be involved in normal keratinization, desquamation and promotion of the microflora's antimicrobial abilities (Oh and Oh, 2009). Flooring surfaces that are difficult to dry may cause feet to be in constant contact with moisture. This can be an additional problem for dog breeds with excess foot hair that may trap additional moisture. Flooring that is difficult to rid of moisture may also trap chemicals used during routine cleaning that could cause further irritation to the feet and alter pH levels. Skin pH for a normal dog can range anywhere from 4.85-9.95 depending on anatomical site, gender, excitement level, breed, age, sweat, diet, allergies, sebum, infection, neuter status and much more (Matousek and Campbell, 2002; Ruedisueli et al., 1998). There is little research published on what normal foot skin pH is in dogs, but previous studies have reported interdigital skin pH to range from 6.27-6.9, palmoplantar skin pH of 6.43 and foot pad pH to range from 7.1-7.15 (Breathnach et al., 2010; Král and Schwartzman, 1964; Meyer and Neurand, 1991; Oh and Oh, 2009). Deviations outside of a normal pH range for dog feet could indicate an alteration in the microbial foot environment or possible foot health issues, as alterations in pH can be due to disease (Chikakane and Takahashi, 1995). For instance, dogs with immunomodulatory-responsive lymphocytic plasmacytic pododermatitis have been found to have a significantly higher foot pH compared to healthy dogs (Breathnach et al., 2010). The foot pH can be impacted by the dog's foot health, which can ultimately be influenced by the flooring surfaces' ability to promote cleanliness. The flooring type's ability to promote these factors must be understood when choosing the appropriate flooring type for dogs, but currently research is not on par to support regulations on kennel flooring type.

Current Recommendations for Kennel Dog Flooring

Flooring type likely impacts dog welfare as observed in other species, by having the same behavioral and physical influences. Professionals typically advise that dogs be kept on solid flooring or at least have access to solid flooring (Hubrecht, 2002). However, dogs housed in confinement such as shelters, research facilities, CB facilities or working kennels may spend more time on a single flooring surface unlike many dogs in homes. Additionally, dogs in confinement may spend an increased amount of time in close contact with excrement than dogs in homes or other areas in which they are free-ranging, resulting in irritation to their feet. Not only should the flooring surface be simple to clean and rid of excess moisture, but the dog's exposure to waste material must also be considered. Improper flooring that does not allow for full drainage and removal of urine and fecal matter can ultimately lead to foot health concerns. As mentioned in other species, the texture of the flooring and the friction can affect the risk of slipping. Therefore, when choosing flooring types for dogs, accounting for the increased urine and fecal matter as well as promoting the dog's safety is important. One study focused on flooring as a factor in dog foot health was conducted by Kovács et al. (2005), who found that interdigital cysts occurred more in Beagles housed on polyvinyl chloride coated flat bar flooring than Beagles housed on diamond-shaped coated or flat bar steel. The researchers also found that dogs with higher body condition scores were more likely to have interdigital cysts. Investigating the foot health of dogs housed on perceived detrimental flooring surfaces can provide important insight about whether those flooring types are appropriate for dog housing.

In regard to dog housing, current recommendations are often not based in science. The National Research Council's (NRC) guidelines for animal care suggest that terrestrial animals should be kept on solid, perforated or non-slip flooring and if flooring types with openings are utilized, it should be appropriate for the animal (NRC, 2013). While these are good recommendations, kennel owners may not know what the appropriate flooring features are that promote good foot health in the species of interest. The Laboratory Animal Management guide for Dogs suggests that flooring should be easy to clean, resist wear, be slip resistant and promote the removal of moisture (NRC et al., 1994). Suggestions on desirable flooring properties are well documented, but there are some flooring types that meet these requirements that are still criticized as being inappropriate for dogs (e.g. non-solid flooring CVMA, 2007; HSUS, 2010; HSVMA, 2013). The science needed to distinguish which flooring types meet current recommendations and can be proven to promote dog welfare is still lacking.

Study Objectives

To assess dog foot health on a given flooring type, it is important to develop tools that can be utilized in the field and other environments. Currently there are no published foot health assessment tools for dogs to provide a standard way to assess dog foot health, which would help in evaluating the suitability of kennel flooring. There are some foot health assessment tools published in other species (e.g. pigs Díaz et al., 2013; dairy cattle Norring et al., 2008) or for human health (e.g. Bristol Foot Score, Barnett et al., 2005), but none concerning dog foot health.

To begin filling gaps in the literature concerning dog flooring and foot health, this study sought to understand the current state of foot health in dogs housed in CB facilities. The specific aims of this study were: 1) to characterize dog foot health in CB facilities as a function of the length of time dogs were housed on diamond-shaped coated expanded metal (DCEM), polypropylene (POLY) and concrete (CON) indoor flooring, 2) to characterize visual dog body cleanliness and kennel cleanliness as a function of the flooring substrate and 3) to determine the efficacy of kennel cleaning procedures. This study had three hypotheses. The first hypothesis was that foot health problems would increase and be more serious as time housed on the indoor flooring increased. If any of the flooring types examined caused foot health concerns, then detrimental foot health conditions should have been observed. The second was that visual dog body cleanliness and visual kennel cleanliness would be positively correlated. The final hypothesis was that the majority of samples from kennels would not show evidence of fecal contamination after routine cleaning. If relatively low numbers of kennels indicated fecal contamination, then dogs should have low health risks from fecal bacteria as a result of the current management procedures used.

3.1 Materials and Methods

3.1.1 Ethics Statement

The experimental methodology was pilot tested prior to study. All CB facility owners provided informed consent to the testing procedures and were made aware that they were free to withdraw at any point without penalty. The Institutional Animal Care and Use Committee, Institutional Review Board and the Clinical Trials Office in the College of Veterinary Medicine at Purdue University approved all experimental procedures.

3.1.2 Subjects

Five commercial breeding kennels meeting the study criteria for the number of dogs housed, flooring types of interest and physical status of the subjects were recruited for participation in the study. The occurrence of dog foot health problems in commercial breeding facilities was unknown. Therefore, the prevalence of foot health problems was estimated to be 50% for the purpose of sample size calculation. After factoring in the amount of dogs that would be feasible for data collection, 30 dogs per facility was determined to be necessary (n=150). After the data collection at facilities two and three were completed, foot health problems were observed in relatively low proportions (4/30 and 7/30) and believed to be greatly impacted by facility management. Therefore, increasing the number of facilities with different management practices was deemed to be more important than increasing the number of dogs sampled within a facility. Therefore, facilities with less than 30 dogs available after excluding bitches that were close to whelping or nursing puppies, were also sampled. Thirteen breeds of dogs were examined (n= 118; females=95, males=23) onsite at their home facilities. Subjects were randomly sampled at facilities one and two and all dogs were sampled at facilities three, four and five that met the study criteria. Dogs over one year of age, considered to be generally healthy, and not in the last two weeks of gestation or nursing puppies were utilized. The dogs were single, pair, or group housed in their home pens and the flooring substrate assessed was the indoor flooring currently used at the facility, which was diamond-shaped coated expanded metal (DCEM), polypropylene (POLY) or concrete (CON). There was missing demographic information from one dog at facility two (time housed at facility), one dog at facility three (time housed at facility) and one dog at facility four (time housed at the facility), as information on the time housed at the facility was not readily available for these dogs from the facility's records. Because of missing information, calculations using time housed at the facility did not include these dogs (see Table 1).

Table 1: Number of eligible dogs at the facility, breed distribution, sex distribution by breed, number of dogs assessed, age mean (±SD) and range, time on flooring mean (±SD) and range and flooring substrate at facility with number of dogs housed on each flooring substrate.

Facility	Number of Eligible Dogs	Breed	Sex	n	Age (months)	Time Housed at Facility (months)	Indoor Flooring Substrate
1	128	Yorkshire Terrier (10)	F(8) M(2)	30	37.8 (±19.2), 13-79	22.7 (±7.2), 10-32	DCEM (30)
		Maltese (12)	F (11) M (1)				
		Miniature Pinscher (8)	F (6) M (2)				
2	116	Miniature Schnauzer (10)	F(6) M (4)	30	31.6 (±23.0), 12-118	29.1 (±23.4), 8-114	POLY (30)
		Havanese (10)	F (9) M (1)				
		Coton de Tulear (10)	F (8) M (2)				
3	61	Lhasa Apsos (20)	F (18) M (2)	30	44.7 (±20.1), 17-106	37.9 (±15.9), 12-70	DCEM (30)
		Miniature Australian Shepherd (10)	F (9) M (1)				
4	28	Rottweiler (8)	F(5) M (3)	8	38.5 (±12.7), 20-53	29.3 (±20.1), 6-53	CON (5) or DCEM (3)
5	73	Weimaraner (7)	F(5) M (2)	20	40.1 (±16.2), 14-74	34.0 (±17.3), 6-74	CON(10) or DCEM(10)
		Wheaton Terrier (7)	F(6) M (1)				
		Dog de Bordeaux (1)	F(0) M (1)				
		Pembroke Welsh Corgi (5)	F(4) M (1)				

3.1.3 Facilities

The indoor flooring substrate at facility one was DCEM (for an example see Figure 1) indoors measuring 122.94 cm x 79.76 cm. The dimensions of the openings were approximately 2.54 cm x 1.27 cm. Dogs had continuous access to outdoor kennel portions between 4:30am and 5:00pm and were locked indoors after 5:00pm. At facility two POLY flooring was used for the indoor substrate (for an example see Figure 2) and kennels came in two different sizes. The larger kennel size was 142.24 cm x 111.76 cm; the smaller kennels were 142.24 cm x 93.98 cm. The dimensions of the flooring openings were 2.54 cm x 2.54 cm. Dogs had continuous access to outdoor portions of the kennel between approximately 5:30am and 5:30pm. Afterwards dogs were locked indoors overnight. At facility three, DCEM was utilized for the indoor flooring substrate with kennels measuring 152.00 cm x 91.44 cm. The dimensions of the flooring openings were 3.81 cm x 1.91 cm. At facility three the dogs had 24 hour access to the indoor and outdoor portions of the kennel. At facility four, CON flooring (for an example see Figure 3) or DCEM flooring substrates were used indoors measuring 152.40 cm x 121.92 cm. The dimensions of the DCEM flooring openings were 2.54 cm x 1.27 cm. Dogs had 24 hour access to outdoor portions of the kennel. At facility five, CON or DCEM indoor flooring substrates were also used with three kennel sizes. The largest kennel size was 152.40 cm x 121.92 cm, the second largest kennel size was 121.92 cm x 121.92 cm and the smallest kennel size was 121.92 cm x 91.44 cm. The dimensions for all flooring openings at facility five were approximately 3.18 cm x 1.91 cm. At all facilities, outdoor areas of the kennels had concrete flooring. Dogs additionally had access to grass or gravel play yards for approximately one to two hours three times per week at facility one, one hour three times per week at facility two, 20 minutes six days per week at facility three, 20 minutes to two hours daily at facility four and 45 minutes to one hour two times per week at facility five.

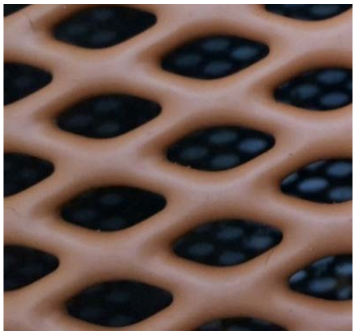

Figure 1: DCEM flooring type used at facilities one, three, four and five

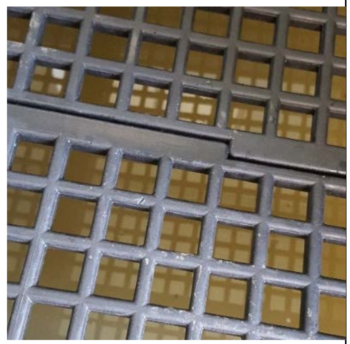

Figure 2: POLY flooring type used at facility two

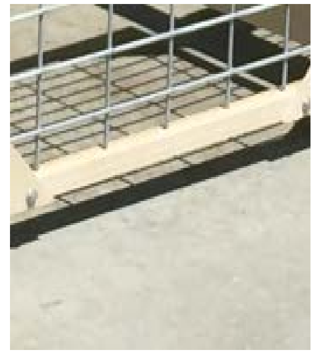

Figure 3: CON flooring used at facilities four and five

3.1.4 Dog Metrics

Physical examinations of the dogs to assess body condition and foot health were conducted by a licensed veterinarian for facilities one, four and five and a veterinary dermatologist for facilities two and three. During the examination, each dog's body condition score, hock, elbow and foot health and visual body cleanliness score were recorded by a separate experimenter and another experimenter served as the handler. For certain dogs the facility owner served as the handler to minimize distress. Data were collected during early May 2016 for facility one, late August 2015 for facilities two and three and in early February 2016 for facilities four and five. Physical exams were ceased if dogs showed signs of severe distress during the exam.

Body Condition Score (BCS)

Because previous research found body condition score (BCS) to be correlated with interdigital cysts in laboratory Beagles (Kovács et al., 2005), the current study scored the body condition of dogs to determine if it was correlated with any adverse foot health conditions. BCS was based on a five point scale from the Ohio State University's Veterinary Medical Center (1= emaciated, 3=ideal and 5=obese) (see Appendix Table A.1).

Hock and Elbow Health

The physical exams included visual assessment of the dog's hocks and elbows, which were assessed for the presence of any abnormality that could likely be influenced by flooring (e.g. inflammation, erythema (redness), alopecia (hair loss), calluses, cutaneous lesions, etc.).

Foot Health

Dogs' feet were visually assessed for evidence of pododermatitis, interdigital cysts, cutaneous lesions, erythema (redness), alopecia (hair loss), foot pad fissures (cracks) and hyperkeratosis, and measured for foot pH and toenail length/health.

Foot pH

Foot pH was collected because factors such as moisture or disease presence (Breathnach et al., 2010) can influence the skin pH of the dogs' feet. Collection was done only for one foot per dog as pilot testing showed no differences between interdigital or palmoplantar swabs or between feet. Foot pH was collected using a cotton swab moistened with deionized water and swabbed interdigitally and on the palmoplantar aspect. The swab was then pressed against a pH strip (Healthy wiser® or Multistix® 10SG SIEMENS). Several of the dogs had long or matted interdigital hair or hair on the palmoplantar region making it difficult to directly contact the skin in all subjects.

Toenail length/health

Toenail length/health was assessed to understand if gridded flooring resulted in increased toenail length/health issues. Scores for each individual toenail were based on a five point scale developed by the experimenters (see Appendix Table A.2), with 1 being a toenail of adequate length, and 5 being onychocryptosis (increased nail length/curvature to the point of growing into the foot pad) or presence of an abnormality such as onychoclaisis (broken) or onychoschizia (split) toenails. An average score for each foot was then calculated.

