REPORT OF THE COMMITTEE ON ANIMAL WELFARE

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The Committee met on October 24, 2012 at the Greensboro Sheraton Hotel, Greensboro, North Carolina, from 8:00 a.m. - 12:05 p.m. There were 52 members and 30 guests present. After the Chair called the meeting to order, the final agenda was approved, activity during the past year was summarized and operational procedures were reviewed. Members were referred to the USAHA website to review the 2011 resolutions and responses. The Chair then introduced the first speaker for the session.

Time Specific Papers

Brant A. Schumaker presented a time-specific paper on The US Pet Trade in Dogs and Contagious Disease—Animal Welfare Impacts of an Outbreak of Canine Distemper.

Julie Gard presented a time-specific paper on Proactively Addressing Lameness—Evaluation and Development of the Bovine and Equine Foot in Response to Variations in Management Practices.

Both papers, in their entirety, are included at the end of this report.

Presentations

Behavior—The Animal's Commentary on Its Biological Processes and Welfare

Joe Stookey
Western College of Veterinary Medicine, University of Saskatchewan

The functional significance of an animal's behavioral repertoire is no less important than the functional significance of an animal's circulatory, nervous or endocrine system or its musculature or skeletal structure. All these systems are shaped by natural selection and influence an animal's overall success in passing on its genes. Behavior is an animal's overt response to stimuli, tempered by its internal motivation; as such, behavior serves as a commentary on an animal's emotions and cognitive experiences. Therefore, changes in an animal's environment or exposure to positive or negative stimuli will result in both physiological and behavioral responses. In some situations, measuring and monitoring changes in behavior have distinct advantages over physiological measures that can be invasive and require sophisticated laboratory tests. Changes in behavioral activities and in vocalizations help us to better understand the pain associated with routine procedures (e.g., castration, dehorning, branding) and help lead us to alternatives or better pain mitigating strategies. Recently, play behavior has been shown to represent another example of a behavior that changes following a painful experience. Moreover, animal behavior is used to assess animal welfare. Certain behaviors, such as stereotypies (repetitive behaviors with no apparent function) that we see in some confinement systems are generally accepted as indicators of poor welfare. However, the underlying cause of many stereotypies (i.e. bar biting by sows in gestation crates and stereotypies in stabled horses) is more often the result of limit feeding as opposed to confinement per se. Most recently, attempts have been made to measure an animal's cognitive bias (whether the animal anticipates getting a reward or a non-reward following the arrival of a new and unknown test – a test for pessimism or optimism) as an indicator of the animal's emotional health due to housing or past experiences. In the end, understanding and researching animal behavior offers us one of the best views on an animal's commentary about its very essence and life.

What We Know (and Don't) About Pain Management for Farmed Animals

Hans Coetzee
Veterinary Diagnostic and Production Animal Medicine; College of Veterinary Medicine, Iowa State University

At least 9 million calves are castrated in the United States annually. Furthermore, at least 4 million calves are dehorned each year (Dairy) and there are approximately 1 million lame dairy cows in the United States at any given time. Therefore, pain associated with elective management procedures and animal production is a significant animal welfare concern. Although the National Cattlemen's Beef Association (NCBA) and the American Veterinary Medical Association (AVMA) encourage the use of local anesthetics and analgesics to minimize pain and stress associated with dehorning and castration, only 1 in 5 Canadian and US veterinarians currently report using analgesia at the time of castration. Analgesic use is required for piglet castration in the European Union, which may have implications for countries wishing to trade with Europe. Pain management in livestock is challenging for many reasons, including that: 1) pain recognition is difficult in stoic species; 2) no analgesic compounds are specifically approved for pain relief in livestock in the United States; 3) analgesic use constitutes extralabel drug use (ELDU) under the American Drug Use Clarification Act (AMDUCA); 4) there is often a time delay between drug administration and onset of activity (e.g., local anesthesia); 5) many analgesic compounds have inconvenient routes of drug administration (IV) and short drug elimination half-lives that require frequent drug administration for analgesia to be effective; and 6) the cost of analgesic compounds and the associated meat and milk withholding periods are not offset by production benefits in many cases.