Body Cleanliness Score (BCLS)

Body cleanliness scores (BCLS) were collected to assess the impacts of flooring type and to determine if BCLS correlated with visual kennel cleanliness (see facility metrics section). BCLS was based on a five point scale developed by the experimenters with 1 being clean and free of debris, such as excrement or dirt; and a score of 5 indicating that 75% or more of the dog's body was covered in debris (see Appendix Table A.3). Subjects used to score BCLS were the same ones used for physical exams.

3.1.5 Facility Metrics

Cleaning Procedures

Management information was collected through a brief interview with the facility owners (e.g. cleaning protocol and detergents used). Questions included the frequency of cleaning per day and if any additional procedures were performed on weekly, bi-weekly, or monthly basis. The methods used to clean (e.g. using a standard hose) were recorded as well. The timing of cleaning was also recorded as time between cleaning and assessment may influence kennel cleanliness scores.

At facility one, kennels were cleaned at approximately 4:00am daily by first scraping fecal matter towards the edge of the kennel using a shovel. A mixture of water and J&J J-SPRAY XT® (by J & J Chemical Company) was then sprayed in kennels using a hose line. Kennel walls were also scrubbed with a brush if needed. Kennels were disinfected weekly using chlorhexidine misted across kennels after daily cleaning. At facility two, kennels were hosed down at approximately 6:00am with a mixture of water and WYSIWASH® jacketed caplets (by the National Animal Care & Control Association). A mixture of chlorhexidine and water was sprayed weekly across kennels. At facility three, kennels were sprayed with water around 4:00am and 5:00pm on a daily basis. Kennels were cleaned weekly with a mixture of 2 quarts bleach, 6 quarts water and 1 cup of Tide® with bleach (by Proctor & Gamble). Kennels were also cleaned bi-weekly with a mixture of chlorhexidine and water. At facility four, kennels were sprayed using a standard hose with water and kennel walls were scrubbed daily with a brush at approximately 7:30am. Kennels were sprayed weekly with chlorhexidine after routine cleaning procedures. At facility five, kennels were sprayed using a standard hose line that contained J&J J-SPRAY XT® (by J & J Chemical Company) on a daily basis. For kennels containing concrete, flooring was squeegeed after cleaning. Caretakers also sprayed kennels weekly using a hose line containing chlorhexidine. Each month, kennel walls and flooring were scrubbed with a mixture of water and bleach or Purple Power® (by Aiken Chemical Company).

Visual Kennel Cleanliness (KCLS)

Visual kennel cleanliness scores (KCLS) were recorded by an experimenter for each kennel when each dog was removed for the physical exam. KCLS were based on a five point scale similar to BCLS, where a score of 1 was a kennel that was visually clean and free of debris and score of 5 was a kennel almost entirely coved in debris (see Appendix A).

Environmental Swabs

Kennel flooring surfaces were also swabbed for the presence of *Escherichia coli*, used as an indicator of fecal contamination. Swabs of 111 kennel floors (indoor portions only) were collected after normal cleaning procedures. Kennels were pseudo-randomly sampled, except for facility three where all kennels were swabbed. Samples were collected using Swiffer® electrostatic dust cloths (by Proctor and Gamble), previously used to sample *E. coli* (e.g. Murphy et al., 2010), and *Salmonella,* another indicator of fecal contamination (e.g. Burgess et al., 2004; Ruple-Czerniak et al., 2013; Steneroden et al., 2011; Zwede et al., 2009) and were used to sample the entire floor. The cloth was removed using a gloved hand and placed into a sterile Whirl-Pak® (by Nasco). The Swiffer® mop heads were sprayed with 70% ethanol and allowed to dry between samples.

Electrostatic cloth samples were stored in a conventional refrigerator at approximately 1.6 ° C for one to five days. Samples were submitted to the Animal Disease Diagnostic Laboratory at Purdue University to assess the presence or absence of *E. coli*. Electrostatic samples were cultured by aseptically adding 100mL of phosphate buffered saline (PBS, pH 7.4) to the Whirl-Pak® containing the electrostatic cloth. The PBS and cloth were mixed together inside the closed Whirl-Pak® and allowed to sit for about 10 minutes to permit the PBS to soak throughout the cloth. While still in the Whirl-Pak®, the cloth was squeezed to expel the PBS and 100 µL of the resulting liquid was removed from the Whirl-Pak® and plated on a MacConkey agar plate. An "L" shaped spreader was used for confluent growth. The MacConkey agar plate was left undisturbed for 10 minutes to allow the agar to absorb the liquid. Plates were then inverted and incubated at 37°C (± 2°C) for 18-24 hours. Plates were then examined using standard protocols for identifying *E. coli* (i.e. growth of pink to red colonies with a bile salt precipitate surrounding the colonies). *E. coli* was further identified using the MALDI (Matrix-assisted laser desorption/ionization mass spectroscopy) with Bruker Daltonik MALDI Biotyper version 3.1 identification software (model MTX-LRF™ by Bruker Corporation) under standard procedures.

3.1.6 Analysis

Due to large variation between facility management and the breeds housed descriptive statistics were utilized and stratified by facility. Data on breed and sex distribution; age mean (±SD) and ranges; and time on housed at the facility mean (±SD) and ranges are presented for each facility in Table 1. Means (±SD) for foot pH, body condition score, visual dog body cleanliness and kennel cleanliness are presented in appendix D. The percentage of dogs affected with a foot health problem by gender, facility, type of problem, time housed at the facility and age were also calculated (dogs missing the respective demographic information were not included, see figures for more detail). All statistics were performed using STATA IC 11® statistical software. The percentages of kennels that were culture-positive for *E. coli* after routine cleaning at each facility and the proportion of dogs showing foot health problems as a function of gender, age and time housed at the facility were calculated and graphed using Microsoft Excel® 2013 or GraphPad Prism® version 6.00 software.

3.2 Results

3.2.1 Body Condition Score (BCS)

The ideal score for body condition was 3. Mean (±SD) body condition scores were 3.0 (±0.7), 3.2 (±0.4), 3.4 (±0.6), 3.2 (±0.4) and 3.2 (±0.5) at facilities one to five respectively (see Appendix Table D.1). Since most body condition scores were ideal, correlations within each facility between foot health and BCS could not be calculated.

3.2.2 Hock and Elbow Health

Elbow and hock problems were found at facilities one, two, four and five. There were a total of 22 elbow or hock health problems found with 16 dogs showing alopecia (hair loss), three dogs showing calluses, two dogs with cutaneous lesions and one dog with inflammation (see Table 2).

Table 2: Number and percentage of dogs with a hock or elbow health problem present at each facility

	Facility 1 (n=30)		Facility 2 (n=30)		Facility 3 (n=30)		Facility 4 (n=8)		Facility 5 (n=20)	
Foot Health Problem	**Number Affected**	**% Affected**	**Number Affected**	**% Affected**	**Number Affected**	**% Affected**	**Number Affected**	**% Affected**	**Number Affected**	**% Affected**
Alopecia (Hock or elbow)	9	30.0	0	0	0	0	5	62.5	2	10.0
Calluses (Hock or elbow)	1	3.3	0	0	0	0	0	0	2	10.0
Inflammation (Hock)	0	0	0	0	0	0	0	0	1	5.0
Cutaneous Lesions (Hock)	0	0	2	6.7	0	0	0	0	0	0

3.2.3 Foot Health

There were few dogs affected by foot health problems (43/118, 36.4%) overall and most were minor. Foot health problems included erythema (redness), inflammation, dermatitis, alopecia, foot pad fissures (cracks), old scars, hyperkeratosis, calluses, interdigital cysts or cutaneous lesions (see Table 3). There were 15/30 (50.0%) dogs at facility one, 7/30 (23.3%) dogs at facility two, 4/30 (13.3%) dogs at facility three, 5/8 (62.5%) dogs at facility four, and 12/20 (60.0%) dogs at facility five affected with a foot health problem. There was one dog with a missing toe at facility three and no record search to determine why it was missing was conducted. This dog is included in the previous percentages, but not the table 3 below.

Table 3: Foot health problems by facility

Foot Health Problems	Facility 1 (n=30)		Facility 2 (n=30)		Facility 3 (n=30)		Facility 4 (n=8)		Facility 5 (n=20)	
	Number Affected	% Affected	Number Affected	% Affected	Number Affected	% Affected	Number Affected	% Affected	Number Affected	% Affected
Erythema	0	0	3	10.0	3	10.0	1	12.5	0	0
Foot Pad Fissures	1	3.3	2	6.7	0	0	2	25.0	1	5.0
Cutaneous Lesions	4	13.3	1	3.3	0	0	0	0	1	5.0
Cysts	1	3.3	0	0	0	0	0	0	1	5.0
Hyperkeratosis	0	0	1	3.3	0	0	0	0	0	0
Alopecia	2	6.7	0	0	0	0	2	25.0	2	10.0
Inflammation	12	40.0	0	0	0	0	0	0	9	45.0
Dermatitis	1	3.3	0	0	0	0	0	0	1	5.0
Callus	0	0	0	0	0	0	1	12.5	0	0
Scars	1	3.3	1	3.3	0	0	0	0	0	0

There did seem to be a tendencies between foot health problems and gender depending on the facility, but because of the small proportion of males relative to females at each facility, definite tendencies were difficult to determine. Foot health problems were found in 48.0% (12/25) of females and 60.0% (3/5) of males at facility one, 20.8% (5/24) of females and 42.9% (3/7) of males at facility two, 14.8% (4/27) of females and 0% (0/3) of males at facility three, 80.0% (4/5) of females and 33.3% (1/3) of males at facility four and 66.7% (10/15) of females and 40.0% (2/5) of males at facility five. At facility four only dogs housed two years or more had a foot health problem while dogs housed for less than two years did not. Therefore, a possible tendency between the development of foot health problems and time housed at the facility was observed at facility four, but because of the small sample size (n=8) it is difficult to determine definite tendencies. Overall, time housed at the facility did not seem to impact the occurrence of foot health problems (see Figure 4). There was a tendency with age and the occurrence of foot health problems at facility one. However, facility one had only been established for a couple of years and breeding stock were purchased from other places. Therefore, it was difficult to determine if the tendency with age was due to conditions at facility one or from any previous living environments (see Figure 5).

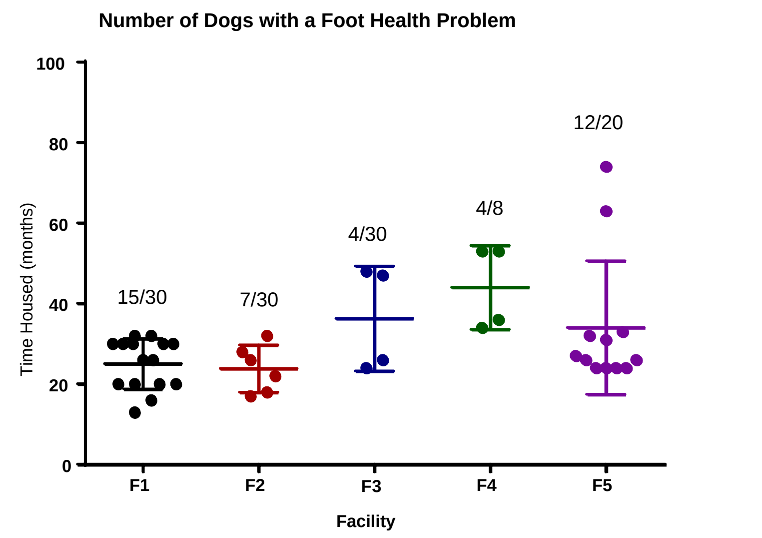

Figure 4: Dogs with foot health problems at each facility by time housed at the facility. Information on time housed at the facility was not available for one dog at facility two and one dog at facility four

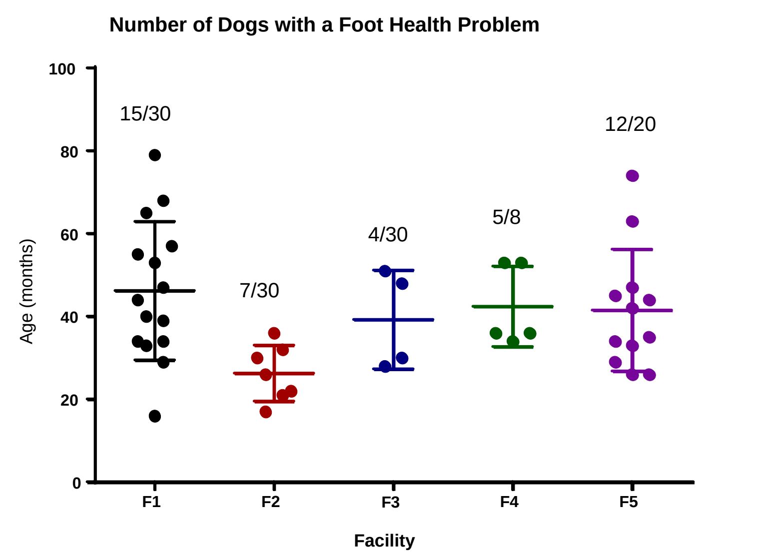

Figure 5: Dogs with foot health problems at each facility by age

Facilities four and five housed dogs on both DCEM and CON. Therefore, figures 6 and 7 show the percentage of dogs with a foot health issues based on the indoor flooring substrate. Flooring type did seem to have an impact on the percentage of dogs with foot health problems, but the sample size was low at facility four. At facility five, only large breed dogs were housed on concrete; therefore, it was unclear if results were due to breed differences. Facilities one, two and three housed all dogs on the same indoor flooring.

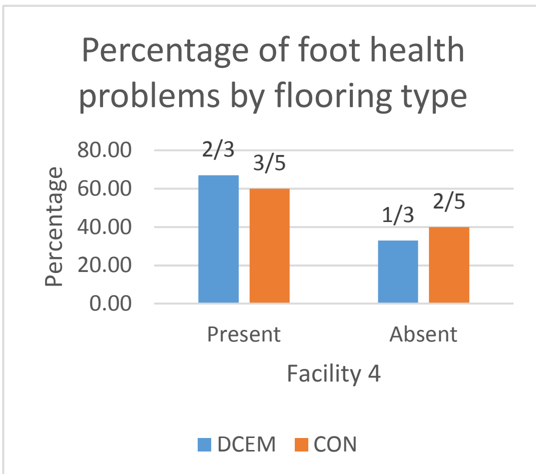

Figure 6: Percentage foot health problems by flooring type at facility four. Numbers above bars are the number present or absent out or the total number of dogs housed on the respective flooring type

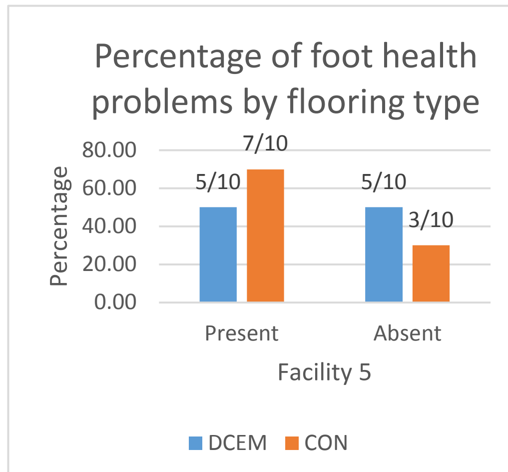

Figure 7: Percentage foot health problems by flooring type at facility five. Numbers above bars are the number present or absent out or the total number of dogs housed on the respective flooring type

Matted foot hair was added as a variable as it was found in 50/118 (42.4%) dogs at facilities one, two, three, and five (see Table 4).

Table 4: Number and percentage of dogs with matted foot hair at each facility

Facility 1 (n=30)		Facility 2 (n=30)		Facility 3 (n=30)		Facility 4 (n=8)		Facility 5 (n=20)	
Number with Matted Hair	%	Number with Matted Hair	%	Number with Matted Hair	%	Number with Matted Hair	%	Number with Matted Hair	%
2	6.7	29	96.7	18	60.0	0	0	1	5.0

The mean (± SD) foot pH values were 6.0 (±0.5), 8.0 (± 0), 7.8 (±0.3), 6.7 (±0.2), and 6.3 (±0.3) for facilities one to five respectively (see Appendix Table D.2). Toenail length tended to be shorter for the rear feet compared to the front feet except at facilities four and five, but overall most toenail length scores were ideal (see Table 5). Figure 8 shows foot pH for dogs with and without matted foot hair. Excess foot hair was thought to trap excess moisture and thus influence pH values, but there did not seem to be a tendency for dogs with matted foot hair to have different pH values than those without matted foot hair.

Table 5: Mean (±SD) toenail score at each facility

		F1	F2	F3	F4	F5
Toenails	**LF**	1.7 (±0.6)	1.3 (±0.4)	1.7 (±0.8)	1.0 (±0)	1.3 (±0.6)
	RF	1.6 (±0.6)	1.3 (±0.5)	1.8 (±0.8)	1.1 (±0.4)	1.2 (±0.4)
	LR	1.3 (±0.5)	1.1 (±0.3)	1.3 (±0.6)	1.3 (±0.5)	1.3 (±0.4)
	RR	1.3 (±0.5)	1.1 (±0.3)	1.2 (±0.5)	1.1 (±0.4)	1.2 (±0.4)

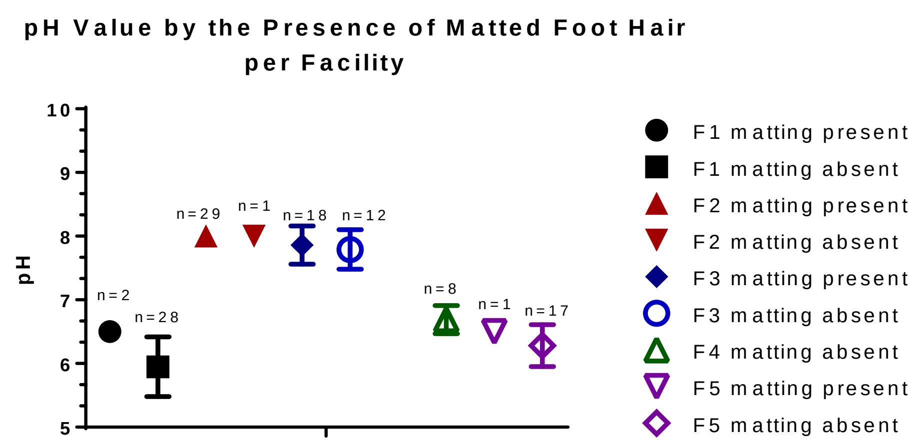

Figure 8: Mean (±SD) pH for subjects with matting present or absent by facility. Facility four (F4) had no dogs classified as matting present. Missing information from two dogs at facility five due to distress.

3.2.4 Visual Dog Body Cleanliness Scores (BCLS) and Kennel Cleanliness Scores (KCLS)

The mean scores at each facility for the visual dog and kennel cleanliness were less than two. Additionally, no dog or kennel scored more than a 2 for cleanliness. The mean BCLS were 1.1 (±0.3), 1.0 (±0.2), 1.0 (±0), 1.1 (±0.4), and 1.1 (±0.2) for facilities one to five respectively, with a score of 1 being clean. The mean (±SD) KCLS were 1.0 (±0.2), 1.1 (±0.3), 1.5 (±0.5), 1.0 (±0) and 1.0 (±0) for facilities one to five respectively, with 1 being clean (see Appendix Tables D.3 and D.4). KCLS were missing from three kennels at facility three; therefore, facility three KCLS average was out of 27.

3.2.5 Environmental Swabs

Environmental swabs of the indoor kennel flooring for *E.coli* indicated that all facilities had less than 50% of culture-positive kennels. For the total samples collected, 19.8% (22/111) were positive. Of the samples collected at each facility, 31.0% (9/29), 26.7% (8/30), 6.7% (1/15), 10.0% (2/20) and 11.8% (2/17) were positive from facilities one, two, three, four and five respectively (see Figure 9). Facilities four and five housed dogs on both CON and DCEM. Positive cultures were found only on DCEM (2/9, 22.2%) at facility four and only on CON (2/11, 18.2%) at facility five.

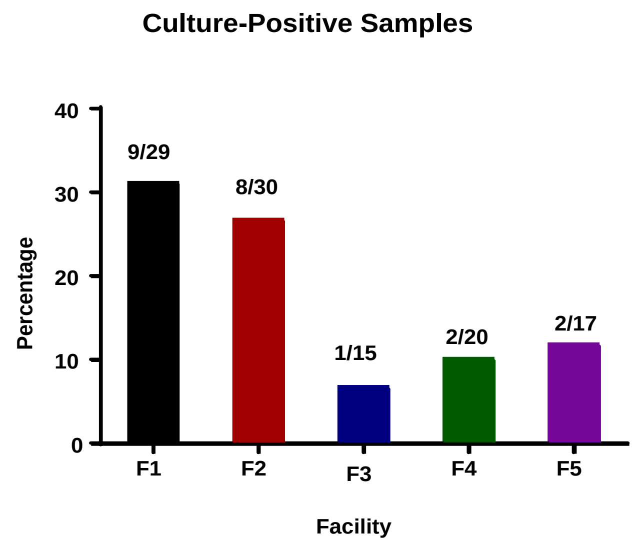

Figure 9: Percentage of culture-positive samples at each facility. Flooring types included: DCEM at facilities one, three, four and five; POLY at facility two, and CON at facilities four and five.

3.3 Discussion

The mean body condition scores in this study were ideal (mean (±SD) =3.2 ±0.5) across all five facilities; therefore, correlations between high BCS and the development of foot health problems could not be made. No further investigation concerning BCS and foot health was conducted. Further research on the impacts of BCS on foot health while on various flooring substrates and with different dog body sizes and conformations is needed to understand the relationship between these factors. However, these findings contradict many of the public reports that dogs in CB facilities are generally in poor body condition and show that ideal body condition can be achieved in CB facilities.

The most common elbow and hock problem found during this study was alopecia and there were also three dogs with calluses. These were observed mainly in large breed dogs (i.e. Rottweilers, Dog de Bordeaux or Weimaraners) or dogs with short hair. Alopecia and calluses on the elbows of large breed dogs are not uncommon, especially when they have increased contact with the ground (Boden, 2001). However, the fact that they were mostly found on the hocks and not the elbows in large dogs is unusual, and may be related to the dogs' resting positions in their kennels. Pregnant bitches may not spend much time in sternal recumbency, reducing the amount of contact elbows have with abrasive flooring. Dogs may have spent more time in lateral recumbency or in a sitting posture when resting, reducing the amount of pressure on elbows. These findings may be similar to those found in dairy cattle, which were found to have lower incidences of limb lesions when housed on warm surfaces compared to cold surfaces. The authors attributed this to cows lying in positions that increase the pressure on limbs to reduce the amount of heat loss from their bodies (Nygaard, 1978). It is possible that the resting posture dogs chose to adopt may have similarly influenced these results. However, this was not investigated in this study and further research assessing the time budgets of these dogs is necessary to understand how resting posture influenced the development of hock and elbow abnormalities. The abrasiveness of the flooring could also have impacted alopecia and callus development. Most of the large dogs were housed on concrete and the small breed short hair dogs were from facility one, which had only been established for a couple of years. This could mean short hair breeds from facility one were previously housed on abrasive surfaces as well. Similarly, a study in pigs found that sows housed on concrete slatted flooring were more likely to have wounds than sows housed on rubber slatted flooring (Díaz et al., 2013). This could mean that large breed dogs and those with shorter coats need different surfaces for resting than the surfaces currently used at the facilities assessed to avoid alopecia or calluses. Inflammation (n=1) or cutaneous lesions (n=2) could be due to other factors not assessed such as an injury from social conflicts, but this would also require further investigation observing the dogs' social interactions.

The first hypothesis was that foot health problems would increase and be more serious as time housed on flooring increased. This hypothesis was not supported by the facilities in this study as the length of time housed at the facility did not seem to influence foot health problems (see Figure 4). Facility one appeared to show an increased tendency of foot health problems with age; however, the facility had only been established for about two years, and the type of housing the dogs had prior to living at facility one was unknown. This is true for any dog that was not born at their facility. At facility four, only dogs housed for more than two years were affected by a foot health problem and there seemed to be a tendency of foot health problems increase with time housed at facility four; however, the total number of dogs at facility four was small (n=8) and definite tendencies were difficult to determine. Other studies that have assessed the development of foot problems or body injuries as a function of the flooring substrate have found issues within the first few months after the investigation began (e.g. dairy cattle, Boyle et al., 2007; sows, Elmore et al., 2010; turkeys, Martland, 1984). In the current study, dogs may not have shown any foot health problems for over a year. Foot health problems could be additionally impacted by other factors such as the management (i.e. cleaning) of the flooring types, the dog sizes/breeds, or a combination of the two. This may result in foot health problems after being housed on the respective flooring substrate for two years. Some foot health problems could also be due to the cleaning procedures and excess moisture in the kennels. The relationship between moisture and foot health problems has been found in turkeys housed on wet litter. Birds housed on wet litter developed pododermatitis and foot ulcerations faster than birds on normal litter (Martland, 1984), which suggests that wet surfaces can hasten the onset of foot health problems. In the current study seven dogs had erythema and 21 had inflammation, which could be precursors to more severe foot health problems such as pododermatitis. Dermatitis was seen in two of the dogs assessed. Additionally, excess moisture can predispose the skin to other infections by gradually softening the stratum corneum with continuous exposure (Miller et al., 2013). At all facilities floors were hosed down with water or water and a cleaning agent (e.g. J&J J-SPRAY XT® or WYSIWASH®, see materials and methods) without drying. At facility five excess moisture was pushed out using a squeegee, which may still leave the flooring slightly damp. It is possible that the excess moisture levels over the course of time resulted in some foot health problems, but this requires more investigation to determine a causal relationship. A study assessing more dogs with the same flooring types under similar and different management procedures is needed to understand how cleaning protocols can impact dog foot health over time. This will help anyone managing or regulating facilities to understand how different flooring types should be managed.

Another foot health problem observed was hyperkeratosis in one dog housed at facility two. This foot health problem has numerous etiologies such as hereditary, distemper virus, hypothyroidism, Zinc responsive dermatitis, pemphigus foliaceus, idiopathic, leishmaniasis, hepatocutaneous syndrome, papilloma virus infection or other causes (Koutinas et al., 2004; Kummel, 1990; Scott et al., 2001). Hyperkeratosis can lead to foot pad fissures (Miller et al., 2013), which was found in six dogs assessed, that may not cause pain in mild forms, but can become painful in more severe cases. This suggests that the hyperkeratosis observed could have been a precursor to other foot health problems observed, such as foot pad fissures.

It is possible that access to multiple flooring surfaces served as a protective factor against foot health problems in some of the facilities. At each facility many dogs had continuous access to two flooring substrates and most dogs had access to three. For instance, dogs at facilities four and five that were housed on CON for both indoor and outdoor kennel portions also had access to a grass play yard, while dogs with access to another indoor flooring type (i.e. DCEM or POLY) had additional access to outdoor CON kennel portions and natural surfaces in play yards. Each facility had varying amounts of access to outdoor play yards, which could have provided different levels of protection to foot health. Studies directly comparing the foot health of dogs housed on one flooring type compared to dogs with access to additional surfaces are needed to better understand the relationship between foot health and number of surfaces dogs are housed on or how frequently dogs have access to other surfaces. Lastly, some animal protection groups believe that dogs in CB facilities are housed on flooring types with improperly sized openings (HSUS, 2010). In this study, it is possible that the opening dimensions were appropriate for the foot size of the dogs housed. This could be why severe foot health problems were rare.

Understanding how factors such as cleaning products, time or frequency of access to other flooring surfaces, exposure to excess moisture or social interactions such as aggression additionally impact foot health in combination with flooring are important to understand. Further investigation comparing the current procedures to slight changes in one of the previously mention factors may provide understanding as to how they impact foot health. For example, a study keeping some dogs under the current facility management conditions and then slightly altering another group's time on other flooring surfaces could indicate how access to other flooring types impact foot health.

The most prominent foot health problem found was matted hair of the interdigital or palmoplantar regions. This was observed at facilities one, two, three and five. This appeared to be due to breed differences, as all the dogs at facility four were short coated breeds (Rottweilers) and short coated breeds at facilities one and five showed no matted foot hair. Therefore, matted foot hair was likely due to management of breeds with long hair and suggests a need to adequately trim foot hair in a timely fashion. Matted foot hair can trap moisture and debris close to the foot skin. Excess moisture over time can soften the stratum corneum (Miller et al., 2013) predisposing the skin to other infections. Moisture can also potentially alter the skin pH, which can result in other foot health problems (Matousek and Campbell, 2002; Oh and Oh, 2009).

Studies assessing dog foot pH are few, but in healthy dogs the foot skin pH has been found to range from 6.27 to 6.9 in the interdigital space (Breathnanch et al., 2010; Král and Schwartzman, 1964; Oh and Oh, 2009) and around 6.4 for the palmoplantar region (Breathnach et al., 2010). Oh and Oh (2009) and Breathnach et al. (2010) utilized a pH electrode when measuring dog foot pH, while the current study utilized moistened cotton swabs and pH test strips. Our technique may have been less accurate compared to those used in previous studies, which may be why all dogs assessed at facility two had a foot pH of 8.0. It may have been more difficult to detect subtle differences in pH with pH strips compared to pH electrodes. However, the mean pH values at facility four (6.7 ±0.2) and five (6.3 ±0.3) are comparable to previous studies, while mean pH values from facilities one (6.0 ±0.5), two (8.0 ±0) and three (7.8 ±0.3) were outside of what has been previously recorded. This could be due to differences in management, the time of year the data was collected or the breeds of dogs.