There is an urgent need for identifying validated methods of pain assessment in order for analgesic compounds to receive regulatory approval. Without such approval use of any compound for pain relief constitutes ELDU and as such is regulated by the AMDUCA. Under AMDUCA, drugs for pain relief can only be used by or under the supervision of a veterinarian who is responsible for determining an appropriate meat and milk withholding period. Potential pain biomarkers include the use of electroencephalography, thermography, accelerometers, cortisol, substance P, pressure mats, algometers, heart rate, prostaglandin E2 and production parameters. Of these, substance P, cortisol, algometers, heart rate and prostaglandin E2 and some production parameters have been shown to be most susceptible to the effects of analgesic compounds.

Recently the European Union has explored a system of minimizing pain in farm animals using the three S's approach: Suppress, Substitute and Soothe. Suppression involves the removal of any source of pain, which includes the use polled genetics to reduce the need for dehorning, selection of boars for reduced boar taint, and genetic selection of cows for improved conformation to reduce lameness. Substitution involves replacing a painful procedure with one that is less painful. This may include freeze branding, as opposed to hot-iron branding; castration and dehorning at the earliest age practicable; and the use of low-stress handling techniques. Finally, soothing involves the use of appropriate analgesic interventions to alleviate pain in the target species. Taken together, these may offer a systematic approach to reducing pain in livestock.

Panel Discussion—Welfare and Market Decisions: What and Who Influences Them?

Retailer Perspective

David Fikes
Food Marketing Institute

As the middle link in the food chain economy of supplier-retailer-consumer, the food retailer plays a unique and central role in value-laden issues such as animal welfare concerns. The food retailer's approach to that middle position is colored by operating in a competitive atmosphere where differentiation is crucial and razor-thin profit margins allow no room for mistakes. Added to that pressure, food retailers are increasingly leaned upon to be the weighted fulcrum that tips the scales one way or the other when it comes to issues in animal agriculture. Whether retailers approach their relationship between supplier and customer as a bridge, a messenger, an advocate or an educator, they must weigh a multitude of factors when making key decisions.

Producer Perspective

R. C. Hunt
Andrews Hunt Farms, Wilson, North Carolina

Addressing the current controversy over sow housing, Mr. Hunt described the process for how the industry moved from extensive to intensive systems and why, as well as his personal experience with both types of systems. Principle reasons for the move to intensive systems included concerns for sow heath, injury prevention and worker safety. He emphasized the importance of communication with producers to ensure that their experiences were appropriately reflected in decision-making and indicated their interest in working with retailers to ensure responsible decisions were made. He also indicated a willingness in the swine industry to consider scientific evidence to support different management systems or strategies for successful implementation of those systems in swine production.

Producer Perspective

Robert Krouse
Midwest Poultry Services, Mentone, Indiana
(Due to illness, Mr. Krouse's written remarks were delivered by Committee Vice Chair B. Thompson)

Mr. Krouse discussed the development of United Egg Producers' (UEP) animal welfare program, including its impetus and the creation of its independent Scientific Advisory Committee on Animal Welfare. Three objectives for the program were identified: (1) standards that respected the experience of farmers and could also be supported by the best science available, (2) inclusion of mandatory third-party audits, and (3) acceptability of the program to egg farmers and their customers, including grocery stores, restaurants, and food processors. He explained that egg farming practices are being constantly challenged by the USDA, Food and Drug Administration (FDA), customers in the grocery and food service industries, their end users and animal rights activists, and that these challenges have been targeted not at individual farmers but at the industry as a whole. The egg industry needed a program where egg farmers would know what was expected of them, would know what was being done and why, and could document compliance for their customers. He emphasized the importance of anticipating and reacting appropriately to challenges, and used UEP's stepwise development of conventional cage, then cage-free and organic, and finally, its current work on standards for enriched colony housing as an example of how the UEP's program has allowed them to address challenges in a positive, proactive way.

World Animal Health Organization (OIE) Animal Welfare Initiative—What, Who and Where It's Going

Michael David
International Animal Health Standards Unit, National Center for Import and Export, USDA-APHIS, Veterinary Services (VS)

In 2001 the OIE expanded its mandate to include animal welfare. Since that time the OIE has drafted and its Membership (the Delegates) has adopted welfare chapters on transport, humane slaughter, killing for disease control, use of animals in research and education, and stray dog control. In addition, the OIE has also adopted chapters on the transport of farmed fish, and on proper procedures for stunning farmed fish. Two key principles which guide the development of any welfare chapter are that any recommendation must be based on sound science and be outcome focused.