Matted foot hair also did not seem to influence foot pH values within facilities (see Figure 8). A multitude of factors can influence pH so there is no clear explanation for why pH at facilities one, two and three were outside of previously reported ranges. Different management procedures were utilized, different breeds were assessed and evaluations occurred during different seasons (facility one in spring, facilities two and three assed in summer and facilities four and five in winter). Any one of these factors or all of them could have contributed to our findings and the large variation may mean that pH is not a useful metric for assessing foot health in the field.

The final metric assessed was toenail length/health. This appeared to be normal across facilities, (see Table 5) indicating that the management of toenails used (i.e. regular trimmings) was effective at keeping them at an adequate length. Rear toenails seemed to be slightly shorter than front toenails, probably because dogs naturally push off with their rear feet when running (Elliot, 1983). This finding suggests that even if the kennel flooring type is not abrasive enough to allow natural grinding of toenails, regular trimming can be enough to keep them at a healthy length.

The second hypothesis was that visual dog body cleanliness scores (BCLS) and kennel cleanliness scores (KCLS) would be positively correlated. For both of these scales a score of 1 was considered clean and 5 was more than 75% of the dog's body or kennel flooring covered in debris. Because these data were highly collinear and did not follow a monotonic function, correlations could not be performed. A McNemar's test assessing agreement between the two scores was also not possible, because of the assumption of independence was violated, as each dog did not necessarily come from a unique kennel. However, both kennels and dogs visually appeared to be clean. Flooring types with openings were believed to allow for debris to pass through; therefore, keeping the environment relatively clean. Similarly, a study done in beef cattle found that animals housed on slatted flooring tended to be cleaner than those housed on solid flooring (Elmore et al., 2015). Another study in farm blue foxes found that animals housed on wire mesh flooring had cleaner pelts compared to those with access to sand flooring (Korhonen et al., 2003). However at facilities four and five, dogs housed on solid CON flooring were also clean. This indicates that management at these facilities and the dogs may be as important as the flooring choice for dog and environmental cleanliness. It is also possible that indoor-outdoor access allowed kennels and dogs to remain clean. Wagner et al. (2014) found that dogs housed in double compartment kennels in shelters were more likely to eliminate away from their resting area. Therefore, dogs may be likely to remain cleaner if they can eliminate away from the places they rest (i.e. indoors) to avoid resting near or in excrement. In conjunction with the requirement for facility owners to remove debris from kennels on a daily basis (USDA, 2013), sound management, allowing dogs outdoor access (i.e. outdoor kennel portions) and flooring surfaces that are easy to maintain may help to keep kennels and dogs clean.

The final hypothesis was that the majority of samples would not show evidence of fecal contamination after routine cleaning if the management procedures were effective at reducing fecal contamination. The current study supported this hypothesis for the five facilities examined. Although each facility had their own methods and two facilities had two different indoor flooring surfaces, the majority of kennels were negative for the recovery of *E.coli* (80.2%) after routine cleaning procedures were completed (see Figure 9). It could be argued that the technique was not effective at sampling *E.coli*. However, previous studies using electrostatic dry cloths have sampled *E. coli* (e.g. Murphy et al., 2010) and *Salmonella*, and have reported no issues with the electrostatic cloth's usefulness as a tool to sample the environment (e.g. Burgess et al., 2004; Ruple-Czerniak et al., 2013; Steneroden et al., 2011). Zewde et al., (2009) reported that the Swiffer ® cloth may not be as effective at sampling *Salmonella* from individual slats on slatted flooring in swine barns compared to the conventional drag method, but the difference in the number of positive samples between the electrostatic cloths compared to the conventional drag method was not statistically significant.

The cleaning procedures at all five facilities consisted of spraying organic material into the water filled pits or drains with hose lines containing water or water combined with some agent (e.g. WYSIWASH® at facility two or J&J J-SPRAY XT® at facilities one and five). For samples that were culture-positive, it is possible that *E.coli* could have aerosolized from nearby pens with fecal matter or from the pits below the kennels for DCEM and POLY flooring to a small degree during cleaning. However, samples were taken after routine cleaning rather than disinfection, so some positive samples were expected. Kennels at the facilities sampled seemed to have a low percentage of fecal contamination after cleaning. There was a wide range in the percentage of kennels showing fecal contamination across facilities suggesting that the cleaning procedures utilized at each facility had varying levels of effectiveness at reducing fecal contamination on their respective flooring types. The relatively low levels of fecal contamination can be related to the cleaning protocol, the frequency of disinfection and the behavior of the dogs themselves. Dogs may eliminate primarily in the outside portion of the kennel and it is possible that more fecal contamination exists in the outdoor kennel portions. This was not assessed in this study, but future studies looking at the dog's exposure to fecal contamination may want to additionally assess outdoor kennel portions.

Overall, the foot health of the dogs was normal for the majority of dogs assessed and all dogs and their indoor environments appeared clean as well. These findings are very different from reports that all dogs in CB operations are typically in poor physical condition and kept in squalid conditions (ASPCA, n.d.). It is important to note that there are limitations to this study mainly concerning generalizability of the findings. First, evaluating more animals, assessment of different breeds and dogs of various sizes and other flooring substrates are all important to better understand how flooring substrate impacts dog welfare. Second, this study assessed only Amish breeder kennels in Odon, Indiana. Amish breeders are an important and diverse part of the CB industry, but to fully understand the state of welfare in CB facilities, it is necessary to assess non-Amish breeding kennels in other areas inside and outside the state of Indiana.

Further, most of the licensed commercial dog breeders are in Missouri, Iowa, Ohio, Oklahoma, Indiana and Kansas (USDA, 2015b). Therefore, future studies must consider the possible influences that culture and geographic location (i.e. different weather conditions, religious beliefs, business styles, regulations or available resources) could have on CB facility management and dog welfare outcomes.

It is important to consider that all facilities in this study were recruited on a voluntary basis. As facilities containing dogs with obvious signs of foot health and cleanliness issues would not likely volunteer for this study, it is likely that this introduced selection bias towards the positive. However, this does additionally indicate that the public perception that body condition, foot health, and cleanliness are huge problems in every CB facility is not true. Additionally, it shows that low amounts of foot health and cleanliness problems are present in some CB facilities and is possible for all CB facilities.

It is also likely that by warning the facility owners about data collection in advance allowed some facility owners to treat any foot health or cleanliness issues. However, some problems were found even though facility owners knew the subjects in advance. Additionally, some aspects of foot health take time to be remedied (e.g. cutaneous lesions). Lastly, three of the facilities (facilities three, four and five) decided to participate at a later date and had minimal time to prepare (i.e. one or two days). Therefore, forewarning did not likely have a large influence on the results at these facilities.

Additionally, the effects of access to multiple and natural flooring substrates on dog foot health and general welfare are important to understand. It is unknown to what extent having access to natural surfaces, such as grass or another solid surface beyond concrete, can impact dog foot health. However, it is possible that these factors may protect dogs' feet from injury or disease. Piglets housed outdoors showed a lower incidence of foot health problems compared to piglets housed indoors on artificial flooring surfaces (Kilbride et al., 2009), suggesting that access to different or even natural surfaces may protect foot health.

Despite the limitations in generalizability, this study indicates that good body condition, foot health, environmental cleanliness and dog cleanliness can be achieved in commercial breeding facilities. Future studies should aim to assess additional aspects of dog physical welfare and behavioral welfare on various flooring surfaces to increase the current understanding on how flooring surfaces effect dog well-being.

CHAPTER 4. VISUAL EVALUATION OF DENTAL AND EAR HEALTH IN DOGS HOUSED IN COMMERCIAL BREEDING FACILITIES

The physical well-being of dogs, including dental and ear health, is believed to be extremely poor in commercial breeding (CB) facilities (HSVMA, 2013; n.d.). The most common dental health concern in CB kennels is periodontal disease (PD), which is one of the most common disease of dogs in the U.S. (Gorell, 1998; Kyllar and Witter, 2005). PD has been reported to affect about 80% of dogs over the age of two years (Harvey, 1998; Wiggs, 1997). However, early signs can begin around two to three years of age (AVMA, 2015). PD is defined as an infection of the periodontal membrane characterized by loosening and shedding of the teeth (Boden, 2001). The symptoms initially noticed by owners typically consist of excessive drooling and halitosis (Rice and Longfellow, 2003). However, other indications of dental disease can include pain, weight loss and failure to chew food (Boden, 2001). After initial symptoms are identified, more in-depth assessments such as dental probing under anesthesia and radiographs are usually performed in a clinical setting (Niemiec, 2008a). Dogs can experience gingival bleeding, inflammation, bone or tooth loss when they have periodontal disease (Niemiec, 2008b) and in severe cases, other systemic infections can also occur. Bacteria associated with PD can spread to other areas of the body causing liver, heart, kidney, lung and even brain damage (Niemiec, 2008b). There has also been an observed relationship between diabetes and periodontal disease (Niemiec, 2008b). Some organizations claim that breeding stock typically have severe PD (HSVMA, 2016). However, as with other health concerns in CB facilities, there are no studies to determine if such claims apply to all CB facilities or commonness of these issues. Studies have been conducted in other populations such as the general pet population, in specific facilities (i.e. research facilities), and in other countries (Harvey, 1994; Kyllar and Witter, 2005; Marshall et al., 2014). If any of the dental health issues exist in CB facilities that other organizations claim exist, this could pose a serious health risk to dogs in CB facilities.

Ear health issues are of equal concern in regards to the welfare of dogs in commercial breeding facilities. Otitis externa (inflammation of the external ear canal) is a common ear problem affecting around 3-20% of dogs (Logas, 1994; Stout-Graham et al., 1990; Święcicka et al., 2015), which can eventually lead to other conditions (i.e. otitis media or otitis interna) (Harvey and Paterson, 2014; McKeever and Torres, 1997). Otitis externa occurs more in older dogs, but any dog can be affected and certain breeds, such as Cocker Spaniels, tend to be at a greater risk (Angus et al., 2002) due to having more apocrine glands in the ear canal or with pendulum type pinnae (Barrasa et al., 2000; McKeever and Torres, 1997; Stout-Graham et al., 1990). Predisposing factors for otitis externa include excess moisture in the ear canal or pinna conformation; primary causes include grass awns, various microorganisms (e.g. increased *Malassezia* growth), ectoparasites, dermatological issues, foreign substances in the ear and food allergies; and perpetuating factors include inflammation or other pathological changes (Carlotti, 1991; Harvey and Paterson, 2014; Saridomichelakis et al., 2007). Dogs with otitis externa sometimes show repeated head shaking, pawing or digging at the ear, causing trauma which can manifest as cutaneous lesions on the pinna, pain, redness and/or inflammation of the ear canal. Dogs may even have a foul smell in the ear (Harvey and Paterson, 2014; Rice and Longfellow, 2003). These symptoms typically result in further examination such as cytology and examinations using otoscopes for diagnosis (Harvey et al., 2001). Claims that breeding stock typically receive poor grooming, impacting comfort, normal movement and eye and ear health are common perceptions (HSVMA, 2016). If ear health is poor in CB facilities, not only might dogs experience pain and be at risk for hearing loss and damage to the tympanic membrane, but this can eventually result in neurologic issues (Harvey et al., 2001; Harvey and Patterson, 2014; Święcicka et al., 2015). There are breed differences in ear health problems (e.g. increased likelihood in Cocker Spaniels), but selecting against dogs with histories of ear disease can help improve the health of dogs in CB operations and the pet population through genetic means. Additionally, reducing exposure to other risk factors (e.g. excess ear canal moisture and allergen exposure) can protect dog ear health.

Preventive Care

It is important to understand the current state of dog physical welfare in CB facilities in regards to dental and ear health. These health metrics can be impacted by environmental and genetic factors, but one of the most important ways to promote good physical health is through preventive care. Generally, preventive care is the most effective way to slow the development of PD. Regular brushing (daily brushing is recommended, but sometimes several times a week is enough), abrasive foods to provide mechanical cleaning, other dental products (e.g. dental sprays), water/ food additives, toys, dental treats and yearly veterinary dental exams are all typically recommended options (AVMA, 2015; Gorell, 1998; Harvey, 1998; Harvey et al., 1996; Watson, 1994). The American Veterinary Dental College (AVDC) also states that chlorhexidine rinses and gels work well at reducing plaque accumulation, which has been shown to slow the development of calculus, plaque, and gingivitis in laboratory Beagles (Hamp et al., 1973). Antimicrobial substances (e.g. metronidazole, clindamycin and vancomycin) have also shown varying abilities to slow plaque formation (Heijl and Lindhe, 1979), but not prevent it. Ultimately, some cases need dental scaling under anesthesia for removal of plaque and calculus in the subgingival area and on tooth surfaces using ultrasonic and sharpened scaling tools (Niemiec, 2008b). This procedure is followed by polishing the tooth surfaces (Niemiec, 2008b). Non-anesthetic dental scaling holds potential danger for the dog and the individual performing the procedure. This is because the use of sharp objects can cause injury to the dog even with slight head movement, in which case the dog may bite the person performing the scaling (AVDC). It also prevents a full assessment of all tooth surfaces, including the subgingival area where periodontal disease occurs (AVDC). Additionally, scaling without polishing can leave the tooth surface rough, which can hasten the attachment of plaque (Niemiec, 2008c). The degree of preventive care and techniques that are commonly used are unclear in the CB industry and require further investigation.

Cleaning the ear canal using mechanical methods with approved solutions or irrigation by a veterinarian can help keep ears healthy and prevent excess cerumen (a combination of sebaceous and ceruminous gland secretions with epithelial cells, commonly referred to as earwax) build-up (Harvey et al., 2001; Harvey and Paterson, 2014). The type of solution used can vary depending on whether tympanic damage has occurred and on the characteristics of ear discharge. Also removing excess hair may be necessary for some breeds as hair may trap debris and increase the risk of ear canal blockage. Factors such as moisture can increase the risk of conditions like otitis externa; therefore, drying agents are often recommended after cleaning. Additionally, if the tympanic membrane has suffered damage, certain solutions or pressure from water can worsen damage (Harvey and Paterson, 2014).

The type of preventive care and the technique used to administer it can impact the dental and ear health of dogs. Since dogs in CB facilities are either kept as breeding stock or temporarily kept until later sale as pets, the health of dogs in the CB industry can additionally impact dogs in the pet population. Additionally, CB facilities may have other special considerations in regards to dental and ear health such as how the welfare of bitches and their offspring is impacted.