At its May 2012 General Session, the OIE adopted a new welfare chapter on housing and production, specifically, on Beef Cattle Production Systems. This is the first time the OIE adopted a chapter that provides basic guidelines on production practices for a livestock species. It is anticipated that for 2013, the OIE will present a chapter on the Housing and Production of Broiler Chickens, and for 2014, a chapter on Dairy Production Systems.

The OIE has also hosted several Global Conferences on Animal Welfare. The first conference was aimed at raising awareness of the existing OIE welfare chapters; the second conference was focused on encouraging countries to begin to implement the existing guidelines; and the next conference, which will be held in Malaysia in November 2012, will evaluate the effectiveness of countries in implementing the guidelines.

The OIE is aware of the challenges many countries have in implementing the recommended welfare guidelines, and has shown a willingness to work with Member countries to provide support within the framework of its capacity-building initiatives.

Committee Business

The business meeting followed the last presentation and the presence of a quorum was confirmed. One resolution entitled, "Controlled Substances Act Regulations Applying to Drug Enforcement Administration Registrants Acting Remotely for Registrant's Principal Place of Business" was introduced and, after discussion, approved by the Committee to be transmitted to the Committee on Nominations and Resolutions.

The Committee on Animal Welfare adjourned at 12:00 p.m.

THE US PET TRADE IN DOGS AND CONTAGIOUS DISEASE—ANIMAL WELFARE IMPACTS OF AN OUTBREAK OF CANINE DISTEMPER

[1]Brant A. Schumaker, [1]Myrna M. Miller, [1]Jacqueline L. Cavender, [1]Todd E. Cornish, [1]Donald L. Montgomery, and [1]Donal O'Toole
[1]University of Wyoming, Department of Veterinary Sciences

Canine distemper uncommonly affects the pet trade in the United States, in large part due to effective vaccines against canine distemper virus. The presentation described the animal welfare-related consequences of distemper affecting 24 young dogs of multiple breeds shortly after sale by two pet stores in Wyoming over a 37-day period, extending August through October 2010. To the authors' knowledge, it was the largest outbreak of distemper in pet dogs in Wyoming within the past 20 years.

Diagnosis of distemper was established by a combination of fluorescent antibody staining (FA), reverse transcriptase polymerase chain reaction (RT-PCR), negative stain electron microscopy, and necropsy/histopathology. Sequences of canine distemper virus were obtained from two affected dogs. They were identical based on viral hemagglutinin gene sequences, and were distinct from hemagglutinin sequences obtained in 2010 from a dog diagnosed with distemper in rural Wyoming.

The breeding property from which the pups originated was located in Kansas and was quarantined by the state's Animal Health Department. Puppies intended for sale were tested for distemper, and distemper was diagnosed on site in November 2010. At that point 1,466 dogs were euthanized to prevent dispersal of the disease through commercial channels. The disease investigation underscored the risks inherent in large-scale dog breeding when vaccination, biosecurity and other animal care practices are suboptimal.

The canine breeding facility was inspected by both state and federal agencies. Animal care and disease prevention and control problems identified included limited medical records; limited quarantine space; dogs without food; no extra food in storage; watering units at the wrong height; inadequate pen space; introduction of purchased dogs of unknown health status from multiple sources, including pet auctions; transport of dogs in inadequately disinfected crates; and recurrent contact between dogs in the breeding facility and local wildlife, such as raccoons and skunks. Although multiple, repeated violations of the Animal Welfare Act were reported, the facility was fined only twice and issued a single formal warning during its 19-year history. A 2010 audit by the USDA's Office of the Inspector General documented problems with inspections of federally licensed dog breeding facilities in the United States. Some practical steps to prevent and control canine distemper and other diseases and improve animal welfare in similar facilities were described.

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PROACTIVELY ADDRESSING LAMENESS—EVALUATION AND DEVELOPMENT OF THE BOVINE AND EQUINE FOOT IN RESPONSE TO VARIATIONS IN MANAGEMENT PRACTICES

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There are a myriad of opinions about what is necessary and humane handling and care of animals and what constitutes good animal welfare. These opinions are influenced by a person's values, knowledge and experiences. The American Veterinary Medical Association (AVMA) describes animal welfare as how an animal is coping with the conditions in which it lives. AVMA also suggests that ensuring animal welfare is a human responsibility that includes consideration for all aspects of animal well-being, including proper housing, management, nutrition, disease prevention and treatment, responsible care, humane handling, and, when necessary, humane euthanasia (https://www.avma.org/public/AnimalWelfare/Pages/default.aspx). The AVMA further defines animal well-being as the conditions in which animals experience good health, are able to effectively cope with their environment, and are able to express a diversity of species-typical behaviors. (https://www.avma.org/public/AnimalWelfare/Pages/default.aspx). Using this framework, protecting an animal's welfare means providing for the animal's needs and includes consideration for all aspects of its well-being. Responsible use of animals for human purposes, such as companionship, food, fiber, recreation, work, education, exhibition, and research conducted for the benefit of both humans and animals, is consistent with the Veterinarian's Oath, the AVMA's Principles of Animal Welfare (https://www.avma.org/KB/Policies/Pages/AVMA-Animal-Welfare-Principles.aspx) and AVMA policies addressing a range of issues across species. The Principles emphasize that animals must be provided water, food, proper handling, health care, and an environment appropriate to their care and use, with thoughtful consideration for their species-typical biology and behavior, and that animals should be cared for in ways that minimize fear, pain, stress, and suffering. Accordingly, it is necessary for procedures related to animal housing, management, care, and use to be continuously evaluated, and when indicated, refined or replaced. Conservation and management of animal populations should be humane, socially responsible, and scientifically prudent, and animals should be treated with respect and dignity throughout their lives and, when necessary, provided a humane death. The veterinary profession continually strives to improve animal health and welfare through scientific research, education, collaboration, advocacy, and the development of appropriate legislation and regulations.

Additional organizations such as the World Organization for Animal Health (OIE) (http://www.oie.int/), the American Association of Bovine Practitioners (AABP) (www.aabp.org) and the American Association of Equine Practitioners (AAEP) http://www.aaep.org/avmawelfare_principles.htm have typically supported AVMA principles and policies. The AABP has a position on animal welfare, has adopted Principles outlined at (http://www.aabp.org/public/Animal_Welfare/AABP-Prin_An_Welfare-6.2011.pdf), and states, "Humane care and handling of all animals is a key commitment made by the veterinary profession, which includes both treating animals humanely and ensuring that others do so. That the determination of what is humane and appropriate animal care should be based on science." The AABP believes that management systems, medical practices and surgical procedures should minimize pain, discomfort and distress; utilize current scientific and expert opinion where available; and that the health, productivity, behavior, and physiological responses of the animal are reflective of its welfare. Animal production is part of the chain of food production and healthy animals are more often the most productive animals. Healthy animals have a greater ability to combat disease than those that are stressed and or immunocompromised. Producers have taken this into account, along with consumer expectations and demands in the domains of animal health, welfare and environment, and have developed good agricultural practices (GAP) as outlined in 2004 by the Food and Agricultural Organization (http://www.fao.org/prods/gap/Docs/PDF/5-GAPworkingConceptPaperEXTERNAL.pdf).

Hence, it is the authors' belief that animal welfare is a leading issue occupying the attention of the veterinary and livestock communities, as well as that of consumers. Therefore, the evaluation of disease states, such as lameness, and the development and application of protocols to prevent them are necessary to protect animal welfare and ensure productive animals. In a study by Kossaibati and Esslemnont[1], lameness was described as one of the two most costly diseases in the dairy industry due to its significant negative effects on the well-being and economic productivity of beef and dairy cattle. Lameness is highly prevalent in today's beef and dairy industry, with reports of nearly 20% for parity one animals and almost 50% for cows that are greater than parity one[2]. In a recent article by Leach et al.[3], prevalence estimates of lameness in European countries were reported to range from 19% on organic farms in Germany, to 31% in Simmental dairy herds in Austria, to 36% in UK herds. Additionally, it was stated that "...lameness is the most significant challenge for the dairy industry to overcome given obvious disruption of animal welfare and severe economic losses."[2-5]