Dental and Ear Health Implications for Dogs in Commercial Breeding Facilities

The pain and discomfort associated with dental and ear disease can affect dog behavior (e.g. reduce food consumption or increased head shaking) and cause suffering and other systemic infections. Effects of poor dental and ear care can affect puppies as well as breeding dogs. For example, the bacteria that cause periodontal disease have been associated with low birth weight and premature birth in humans and stunted fetal growth in mice (Lin et al., 2003; López et al., 2002). This is important for dog breeders to understand because proper preventive care can impact the health of breeding bitches and their offspring. In addition to possible negative effects on fetuses, bitches with periodontal disease may have decreased food intake due to pain, thus affecting the nutrition of both the bitch and unborn puppies (Hefner, 2015). Decreased food intake can also impact body condition of any of the dogs housed and compromise dog welfare. Currently, little is known about the preventive care practices or the current state of dental and ear health in CB facilities. However, both can have a significant impact on health in the pet population as future owners and caregivers can become responsible for medical expenses.

Typically, when evaluating dental or ear health, methods such as dental probing under anesthesia, radiographs, ear cytology or examinations using otoscopes (Harvey et al., 2001; Niemiec, 2008a) are used for diagnosis. However, having the ability for owners or caretakers to periodically assess dogs in a high volume commercial breeding facilities can help to identify issues at an early stage. Therefore, simple but valid visual assessments of dental and ear health can provide caretakers with tools for periodic physical welfare assessments and can aid in characterizing the welfare of dogs in commercial breeding operations and in determining if veterinary intervention is necessary. This study aimed to characterize dog dental and ear health in CB facilities. This study also aimed to assess other risk factors such as age, breed size and body condition score. The hypotheses were that 1) periodontal disease would increase as age increased and as dog size decreased and that 2) dogs exhibiting pendulous ears and larger amounts of hair in the ear canals would have more ear health problems than dogs without these traits breeds.

This study provided insight on the state of dental and ear health in CB facilities. Additionally, simple physical welfare metrics that can be done visually are provided for auditors, facility owners and caretakers to utilize in monitoring the welfare of dogs in CB operations.

4.1 Materials and Methods

4.1.1 Subjects

The same commercial breeding facilities used in the previous experiment in chapter three were recruited for participation to assess dog dental and ear health. Data at facilities two and three were collected at a later date than data from the previous chapter due to the addition of this portion of the study after initial data collection (August 2015 for chapter three data and December 2015 for dental and ear health). Additionally, some animals were not available for assessment due to being close to whelping or nursing puppies. Thirteen breeds of dogs were examined (N=101, facility one =30 dogs, facility two =23 dogs, facility three =20 dogs, facility four =8 dogs and facility five =20 dogs) (see Table 6).

Table 6: Breed distribution, age mean (±SD) and range, and sex distribution by breed.

Facility	Breed	Sex	Age (months)
1	Yorkshire Terrier (10)	F(8) M(2)	37.8 (±19.2), 13-79
	Maltese (12)	F (11) M (1)	
	Miniature Pinscher (8)	F (6) M (2)	
2	Miniature Schnauzer (10)	F(6) M (4)	30.6 (±23.3), 12-118
	Havanese (9)	F (8) M (1)	
	Coton de Tulears (4)	F (3) M (1)	
3	Lhasa Apsos (13)	F (11) M (2)	42.0 (±17.4), 17-74
	Miniature Australian Shepherds (7)	F (7) M (0)	
4	Rottweiler (8)	F(5) M (3)	38.4 (±15.7), 20-65
5	Weimaraner (7)	F(5) M (2)	38.9 (±15.0), 14-65
	Wheaton Terrier (7)	F(6) M (1)	
	Dog de Bordeaux (1)	F(0) M (1)	
	Pembroke Welsh Corgi (5)	F(4) M (1)	

4.1.2 Dog Metrics

Physical examinations to assess body condition score, periodontal disease (PD) and ear health were conducted by a licensed veterinarian and a separate experimenter served as the written recorder. Dogs were only visually assessed due to the restriction of working in the field. Therefore, other diagnostic procedures such as dental probing, radiographs, cytology or otoscope exams were not utilized.

Body Condition Score

Dogs were scored for body condition using a 1-5 scale from the Ohio State University Veterinary Medical Center. A score of 1 was considered emaciated, 3 was ideal and a score 5 was obese.

Dental Health

Scale was borrowed from the American Veterinary Dental College (AVDC) and used for visual assessment of periodontal disease (see Appendix Table A.4). Dogs were scored for periodontal disease using a scale of 0-4 (dental grade 0= normal gum and minimal to no calculus and 4= severe gingival inflammation, recession, loose or missing teeth, pus, gums that easily bled, and large amounts of calculus).

Ear Health

Visual assessments were developed by the experimenters (see Appendix A.5 and A.6). Ear health was assessed on a scale of 1-4 for debris in the ears (1= ear canal was clean and free from debris and 4= debris was completely blocking the canal making it impossible to see without its removal). Ear health was also assessed on a scale of 1-4 for excess hair in the ears (1= ear canal had no excess hair and 4= severe amounts of excess hair) and on a scale of 1-4 for inflammation and swelling in the ears (1= skin of ear was normal and free from inflammation with no pain present and was not hot to the touch and 4= skin showed severe erythema and inflammation with pain present and skin was hot to the touch).

4.1.3 Facility Metrics

Management information (e.g. preventive dental and ear care practices, diet, treatment provided and person providing treatment) was collected through a brief interview with the facility owners.

Diets

All adult dogs were fed commercially prepared diets (see Appendix C for more detail).

Dental Care

Dental care included adding chlorhexidine into the drinking water, visual assessments by facility owners, and the use of commercial available products. Facility one added chlorhexidine into the drinking water approximately four times per week. Dogs were visually assessed twice per year and scored by the owner using the dental assessment from the Board of Animal Health in the state of Indiana (BOAH, 2015). If the owner felt that a dog's dental health required more attention the attending veterinarian was consulted, and any treatment deemed necessary by the veterinarian was provided. At facility two, chlorhexidine was also added into the drinking water two to three days a week at about 1 mL of chlorhexidine per gallon of water. The owner stated that dental health was graded by the owner three to four times per year using the dental assessment provided by the Board of Animal Health in the state of Indiana (BOAH, 2015). Any dog that scored a 3 or more was provided additional veterinary care. The owner of facility three assessed teeth every two weeks and utilized Plaque Attack Spray ® (by Exceptional Products, Inc). During checks, the owner occasionally would scrape loose plaque off with his fingernail. The attending veterinarian was called when the owner believed dental health required medical attention and recommended care was provided. At facility four, chlorhexidine was added into the water three to four days a week. Dogs were additionally provided with Kongs® (by Kong) to chew on. Teeth were assessed by the owner using the Blue Ribbon scale (not readily available) every three months. If the caretaker or owner felt any dog's teeth were in poor condition, then the attending veterinarian was consulted. Any advice from the veterinarian was followed, and if advised by the veterinarian, the owner provided clindamycin hydrochloride capsules. The owner also manually scaled plaque with a dental scaling tool or fingernail. Facility five provided Vet Basics® Enzymatic Dental Chews (by Revival Animal Health). Every three months teeth were checked by the owner using the dental assessment provided by the Board of Animal Health in the state of Indiana (BOAH, 2015). If the owner felt that a dog required additional medical attention, the attending veterinarian was consulted and veterinary recommendations were followed.

Ear Care

Ear care included regular grooming and the use of medicated solutions. At facility one, ears were cleaned approximately every eight weeks or as needed. If the owner determined there was a problem then veterinary care was provided. Ear hair was also trimmed during regular grooming and plucked as needed every eight weeks. At facility two, ear hair was trimmed as much as possible with shears, and four times a year one drop of Ivomec® solution was placed in the dogs' ears. At facility three, ears were plucked every eight weeks during grooming, and were also checked every two weeks. At facility four, ears were checked every three to four weeks and cleaned as needed. At facility five, ear hair was clipped as much as possible during grooming, which occurred about three times per year. During grooming, Ket Flush ® (by Butler Schein™ Animal Health) a ketoconazole-EDTA-Tris Multicleanse Topical Flush was used.

4.1.4 Analysis

Descriptive statistics were used to represent dental and ear health findings due to large variation between breeds and facility management and stratified by facility. Data on breed and sex distribution and age mean (±SD) and range are presented for each facility in table 5. Descriptive statistics (i.e. means (±SD) and ranges) were conducted using STATA IC 11 ® statistical software and graphs were created using GraphPad Prism® version 6.00 software.

4.2 Results

4.2.1 Body Condition Score

The mean (±SD) body condition score at each of the five facilities is shown in table 7. Since body condition score was ideal across all facilities for the majority of dogs, no further investigation was conducted.

Table 7: Mean (±SD) Body Condition Score by facility

Facility	n	Body Condition Score mean (±SD)
1	30	3.0 (±0.7)
2	23	3.2 (±0.5)
3	20	3.5 (±0.7)
4	8	3.2 (±0.4)
5	20	3.2 (±0.5)

4.2.2 Dental Health

There were 23/100 (23%) dogs that had a periodontal disease (PD) grade of 0, 48/100 (48%) dogs had a PD grade of 1, 19/100 (19%) dogs had a PD grade of 2, 4/100 (4%) had a PD of 3 and 6/100 (6%) dogs had a PD grade of 4 (dental grade missing from one dog at facility five as exam was ceased early due to distress). One dog at facility two did not have any teeth and was assigned a dental grade of 4, as the reason for pulling teeth is an indicator of previous severe dental health issues. However, no medical record search to determine the reason why teeth were pulled was conducted.

Table 8: Percentage of dogs by periodontal disease severity and facility

Dental Grade	Facility 1 (n=30)		Facility 2 (n=23)		Facility 3 (n=20)		Facility 4 (n=8)		Facility 5 (n=19)	
	Number Affected	%	Number Affected	%	Number Affected	%	Number Affected	%	Number Affected	%
0	8	26.7	6	26.1	4	20.0	3	37.5	2	10.5
1	6	20.0	14	60.9	12	60.0	5	62.5	11	57.9
2	10	33.3	2	8.7	3	15.0	0	0	4	21.1
3	3	10.0	0	0	1	5.0	0	0	0	0
4	3	10.0	1	4.4	0	0	0	0	2	10.5

4.2.3 Dental Grade and Age

There was not a tendency of increasing periodontal disease severity with increasing age (see Figures 10-15), as many of the dogs assessed were relatively young.

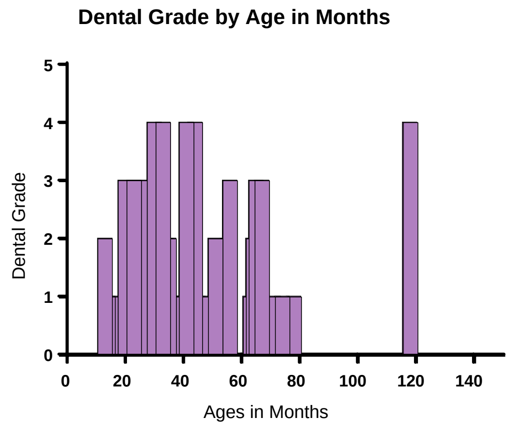

Figure 10: Dental grade by age including all individuals at each facilities.

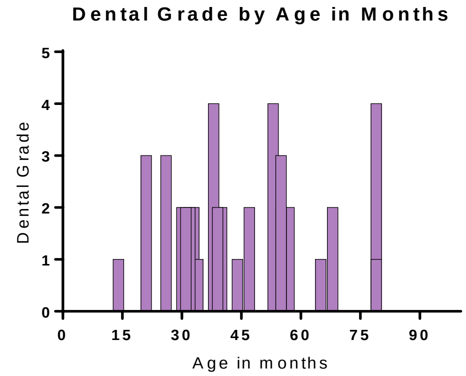

Figure 11: Dental grade by age in months at facility one

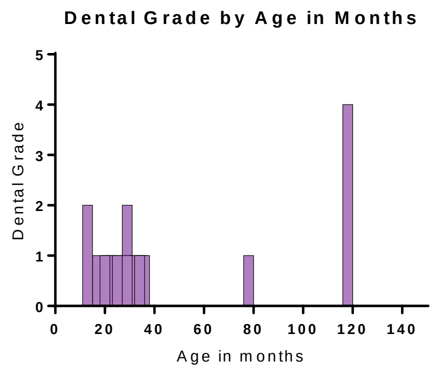

Figure 12: Dental grade by age in months at facility two.

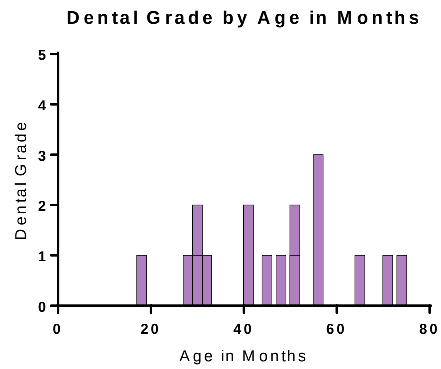

Figure 13: Dental grade by age in months at facility three.

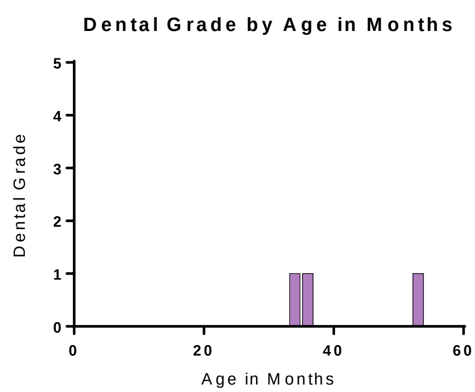

Figure 14: Dental grade by age in months at facility four.

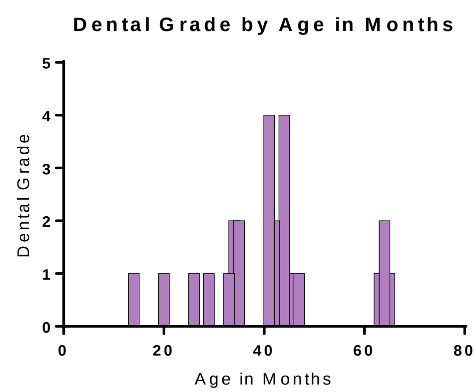

Figure 15: Dental grade by age in months at facility five. Score missing from one dog

4.2.4 Dental Grade by Breed/Dog Size

Small size has been reported to be a risk factor for periodontal disease (e.g. Kyllar and Witter, 2005). Figure 16 shows the dental grade by breed. In this study, breeds weighing 20lbs or less were considered small, breeds 21 to 45lbs were considered medium and dogs over 45lbs were considered large. Breeds receiving the highest dental grades were small or medium breeds; therefore, figure 17 shows dental grade based on breed size categories. Of the 29 dogs receiving a grade 2 or more none were large breed dogs, six were medium sized dogs and 23 were small breed dogs across all facilities. Large breed dogs received dental grades of 0 or 1, medium breeds received dental grades 0, 1, 2 and 4 and small breeds received all dental grades. The number of dogs receiving a dental grade of 4 (severe periodontitis) was low (n=6) and the number of small breed dogs was much more than the number of medium of large breed dogs assessed. However, there was a tendency towards large breed dogs having better dental health than small breed dogs. Facilities one, two and three housed small dogs; facility four housed large dogs; and facility five housed medium and large dogs. Facility five was the only facility where dogs of different sizes were housed under the same management (see Appendix Figure E.3).