Problems with lameness often lead to additional negative impacts on production, including reductions in milk production (through increases in mastitis and decreases in feeding) and decreases in reproductive indices in cattle[2-7]. In a recent study[4], cows detected with clinical lameness during the first 70 days of milk production were 25% less likely to become pregnant compared with cows that were not lame. In dairy cattle this is especially problematic due to already low pregnancy rates, approximating 18% in some herds[6]. Lameness is known to lead to earlier culling of animals as well as lower carcass weight, conformation class, and fat cover, and lower carcass economic value. Earlier identification and treatment can improve the value of the carcass and reduce culling rates[2,8,9]. As reported for a study by Booth et al.[9], "Lameness was never associated with increased survival in any of the models studied," which highlights the importance of preventing lameness.

The economic impact of lameness is significant. Each episode is estimated to cost $302 to $446 and these costs increase with the severity of the lameness[9,10]. In a study by Barker et al.[7], milk losses associated with sole ulcers and white line disease were estimated to be 574 and 369 kg/cow, respectively, per 305 days' lactation in 30 herds. The costs of specific lesions were also determined in a recent study to be $216.07, $132.96 and $120.70, per case of sole ulcer, digital dermatitis and foot rot, respectively[11]. The main contributors to the total cost per animal were milk loss for sole ulcer (38%), treatment cost for digital dermatitis (42%), and the effect of reduced fertility for foot rot (50%)[11]. Based on this information it was recommended that 97.3% of foot rot cases, 95.5% of digital dermatitis cases and 92.3% of sole ulcer cases be treated[11]. Results of these studies are important information for producers that can assist them in making appropriate decisions on treating lameness, as well as create awareness of the ramifications of lameness in their herds. In another recent study by Eterma et al.[12], decision support models were developed and utilized to predict the economic profitability of such actions. Although this kind of modeling is beneficial and important for producers, prevention of lameness is even more important than determining whether lameness is worth treating.

Prevention of lameness has been looked at from many angles because many factors affect hoof health, including genetics, conformation, diet, contagious agents, hygiene, housing systems, animal behavior, and management[2,3,13]. It is well known that foot and leg disorders that result in lameness tend to be higher in confined management systems and at greater production levels[2,3,13]. There are a number of studies looking at different flooring and its effects on foot health[12-16]. In a recent study[15] evaluating rubber-matted feed stalls together with asphalt walkways there were found to be reductions in claw wear (3.29 +/- 0.31 and 4.10 +/- 0.32 mm/month for lateral and medial claw, respectively). Also, in a recent study[17], it was shown that housing significantly impacted the strength/laxity, laminar morphology, connective tissue, and biochemistry of the sole. In this same study, sole lesions were assessed and were found to be significantly worse in heifers housed in cubicles compared with those in straw yards, and in lactating/pregnant heifers compared with maidens[17]. Cubicle housing and parturition each increased connective tissue metabolism (and were additive in this study) and these changes in connective tissue composition impaired the biomechanical resilience of the hoof[17]. As this study would indicate, changes in the structure of the foot are able to be influenced by housing, management, and pregnancy/hormonal status of young stock. In an another study[18], housing calves in slatted pens from 3 to 7 months of age was associated with a 1.7-fold increase in culling risk, compared with housing calves in litter pens. Cows for which housing system had been changed 4 times before their first calving were at 1.4 times increased risk for culling when compared with cows that underwent 2 housing changes. These results indicate that rearing factors affect the productive life of dairy cows.

The ability of the environment to influence the development of the foot has been grossly observed in Mustangs and range cattle but has not been scientifically assessed. Range cattle and Mustangs must cover long distances to obtain food and water, and tend to have larger feet and tougher solar surfaces than cattle on small grass lots. Non-scientific examination of Mustang and range cattle feet reveals the weight-bearing surface to be greater than in animals with similar body frame size; hence, more surface to bear the animals' weight. The environment selects for better feet through "survival of the fittest" and, in turn, influences the gene pool, selecting for animals that are most able to survive these rugged environmental conditions. Accordingly, Mustangs have been bred to quarter horses and thoroughbreds to improve the feet of these breeds. Genetics is not the only player, however, as shown from results of recent studies[17,18] where the environment also significantly affected the health and development of the foot. There seems to be missing information on what is necessary for optimal growth and development of the bovine foot, as well as the equine foot, so more studies are needed to determine how the environment plays a role in foot development. It has been estimated that more than 90% of lameness in cattle has its origin in their feet[1,2]. Accordingly, the production of healthy functional feet is a logical starting point in the prevention of lameness. Evaluation, development and implementation of better management protocols are imperative for improving the well-being of livestock through prevention of lameness in growing and adult animals. A recent review by Cook and Nordlund[16] addressed various aspects of the dairy cow's environment, including comfort of free stalls, stocking densities, and rubber flooring, and the impact of these on lameness. This study, as well as others, highlighted that changes in environment can assist in meeting the developmental needs of animals[16-18].

We are interested in more fully evaluating the use of housing and management to create positive changes in the bovine and equine foot. The positive changes being evaluated are an increase in the amount of bone resulting in more surface area to bear weight, and an increase in the size and thickness of the digital cushion. The digital cushion functions as a shock absorber and protects the structures underneath[2,17,19]. Decreases in the thickness of the digital cushion in cattle have been reported to be related to contusions of the claw horn capsule and such contusions are a consequence of the lesser capacity of the digital cushion to dampen the pressure exerted by the third phalanx on the soft tissue beneath[2,17,19]. Also, it was shown in a study by Bicalho, et al.[2] that the prevalence of sole ulcers and white line disease is significantly associated with the thickness of the digital cushion. Cows having a digital cushion of thickness in the upper quartile had an adjusted prevalence of lameness 15% lower than those having a digital cushion of thickness in the lower quartile[2].

If the characteristics of housing that produce a healthy foot could be identified (so that the foot would possess increased biomechanical resilience with more effective weight bearing), then (logically) there would be a decrease in appearance and severity of lesions. If these positive changes could be induced by implementing new housing and management protocols for calves and foals at minor cost they would be welcomed and adopted by producers and supported by consumers.

Additionally, there is growing pressure in the equine and, especially, the food animal industries to improve the welfare of animals to meet the demands of consumers for animals and products that are welfare-certified. Establishment of management practices that improve the welfare of animals often results in increased sustainability of the production system due to increases in production and longevity in the herd. The ability to reduce culling rates and retain animals in the herd for longer periods of time is economically beneficial for producers because it raises the net income of the operation. The major cost associated with herd replacements is rearing cost. For example, the replacement heifer, especially the dairy heifer, is considered to be a cost to the dairy operation and not a potential profit center[20]. Heifers are viewed as an expense and not as an investment, so the dairy heifer grower industry was developed[21]. Although the dairy heifer grower industry has provided opportunities, it has also presented challenges in terms of growing quality heifers[21]. The cost of raising heifers in 2010 was found to be, on average, between $1,600 and $1,850 and these expenditures did not guarantee that the heifer would be an exceptional or even fair animal in the production system[21]. Additionally, replacements in beef herds are not truly profitable until they reproduce and offspring are able to be raised. Therefore, management protocols that allow replacements, including breeding bulls, to maximize productive life are of economic benefit to the farmer and welfare benefit to the animal. Culling rates in dairy farming can be highly variable, ranging from 16% to 45% with a rate of 30% considered to be a goal. This says something about the rigors of the industry[6]. For an animal to reach its full potential the needs of the animal need to be addressed.

Various factors come into play when rearing a production animal, including nutrition, housing, and prevention of disease. Adequate nutrition, starting with appropriate colostrum consumption by the foal, calf, piglet, etc., followed by meeting the nutritional needs of the growing animal, has been shown to reduce mortality and morbidity and allow for more productive replacements. Appropriate housing with attention to biosecurity to prevent disease spread, and management protocols that include vaccination and deworming are also important to reduce morbidity and mortality. To ensure animals reach their genetic potential all factors should be analyzed and modified as necessary to produce the healthiest and most productive animal. The ability of animals to live comfortably due to appropriate foot development, whether on concrete pads or in dry lots, will result in greater: longevity in the herd (reduction in culling rates), fertility, milk production and weight gains. The bottom line being increased profit margins for the producer and producing welfare-certified products that meet consumer demands. Unfortunately, management protocols often focus on preventing one disease state, while inducing or predisposing to another so protocols need to be fully evaluated. The development of new protocols that are effective in preventing lameness, which can be adopted by the livestock industry and incorporate welfare-certified practices resulting in the production of replacement animals that can withstand the rigors of the industry, lead to enhanced productive life and is the focus of the research reported here.