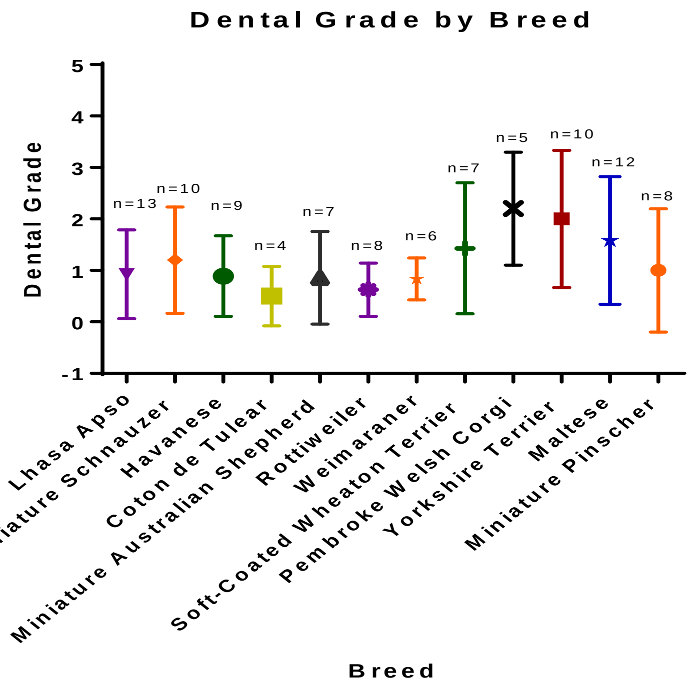

Figure 16: Mean (±SD) dental grade by breed. There was only one Dog de Bordeaux with a dental grade of 1.

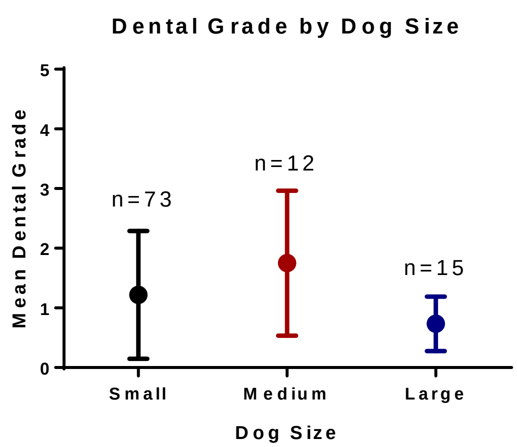

Figure 17: Dental grade for all dogs by dog size: 1= small (≤20lbs); 2=medium (21-45lbs) and 3=large (>45lbs)

4.2.5 Ear Health

The majority of dogs at each facility received a score of one for either ear debris or erythema (see Tables 9 and 10) or excess hair. Two dogs scored an excess ear debris and hair score of 3. These dogs were housed at facility 3 and where both Lhasa Apsos. Overall, 28/101 (27.7%) dogs showed excess ear debris (mostly long hair breeds), 23/101 (22.8%) dogs showed excess hair and 9/101 (8.9%) dogs showed ear erythema.

Table 9: Percentage of dogs in each category for excess ear debris by facility

Score	Ear	Facility 1 (n=30)		Facility 2 (n=23)		Facility 3 (n=20)		Facility 4 (n=8)		Facility 5 (n=20)	
		Number Affected	%	Number Affected	%	Number Affected	%	Number Affected	%	Number Affected	%
1	**L**	27	90.0	14	60.9	10	50.0	8	100.0	16	80.0
	R	27	90.0	15	65.2	10	50.0	8	100.0	18	90.0
2	**L**	3	10.0	9	39.1	8	40.0	0	0	4	20.0
	R	3	10.0	8	34.8	8	40.0	0	0	2	10.0
3	**L**	0	0	0	0	2	10.0	0	0	0	0
	R	0	0	0	0	2	10.0	0	0	0	0
4	**L**	0	0	0	0	0	0	0	0	0	0
	R	0	0	0	0	0	0	0	0	0	0

Table 10: Percentage of dogs in each ear erythema category by facility

Score	Ear	Facility 1 (n=30)		Facility 2 (n=23)		Facility 3 (n=20)		Facility 4 (n=8)		Facility 5 (n=20)	
		Number Affected	%	Number Affected	%	Number Affected	%	Number Affected	%	Number Affected	%
1	L	30	100.0	21	91.3	14	70.0	8	100.0	19	95.0
	R	30	100.0	22	95.7	15	75.0	8	100.0	18	90.0
2	L	0	0	1	4.4	6	30.0	0	0	1	5.0
	R	0	0	0	0	5	25.0	0	0	2	10.0
3	L	0	0	0	0	0	0	0	0	0	0
	R	0	0	0	0	0	0	0	0	0	0
4	L	0	0	0	0	0	0	0	0	0	0
	R	0	0	0	0	0	0	0	0	0	0

4.3 Discussion

Dogs with periodontal disease (PD) may show decreased food consumption and have a low body condition scores (BCS). However, it was not possible to determine this association because most dogs had an ideal BCS (i.e. BCS=3).

The first hypothesis that PD would increase as age increased and as dog size decreased. PD did not increase with age in this study, which does not agree with previous reports of PD worsening with increased age (Hoffman and Gaengler, 1996). However, this is likely because the dogs in this study were skewed towards younger animals, which was not surprising since these dogs were utilized for breeding purposes. This could potentially reduce the ability to see increasing dental grade with increasing age as most dogs were around age three and may have been too young to show more severe signs of PD (dental grade 2 or more). The majority of dogs assessed scored a grade 0 or 1 for PD, with 23/100 (23%) dogs scoring a grade 0 and 48/100 (48%) scoring a grade 1. Overall, younger dogs combined with preventive care may have reduced the risk for severe periodontal disease in most dogs. It is important to note that dogs scoring a dental grade of 1 showed evidence of gingivitis, which may lead to more severe PD if intervention is not provided. This shows that many of the dogs assessed do have dental health concerns even if gingivitis does not cause permanent damage if treated.

Preventive care is another important factor that impacts dental health and every facility provided some degree of care. Three of the facilities added chlorhexidine to the drinking water. Chlorhexidine administered with a syringe or spraying with a plastic bottle to the teeth and gingivae has been shown to reduce the progression of PD in some studies using a small number of laboratory Beagles (Hamp et al., 1973; Tepe et al., 1983), but further study on its effectiveness as a water additive and its impacts on long term dog health must be conducted. Two facilities provided dogs with chewable items (Kongs® at facility four and enzymatic dental chews at facility five). Chewable toys and dental items have been reported to reduce the risk of PD in dogs (Harvey et al., 1996), and likely helped some dogs in these facilities to avoid serious dental health problems.

It is possible that the scoring method used in this study may have contributed to many dogs scoring low on the dental grade scale. Previous studies have assessed dental health by using radiographs and/or dental probing under general anesthesia (e.g. Butovic et al., 2001; Harvey et al., 1994; Tepe et al., 1983), which were not done in the current study. Therefore, it is possible that certain signs of PD (e.g. deep pockets) were missed during visual scoring. However, because visual assessments are useful in the field for facility owners and anyone else assessing dog dental health without extra diagnostic equipment, further studies should aim to validate visual assessments against more in-depth diagnostics. Ideally, a visual assessment showing any concerns for dog dental health should be followed up with a more in-depth examination and treatment, but accurate initial assessments are necessary to allow for timely allotment of veterinary care.

Another factor associated with dental health previously mentioned is the size of the dog. Larger breed dogs (i.e. Rottweillers, Weimaraners and one Dog de Bordeaux) tended to have lower dental grades (grades 0 and 1). Despite many confounding factors (i.e. preventive care, breed, diet, and age), larger breed dogs appeared to have better dental health. These results are similar to previous studies that reported fewer dental concerns with increasing dog size (Hamp et al., 1984; Harvey et al., 1994; Kyllar and Witter, 2005). However, it is also possible that dogs of a smaller size had an increased chance of showing severe periodontal disease because the majority of dogs assessed were small (≤20lbs).

The overall findings on dental health in this study suggest that breed size is associated with PD severity. However, a study that controls for several confounding factors such as age, diet, preventive care, number of dogs in different breed size categories and breed along with a validated visual scoring tool assessing PD are necessary to accurately characterize periodontal disease in dogs housed at CB facilities. Additionally, the facility owners in this study did their own evaluations and then consulted a veterinarian when they felt it was necessary. More work must also be done to understand the facility owners' or primary caretakers' abilities to rate the dental health of their dogs. This study does indicate that preventive dental care is present in some commercial breeding facilities and that it is possible for the many dogs to have no evidence of periodontal disease or gingivitis, which if treated damage is reversible (i.e. gingivitis).

The second hypothesis that dogs exhibiting pendulous ears and larger amounts of hair in the ear canals would have more ear health problems than dogs without these traits was supported by this study. Ear debris, excess hair in the ear canals and ear erythema was ideal (score 1) for the majority of dogs in the study. However, dogs that had higher ear health scores were typically dog breeds prone to more ear hair. There was some degree of ear care at each facility, such as plucking or trimming excess ear hair during grooming every eight weeks or as needed (see Materials and Methods: Ear Care). Some facilities provided ear drops such as Ivomec® solution or Ket Flush ® a ketoconazole-EDTA-Tris Multicleanse Topical Flush. Ivomec® is typically used for treating ear mites and may not provide any additional protection against other ear health issues if ear mites are not the cause (e.g. otitis externa). Ket Flush® is also provided to treat specific conditions and providing it as part of a normal regiment may not improve ear health. Providing medicated ear treatment without understanding the cause of the disease may not resolve any issues. Additionally, overuse of antibiotics has been reported to be a predisposing factor for otitis externa (Harvey and Paterson, 2014). Thus, using medicated solutions outside of the condition it was meant to treat could be detrimental to dog ear health. Regular cleaning is one of the most effective ways to promote ear health so cleaning using a normal solution and drying agent may be a more effective way of providing preventive care. Despite, the different uses of various solutions the measures in place appeared to support ear health in the majority of dogs.

Some predisposing factors for ear health problems include having pendulous pinnae, being a dog prone excess hair in ear canals, having excess moisture in the ear canals or having more ceruminous glands (Harvey and Patterson, 2014; McKeever and Torres, 1997; Saridomichelakis et al., 2007; Stout-Graham et al., 1990). It is likely that many of the dogs assessed did not have some of the predisposing factors for ear health concerns and that the ear care provided resulted in many dogs not having any ear health issues. However, there were some dogs that showed excess debris and hair in the ear canals, mainly long haired breeds that may require increased monitoring or more frequent care.

The ages of the dogs in this study could also have influenced ear health. Subjects were tended to be younger dogs. It has been suggested that common ear health problems (i.e. otitis externa) are more likely to be found in older dogs especially those between five and eight years (McKeever and Torres, 1997; Stout-Graham et al., 1990). There was no increase in ear health scores in dogs over 60 months of age in this study, but there were only 14 dogs in this category. Preventive care is likely the most important factor influencing ear health, which is likely why most of the dogs showed ideal ear health or mild ear health concerns for erythema, excess debris and excess hair in the ear canal (scores of 1= ideal or 2=mild).

It is important to consider that all facilities in this study were recruited on a voluntary basis. As facilities containing dogs with obvious signs of physical health issues would not likely volunteer for this study, it is likely that this introduced selection bias towards the positive. However, this does additionally indicate that the public perception that severe periodontal disease and poor grooming are present in almost all breeding stock in every CB facility is not true and that good health is possible in CB facilities.

It is also likely that by warning the facility owners about the study in advance may have allowed some facility owners to remedy any health issues. However, some problems were found even if facility owners knew the subjects in advance. Additionally, some aspects of dental health take time to be remedied (e.g. dental prophylaxis). Lastly, three of the facilities (facilities three, four and five) decided to participate at a later date and had minimal time to prepare (i.e. one or two days). Therefore, forewarning did not likely have a large influence on the results at these facilities.

Overall, the presence of dental and ear care management within these facilities contradict many of the reports that dogs in CB facilities receive minimal or no attention in regards to these aspects of care. Following the progression of PD over time may have shown increases in PD as the dogs aged, and possibly a cohort study could have indicated how different management techniques influence the progression of PD.

The preventive care provided may also have helped to improve ear health scores. In addition, the fact that the majority of dogs had no of ear health issues was likely due to the provision of preventative care or having some breeds not prone to ear health conditions (i.e. low levels of ear hair in short coat breeds). The visual assessment of ear health may help facility owners to monitor the well-being of their dogs, allowing them to provide appropriate intervention and adjust preventive care techniques to promote ideal ear health.

Future studies should aim to expand this work at other facilities in other geographical regions outside of Southern Indiana. An additional area for future research would be to assess the facility owner's ability to evaluate the health of their own animals in order for these tools to become useful for facility owners and caretakers. More facilities are needed in order to understand the current state of dental and ear health in CB facilities in the U.S. and to assess the impacts of different forms of preventive care on dog welfare.

CHAPTER 5. CONCLUSIONS AND IMPLICATIONS

To understand dog welfare in CB kennels, this project started with under-investigated areas of the physical environment and dog physical health in dogs from five Indiana CB facilities. The aims of this study were: 1) to characterize dog foot health in CB facilities as a function of the length of time dogs were housed on diamond-shaped coated expanded metal, polypropylene or concrete flooring types; 2) to characterize visual dog body cleanliness and kennel cleanliness as a function of the flooring substrate; 3) to determine the efficacy of kennel cleaning procedures and 4) to characterize dog dental and ear health in CB facilities.