A preliminary study was performed by our research group that included a total of 8 bull calves, 4 Holsteins and 4 Jerseys. The calves were randomly assignment with 4 in a control group and 4 in a treated group with an equal number of Jerseys and Holsteins in each group. The control group was reared in accord with standard practices—in calf hutches until weaning and then housing on pasture lots. The treated calves were housed in calf hutches for the first 2 weeks of life and then were allowed free access to a half-mile lane where they walked for at least 2 miles a day on rocky terrain. When all calves reached 4 months of age they were humanely slaughtered and their legs were collected and evaluated utilizing computed topography (CT) scans. The information from the CT scans was evaluated, using 2 software programs: Mimics 14™ (Materialise; http://www.materialise.com/micro-CT) and 3-D Studio Max (Discreet; www.discreet.com/3dsmax.). A three-dimensional analysis of the medial claw (including middle phalanx (P2) and the distal phalanx (P3)) and the lateral claw (including P2 and P3) of the right rear foot from each calf was performed. The surface area of the individual bones was calculated and evaluated, comparing breed and treatment status. The results of this study revealed that the surface areas of P2 and P3 for the medial and lateral claws in the treated group were increased in each calf by an average of 45mm^2 and 81mm,^{2} and 193mm^2 and 219mm^2, respectively. Additionally, the treated Jerseys had a greater average increase in the surface area of lateral P3 per calf when compared to Holstein controls (349mm^2 in comparison to 90mm^2).

Our preliminary study appears to suggest an environmental role in the development of the boney structures of the bovine foot. Additional studies involving more calves over a longer period of time and incorporating longer walking times may be necessary to permit maximum bone remodeling so that the environment's impact on the bovine foot can be more fully assessed. The effect that the environment may have on the formation of other structures, such as the digital cushion, also needs to be evaluated. Ultimately, it may be necessary to expose animals to essentially range conditions in order to maximize the ability of the environment to effect the development of the structures of the bovine foot including the phalanges and the digital cushion.

To assess the changes seen in livestock feet it is important to evaluate both boney structures and soft tissues. Lameness has been associated with pathologic changes of the lamina; bones (distal phalanx (P3), navicular bone); synovial structures, such as the coffin joint and navicular bursa; and tendons and ligaments, including the superficial and deep digital flexor tendons, and the impar ligament[22,23]. However, little emphasis has been placed on the role that soft tissue structures, such as the digital cushion and the collateral cartilages of the heel region, play in lameness[22-24]. It has been hypothesized that the health of the soft tissue structures of the heel plays a primary role in equine soundness especially the health of the digital cushion because it is the primary landing zone of a functional foot and provides support for distal descent of the pastern[22-24]. The digital cushion in cattle is different than that of the horse, but also has recognized importance in protecting underlying structures[2,4,7,17,19,24].