Flooring, Foot Health and Dog and Environmental Cleanliness

Findings indicated that dog elbow, hock and foot health as well as dog and kennel cleanliness are largely impacted by the management of the flooring types examined and the dogs housed in conjunction with the flooring type itself. Studies on foot health in other species have yielded mixed results, which may be due to management differences. For example, some studies looking at claw health in dairy cattle housed on different flooring substrates had different findings based on either concrete or rubber flooring types, likely because of management differences such as placement of the flooring substrates. In a study by Boyle et al., (2007), there was no difference in claw health in cattle provided concrete compared to rubber passageways. However, another study by Eicher et al., (2013) reported fewer hoof health problems in cattle housed on rubber flooring in freestall barns compared to concrete flooring. The different results between the two studies could be due to many management factors such as the placement of the flooring types. Much like the current study, management likely had a large impact on the results such as the provision of access to multiple flooring substrates. Only the indoor flooring substrates were examined, but these dogs had access to outdoor portions with concrete flooring and varying access to play yards containing natural surfaces. This may have additionally impacted foot health as dogs housed on one flooring type could have a different foot health profile than dogs housed on multiple flooring surfaces. This has not been investigated in dogs, but is important for future studies to consider. The results of this study attest to the need for additional research in commercial breeding facilities to understand how similar flooring substrates impact dog well-being under different management styles. Foot health issues may have also been due to other factors that were neither controlled for nor not assessed (e.g. social interactions or time spent on outdoor kennel flooring versus indoor kennel flooring). Further studies investigating other factors impacting foot health in addition to flooring substrate can aid in clarifying which dog or management practice factors impact foot health and to what degree. Additionally, to further assess how flooring impacts dog welfare, it is important to examine other influencing factors outside of physical health and cleanliness, such as the dogs' abilities to exercise a normal gait, risks for slipping, abilities to display certain postures, or comfort levels.

Dental and Ear Health

Although findings concerning age and periodontal disease (PD) did not agree with previous studies (e.g. Hoffman and Gaengler, 1996), the dogs tended to be about three years of age and may have been too young to show evidence of severe PD. All dogs within a facility received the same dental care, but monitoring dogs to ensure they are responding well is important. Attention to dental health is important when determining what preventive care works best for promoting ideal dental health. Therefore, educating owners that some dogs may not respond well to their standard preventive care and require extra attention is important.

More severe PD was more common in small and medium sized dogs than in large dogs, as none of the large breed dogs (>45lbs.) assessed scored more than one for PD. Previous studies have found PD to be more common with decreasing dog size (e.g. Harvey et al., 1994), indicating that dental health may need more aggressive management in kennels housing smaller breed dogs. In the current study, there was variation in the number of large dogs (n=15) compared to small dogs (n=73). The number of small compared to large dogs may have contributed to the different tendencies in PD between the different dog sizes. Assessment of dogs in CB facilities with more dogs of different sizes under similar management is necessary to further understand the association between dog size and dental health.

Preventive care also impacts PD. Previous studies investigating the provision of preventive care such as chlorhexidine rinses (Hamp et al., 1973) and dental chews (Clarke et al., 2011) found significant differences in dental health between animals provided with dental care and those that were not. Findings from the current study suggest that the preventive care was effective for dogs who had no evidence of PD. The results further indicated that preventive care did not protect all dogs from gingivitis or PD as it was still observed. Therefore, these facilities may need to consider alternative preventive dental care for some dogs who still showed evidence of gingivitis or PD, while still receiving preventive care. As daily brushing is considered the optimal form of dental care, an intervention that comes as close to daily brushing as possible may be necessary to protect some dogs.

Many dogs had ideal ear health indicating low risks for developing ear health problems that can lead to more serious health concerns (i.e. hearing loss or neurologic disorders). This is likely due to the preventive care provided at each facility. However, dogs with long hair tended to have excess ear debris and excess hair in the ear canal, indicating that facility owners may need to tailor ear care to the individual dog and increase the monitoring of dogs prone to excess ear hair.

It is possible that more in-depth diagnostics could have revealed more severe degrees of PD that visual assessments alone could not. However, visual assessments can also provide a tool for a variety of facility owners (i.e. shelter or research facilities) to perform self-assessments that allow for the monitoring of dental and ear health. This can allow for better allocation of resources (i.e. veterinary attention) and can help facility owners determine what preventive care procedures have the most positive impact on dog welfare. Overall, influences of different preventive care practices must be assessed to determine their effectiveness for the dental and ear health of dogs in CB facilities. Additionally, examining how visual scales compare to more in-depth diagnostic metrics (i.e. dental probing or radiographs) is important if visual assessments are to be a reliable tool in assessing the physical welfare of dogs. Also emphasizing the importance for owners to self-monitor their dogs can ensure that both dental and ear health are treated in a timely manner.

Future Recommendations

The amount of unknown information about physical welfare of dogs in CB facilities is vast, but this study has shown that the flooring types examined did not appear inherently detrimental to dog welfare and foot health is likely impacted by flooring as well as other management and dog factors. In addition, management factors (i.e. cleaning or access to multiple flooring types) may greatly influence cleanliness and dog health. This study also showed that, in the facilities examined, some dogs did have evidence of PD or ear health concerns, indicating that preventive care practices protected the health of many, but not all of the dogs assessed. The facility owners for this study were recruited on a voluntary basis. This likely introduced bias and skewed results towards positive outcomes, as facilities that have obvious signs of poor physical dog welfare and environmental cleanliness would not likely volunteer for this study. However, this study indicated that facilities with high levels of dog and environmental cleanliness and good dog health are obtainable.

Expanding research to other CB facilities that have different management styles, breeds, dog sizes, flooring substrates, and that are located in other geographical locations outside of southern Indiana is important to acquire an accurate picture of the CB industry. Future studies must aim to assess additional aspects of welfare, such as mental health, to determine the welfare of dogs in CB facilities. Findings from this study are not limited to only the CB industry, but any facilities housing dogs in kennels. All facilities must consider how the flooring substrates they utilize impacts dog foot health and dog or environmental cleanliness, as well as the state of dental and ear health of the dogs under their care and the effectiveness of any preventive care provided. Policy makers can use this information to make decisions concerning dog management in kennel environments. For example, understanding that, while the flooring substrate itself may not be detrimental, its maintenance, as well as and other aspects of the dogs' environment require equal consideration. This can help improve the physical health of all dogs in kennel environments.

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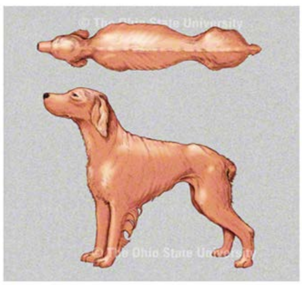
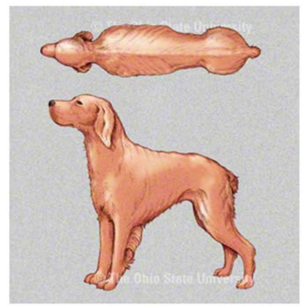
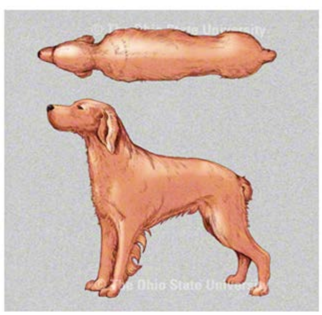
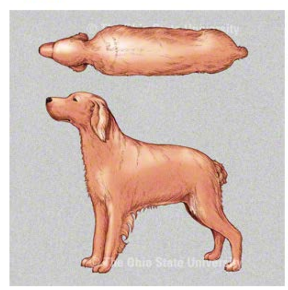
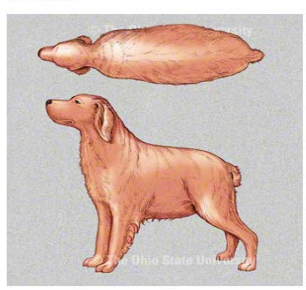
APPENDICES

Appendix A Scoring Tools

(chart retrieved from Ohio State University Veterinary Medical Center retrieved May 2015 retrieved from: http://vet.osu.edu/vmc/companion/our-services/nutrition-support-service/body-condition-scoring-chart)

Table A.1 Body Condition Score

<table>
<tr>
<td>1 = Emaciated
Ribs, lumbar vertebrae, pelvic bones and all body prominences evident from a distance. No discernible body fat. Obvious absence of muscle mass.
</td>
<td>2 = Thin
Ribs easily palpated and may be visible with no palpable fat. Tops of lumbar vertebrae visible. Pelvic bones less prominent. Obvious waist and abdominal tuck.
</td>
</tr>
<tr>
<td>3 = Moderate
Ribs palpable without excess fat covering. Abdomen tucked up when viewed from side.
</td>
<td>4 = Stout
General fleshy appearance. Ribs palpable with difficulty. Noticeable fat deposits over lumbar spine and tail base. Abdominal tuck may be absent.
</td>
</tr>
<tr>
<td colspan="2">5 = Obese
Large fat deposits over chest, spine and tail base. Waist and abdominal tuck absent. Fat deposits on neck and limbs. Abdomen distended.
</td>
</tr>
</table>

Toenail Length and Health

Toes are numbered P1-P5 where P1 is the inside toe (dew) and moving outward. e.g. right front paw (P1 is not pictured)

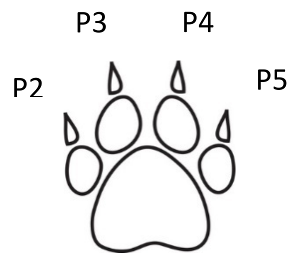


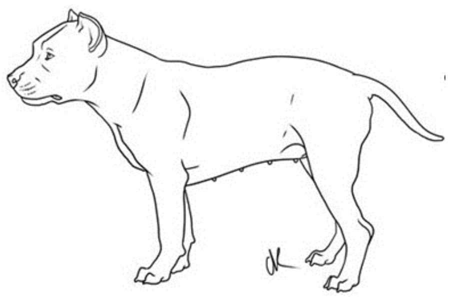
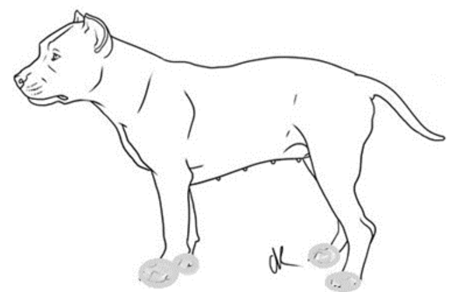
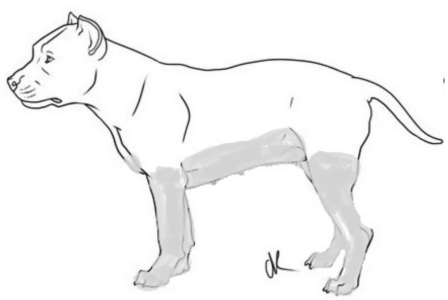
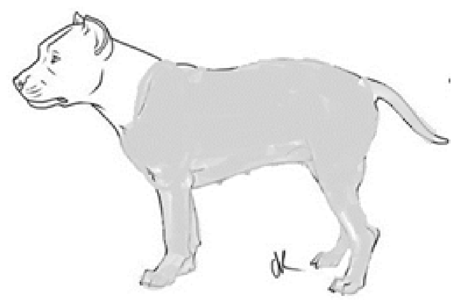
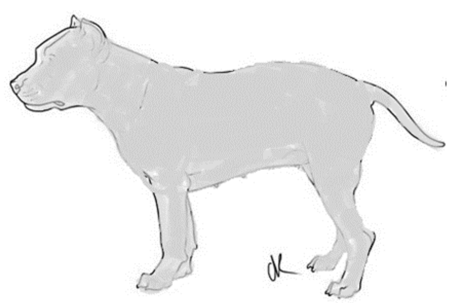
Figure A.1 Toe numbering method

Table A.2 Toenail Score

		
1= normal, healthy length	**2**= Slight onychogryphosis (nails slightly overgrown)	**3**= Onychogryphosis (nails are overgrown but have not yet begun to curl)
		
4= Moderate Onychogryphosis (nails are curling), onychoclaisis (broken) or anonychia (toenails absent) may be seen	**5**= Onychocryptosis (nails are curling), have started to grow into pads, onychoclaisis (broken) or anonychia (toenails absent) may be seen	

Body Cleanliness Score

Table A.3 Body Cleanliness Score

<table>
<tr><td>1- 0%: no debris, dog is clean
</td><td>2- 1-25%: debris on paws only
</td></tr>
<tr><td>3- 26-50%: debris on legs, chest and abdomen
</td><td>4- 51-75%: debris on legs, chest, shoulders, sides, tail and abdomen
</td></tr>
<tr><td colspan="2">5- ≥76%: debris on sides, topline, neck, head or entire body
</td></tr>
<tr><td colspan="2">Debris= any foreign substance such as dirt, mud, grass, twigs, feces, urine, vomit, or blood</td></tr>
</table>

Kennel Cleanliness Scores

Kennel Cleanliness scores:

1- No debris is present on floors. Minimal to no debris is visible on pen walls.
2- Up to 25% of the pen floor is covered with debris. Debris is visible on less than 25% of the walls.
3- Up to 50% of the pen floor is covered with debris. Debris is visible on less than 50% of the walls.
4- Up to 75% of the pen floor is covered with debris. Debris is visible on less than 50% of the walls.
5- Pen floor is almost entirely covered with debris. Food or drinking water is contaminated. Pen walls are almost entirely smeared with debris.

Table A.4 Dental Grading Scale

	Grade	Plaque and Calculus	Gum Health
Normal 	0	none	normal
Gingivitis  	I	Mild amount of plaque	Mild redness
***Early* Periodontitis** 	II	Subgingival plaque	Redness and edema

Table A.4 Dental Grade Scale (continued)

***Moderate* Periodontitis** 	**III**	**Subgingival calculus**	**Redness, edema, gums bleed with gentle probing, gum recession or hyperplasia**
***Severe* Periodontitis** 	**IV**	**Larger amounts of subgingival calculus**	**Severe inflammation, gum recession, loose teeth and/or missing teeth, pus, gums bleed easily, deep pockets**

Table A.5 Ear Debris and Excess Hair Scale

Example	Score	Description
	**1**	**Ear canal is clean and free from debris, no excess hair**
	**2**	**Debris present, but does not inhibit seeing down the ear canal, mild amounts of excess hair may be present**

Table A. 5 Ear Debris and Excess Hair Scale (continued)

	**3**	**Debris is partially blocking the canal making it difficult to see, moderate amounts of excess hair**
	**4**	**Debris is completely blocking the canal making it impossible to see without removal, severe amounts of excess hair**

Table A.6 Ear Erythema Scale

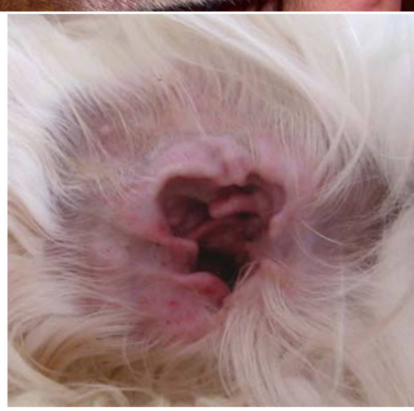
Example	Score	Description
	**1**	**Skin of ear is normal and free from inflammation. No pain present and not hot to the touch.**
 	**2**	**Skin shows mild erythema and free from inflammation. No pain present, skin may hot to the touch.**

Table A. 6 Ear Erythema Scale (continued)

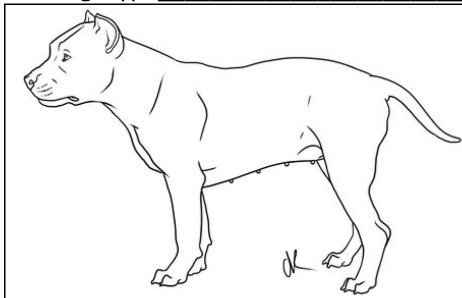
	**3**	**Skin shows moderate erythema. Pain may be present, skin is hot to the touch.**
	**4**	**Skin shows severe erythema and inflammation. Pain is present and skin is hot to the touch**

Appendix B Data Collection Sheet

Dog ID/name:________________________ Study ID#:_______________________________ Facility:___________________ Date/Time:_______________

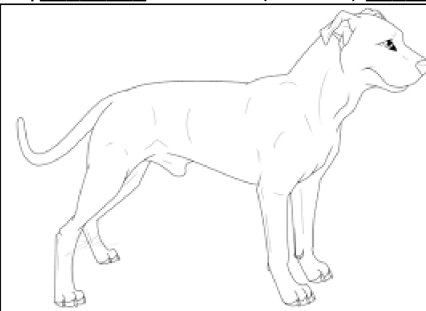
Age:_________________ Breed:_______________________________________ Sex:_________ Housing: Single Pair Group Other_________________

Flooring: Type____ Time: Hours/day________ Duration (months):________ Kennel Cleanliness (1-5) ___



Left side

Notes



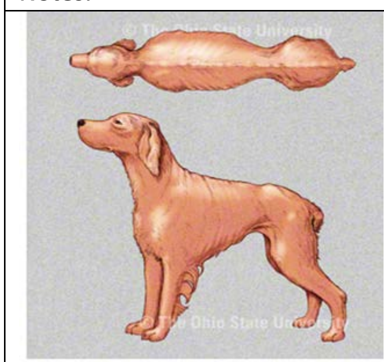
Right side

Notes

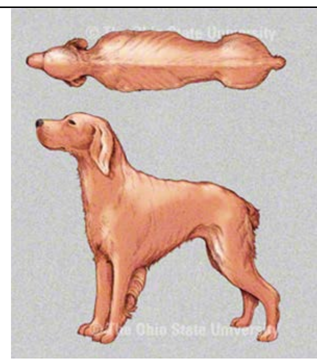
Body Cleanliness Score (% of body covered in debris) 1= 0%, 2= 1-25%, 3=26-50%, 4=51-75%, 5=>76%

Ear Health Conditions					**Dental Health Conditions**				
Long hairs Y/N	Debris (1-4)	Erythema (1-4)	Swelling Y/N	Other	Grade 0	Grade I	Grade II	Grade III	Grade IV

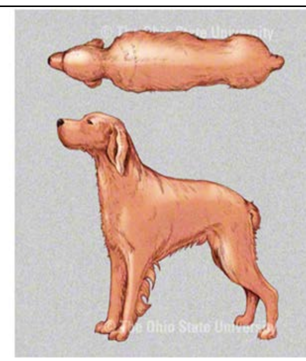
Notes:



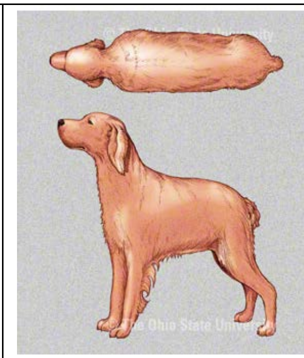
1=Emaciated



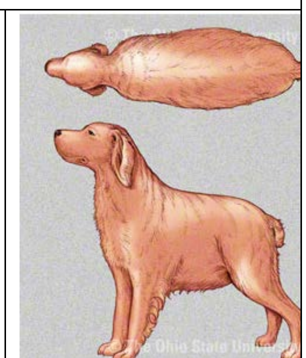
2=Thin



3=Moderate



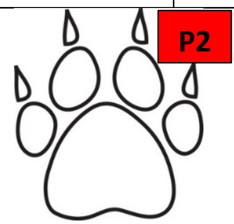
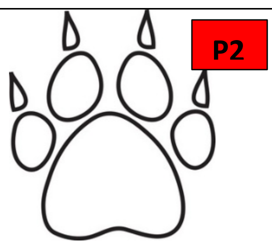
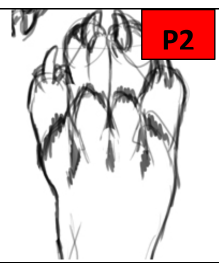
4=Stout



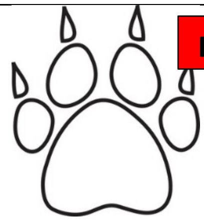
5=Obese

Data Collection Sheet (continued)

Elbow		Sore/Wound	Nodule/cyst	Erythema	Hair Loss	Calluses	Notes
	L						
	R						
Hock	L						
	R						

<table>
<tr><td>LF-bottom
</td><td>LF-top
</td><td rowspan="2">Cutaneous lesion/wound
Nodule/cyst
Erythema
Inflammation
Broken nail
Cracked nail
Missing nail
Toenail length (1-5)
Other</td></tr>
<tr><td>pH
alopecia (0-2)</td><td>pH
alopecia (0-2)</td></tr>
<tr><td>LR-bottom
</td><td>LR-top
</td><td rowspan="2">Cutaneous lesion/wound
Nodule/cyst
Erythema
Inflammation
Broken nail
Cracked nail
Missing nail
Toenail length (1-5)
Other</td></tr>
<tr><td>pH
alopecia (0-2)</td><td>pH
alopecia (0-2)</td></tr>
</table>

Data Collection Sheet (continued)

RF-bottom  P2	RF-top  P2	Cutaneous lesion/wound Nodule/cyst Erythema Inflammation Broken nail Cracked nail Missing nail Toenail length (1-5) Other
pH alopecia (0-2)	pH alopecia (0-2)	
RR-bottom  P2	RR-top  P2	Sore/wound Nodule/cyst Erythema Inflammation Broken nail Cracked nail Missing nail Toenail length (1-5) Other
pH alopecia (0-2)	pH alopecia (0-2)	

Appendix C Definitions and Diets

Elbow and Hock Scoring: Score each elbow and hock on every dog. Note the presence of any of the following (Definitions from Blood and Studdert, 1994; Boden, 2001):

Cutaneous Lesion	an area of erosion, raw, or painful place on the body
Wound	an injury caused by physical means and disrupts the normal continuity of structures
Nodule	a small bump that is solid and can be detected by touch
Cyst	closed capsule or sac-like structures, typically filled with liquid or semisolid substance
Erythema	redness of the skin, as a result of injury or irritation causing blood vessels of the surface to become filled with blood
Alopecia	a loss of hair, partial or complete, in areas where it normally grows
Calluses	localized thickening of the horny layer of the epidermis due to pressure or friction
Abrasion	superficial wound of skin or mucous membrane caused by chaffing, rubbing, etc.

Diets

At facility one, adult dogs were fed NutriSource® Adult Chicken and Rice Formula Dog Food. Adult dogs at facility two were fed the same food as facility one except for Miniature Schnauzers who were fed Tuffy's® Premium GOLD Adult Dog Food. At facility three, adult dogs were fed Nutro™ Max® Adult Mini Chunk Natural Chicken & Rice Recipe Dry Dog Food. At facility four, dogs were fed Tuffy's® Premium GOLD Adult Dog Food and Nutro™ Max® Natural Chicken Meal & Rice Recipe for adult dogs. At facility five, dogs were fed Nutro™ Max® Natural Chicken Meal & Rice Recipe for large breed adult dogs.

Appendix D Foot Health Charts and Figures

Table D.1: Body condition score (BCS).

Facility	n	BCS mean (±SD)
1	30	3.0 (0.7)
2	30	3.2 (0.4)
3	30	3.35 (0.6)
4	8	3.2 (0.4)
5	20	3.15 (0.5)

Table D.2 Foot pH

Facility	n	Foot pH mean (±SD)
1	30	6.0 (0.5)
2	30	8.0 (0.0)
3	30	7.8 (0.3)
4	8	6.7 (0.2)
5	17	6.3 (0.3)

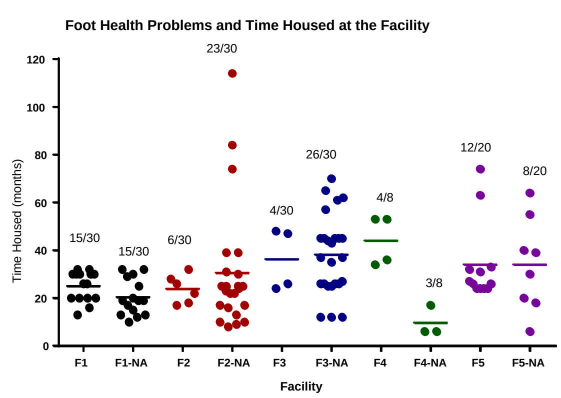


Figure D.1 Foot health problems and time housed at the facility. NA=dogs not affected by a foot health problem. Time housed at the facility information is missing for one dog at facility four and one dog from facility two.

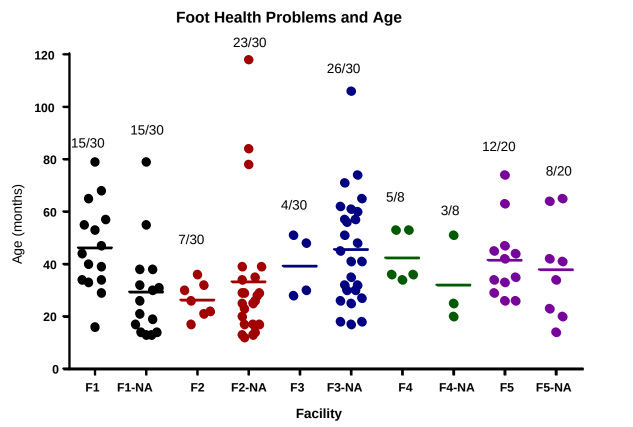


Figure D.2 Foot health problems and age. NA=dogs not affected by a foot health problem

Table D.3 Visual Dog Body Cleanliness Scores

Facility	n	Visual body cleanliness score mean (±SD)
1	30	1.1 (0.25)
2	30	1.0 (0.2)
3	30	1.0 (0.0)
4	8	1.1 (0.35)
5	20	1.1 (0.2)

Table D.4 Visual Kennel Cleanliness Scores

Facility	n	Visual kennel cleanliness score mean (±SD)
1	30	1.0 (0.2)
2	30	1.1 (0.3)
3	27	1.5 (0.5)
4	8	1.0 (0.0)
5	20	1.0 (0.0)

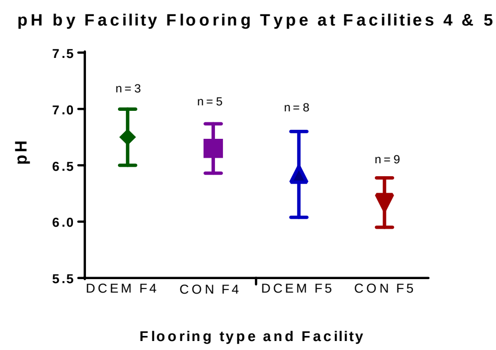


Figure D.3: Mean (±SD) pH by flooring type at facilities four (F4) and five (F5).

Appendix E Dental Grade and Ear Health Charts and Figures

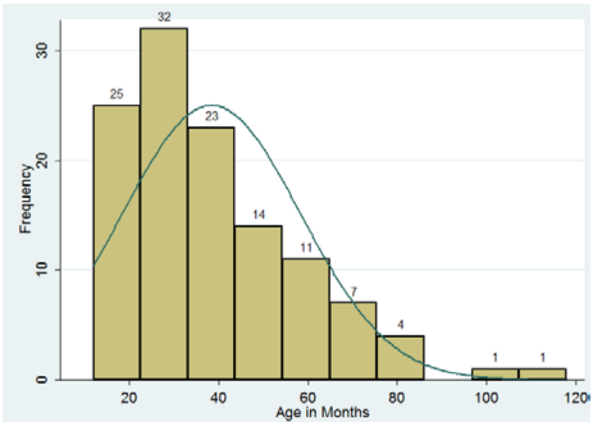


Figure E.1 Histogram of age in months

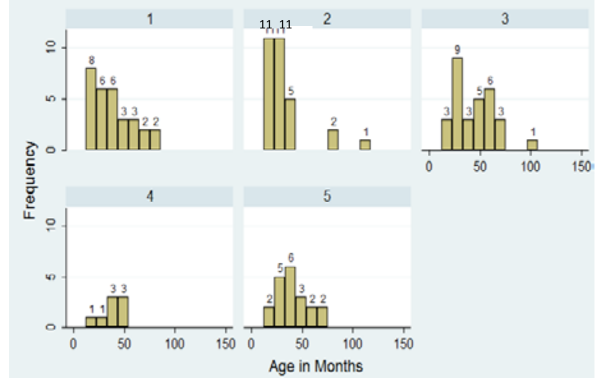


Figure E.2: Histogram of age distribution at each facility

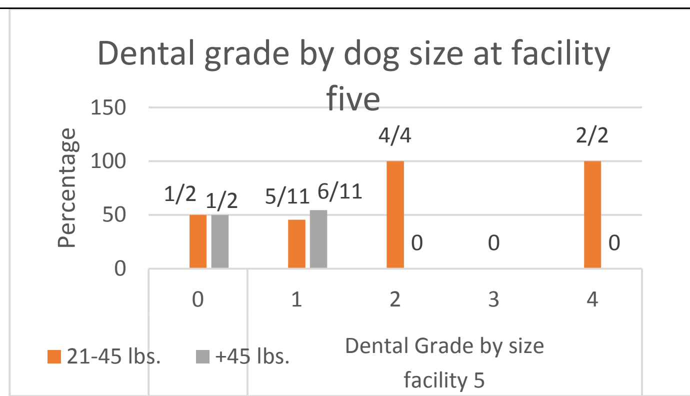


Figure E.3: Dental grade by dog size at facility five. Numbers above graph are the number of dogs with the respective dental grade for the respective dog size classification out of the total number of dogs with the respective dental grade. No dogs had a dental grade of 3. Breeds housed were Weimaraners, Soft-Coated Wheaton Terriers, a Dog de Bordeaux and Pembroke Welsh Corgis.