Because there has been little emphasis on these structures, there has not been a complete set of physical exam parameters defined to evaluate the equine heel. Development of these parameters is important so that every veterinarian can accurately predict the anatomical characteristics of a horse's foot as a first step toward evaluating management protocols aimed at encouraging the development of healthy ones. It was hypothesized that the anatomical characteristics of the heel region of the equine foot can be accurately predicted through physical examination and diagnostic imaging. A study was performed that evaluated 8 left front feet from Thoroughbreds aged 4 to 20 years. MRI and CT scans were performed on each foot along with a clinical examination of cadaver feet that included physical examination, ultrasonographic and radiographic imaging. The physical examination included a video of the foot. Ultrasonographic evaluation included examination and measurement of the heel region, the depth of the central sulcus, and measurements of the area and circumference of the lateral and medial parts of the digital cushion. Radiographic imaging included lateral views where a barium line was placed on the dorsal hoof wall and the medial heel tubule. A zero subject-to film distance was used and the primary x-ray beam was centered on the solar margin of P3. Mimics® is a computer program traditionally used in human medicine to create accurate 3D models of anatomic structures and it was utilized in this study to reconstruct 3D images of the digital cushion, as well as the bony structures of the foot, from the MRI and CT scans. Specifically, raw data from the CT scan of the middle (P2) and distal phalanges (P3) and the navicular bone was imported into the program, and using a preset function, the bones were sectioned and reconstructed. Mimics® was also used for reconstruction of the digital cushion. Raw data from the MRI scan was imported into Mimics®. The digital cushion was hand traced in each slice of the MRI into a mask and then the mask was converted into a 3D image. Following 3D reconstruction, the volumes of the tissues were recorded. Volumes determined using Mimics® allowed the feet to be ranked from highest to lowest volume of the digital cushion. Volume rankings from Mimics® and the physical examination parameters were then compared and ranked from best to worst based on prediction of digital cushion volume. Radiographic results were ranked as well, with lateral radiographs of each foot examined and subjectively ranked from best to worst by comparing heel volume. Additionally, a Mimics ranking was determined using a ratio of the volumes of the reconstructed digital cushion to distal phalanx (DC:P3) and feet were ranked from highest to lowest ratio. A ratio was used instead of the raw digital cushion volume, to standardize for size differences between horses.

Results of the rankings were combined based on physical examination findings, Mimics® volume ratios, and radiographic findings. A linear regression model was used but due to the low number of hooves examined, this study should be considered as a very preliminary screening for measures that may serve as predictor variables for digital cushion volume. A statistical analysis of the physical examination results was promising with respect to the number of fingers that fit between collateral cartilages ($p=0.06$, $r^2=0.47$) and the digital cushion plus frog depth ($p=0.0085$, $r^2=0.71$). Statistical analysis of ultrasonographic results revealed several individual parameters having statistical significance for predicting digital cushion volume: central sulcus to skin depth ($p=0.02$, $r^2=0.62$), lateral digital cushion area ($p=0.05$, $r^2=0.50$), medial digital cushion area ($p=0.02$, $r^2=0.58$), medial digital cushion circumference ($p=0.02$, $r^2=0.60$), and lateral fibrocartilage echogenicity ($p=0.02$, $r^2=0.60$).

Further studies of this kind that more exhaustively define physical examination parameters are necessary to accurately predict the volume of the digital cushion. This knowledge may allow digital cushion evaluation in future studies without the need for an MRI scan or dissection, which would permit more animals to be examined more economically. Additional physical and clinical examination parameters are needed to accurately evaluate collateral cartilage and digital cushion fibrocartilage characteristics. Therefore, a tool to help objectively determine the density of the digital cushion (likely associated with percentage of fibrocartilage) needs to be developed. Continued evaluation of the best methods, tools, and parameters to use for clinical evaluation of the foot, including existing technologies of ultrasound and radiographs, is imperative. Combining all parameters into a single model would be beneficial as would analysis of more feet in its development. There are animal welfare implications to consider such as prediction of hoof health as it relates to readiness for work, risk for lameness, and long-term athletic soundness. These methods can be used in preventive medical practice to prevent and/or curtail significant episodes of lameness, thereby reducing pain and an improving the welfare of the patient. Such methods benefit patient and client alike in that the development of economic methods to provide a reliable prognosis for the horses in question will most likely also support earlier detection and treatment of lameness.

An overarching goal of this project was to evaluate and develop management protocols to prevent lameness. Further development of methods to evaluate boney and soft tissues of the equine and bovine foot will provide methodologies that can be utilized in evaluation of management protocols. The focus of these studies is aimed at the development of a healthy functional foot that can perform in the arena, racetrack, or dairy parlor and result in a healthy and productive animal. This project and others like it provide value to livestock producers not only in the United States but globally. Obtaining information that can be used to develop science-based management practices, which in turn facilitate maximal growth and the health of replacements so as to extend the productive life of an animal provides for increased sustainability in current production systems. In turn, producers should benefit from better economic returns due to improvements in the welfare of their replacements. Extension programs can be utilized to educate livestock producers and agricultural educators so as to facilitate adoption of welfare-friendly management protocols for livestock replacements including prevention and treatment of lameness.

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