The Importance of Functional Conformation in the Longevity of Holstein Cattle

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Introduction

All of us share a great passion for good Holstein cows and it has been this common passion that, over the past 100 years, has been fundamental in the development of our present day Holstein. We appreciate the power of genetic selection and the responsibility that we have in shaping the future of the breed. It is remarkable that the genetic progress made in the first 50 years was made without the benefit of A.I. or embryo transfer and as a result, with all the genetic improvement tools we have at our disposal, the opportunity for rapid progress has never been greater.

However, the industry is very different today than it was 50 years ago. In Canada, there has been a large reduction in herd numbers with many of the 50 – 60 cow tie stall dairies being replaced by 200+ cow free stall dairies. The focus on the individual cow and livestock shows has, in many cases, been replaced by a focus on maximizing production and profitability and developing sophisticated herd management programs. Throughout the 90's intense selection for production resulted in a diminished priority being given to functional type and show cows were even criticized for having inadequate production, being too large, and having a disconnect with the type of cow desired by the commercial breeder. At the same time, researchers were challenging the science (or lack of it) supporting the use of functional type to predict longevity. Some of these researchers extrapolated data from hogs and beef cattle and began promoting crossbreeding in Holsteins. The message they were delivering was that greater longevity could be achieved by breeding a smaller, thicker cow that was able to maintain body condition through the transition period and could utilize hybrid vigor to resist lameness, mastitis and metabolic disorders. Many breeders around the world, including myself, do not share this philosophy and this paper will attempt to identify the important functional conformation traits that are essential for our modern Holstein to remain the most profitable dairy cow.

It is important for all Holstein Associations to speak out in support of good conformation, its value in achieving optimum longevity, and the importance of using science based selection programs to continue to improve the functional correctness of our Holstein cows. It is through initiatives like this that I became involved in a project with Holstein Canada's Type Classification Advisory Committee to look at the accuracy with which we evaluated the type traits and how we could link each trait to functionality. The approach taken by the classification group was to acknowledge the relevance and opportunity for genetic progress in the areas of productive life, health traits, and fertility but to strive to achieve genetic progress in these areas along with, and not in exclusion to, an equal selection priority to continue improving functional conformation.

Based on the conformational changes that we have already noted over the past 100 years, it is inevitable that conformation will continue to change and it will only be beneficial change if we control its destiny. If we ignore the conformation traits, as some researchers have suggested, we will quickly lose much of the progress made by visionary breeders of the past. It was a deep concern for the future functional conformation of the Holstein cow that prompted Holstein Canada's Type Classification Advisory Committee to prepare a video promoting functional conformation. Besides being involved in all aspects of the Holstein business, I have spent the past 35 years as a dairy veterinarian. This experience allowed our video to have a significant focus on anatomy and biomechanics and it is our hope that this will provide additional support for continuing to give priority to functional conformation. Our project began with the dissection of 5 cows to ensure that we had complete knowledge of the anatomy of the conformation traits and that we could clearly demonstrate these traits and accurately correlate their structure with the superficial evaluation made by the judge or classifier. The more difficult task was to begin to gather the scientific data necessary to support the desirable linear score designations. Although much work is still left to be done, the project has already elevated the awareness of the value of good functional conformation.

If one likens a dairy cow to a piece of machinery in a factory, it is clear that a continual increase in output is only possible if we continue to improve the function and durability of the machine as well as the environment in which it operates. Advances in management, housing, nutrition and genetics have raised our expectations for dairy cow production. It then remains a constant challenge to improve the structure (conformation) of the animal to match her production potential so she remains resilient to the stresses of modern confinement systems and can remain trouble free over a long lifetime.

Despite the consistent improvement in physical conformation, a significant proportion of genetic variation in longevity remains unexplained by existing type or production traits. Some bulls that transmit outstanding production and type still have daughters that tend to leave the herd prematurely. We must recognize that many cows leave herds for non-genetic reasons and type traits can only be used as an indirect indicator of expected longevity. Actual culling data are needed to explain the rest of the story as seen in figure 1. Health and daughter fertility traits are becoming much more prominent in genetic evaluations as we seek accurate predictors of longevity and profitability. These traits are dependent not only on conformation and productivity but also on the general health and physiology of the cow, as well as the cow's resiliency to the stress of high production and confinement housing.

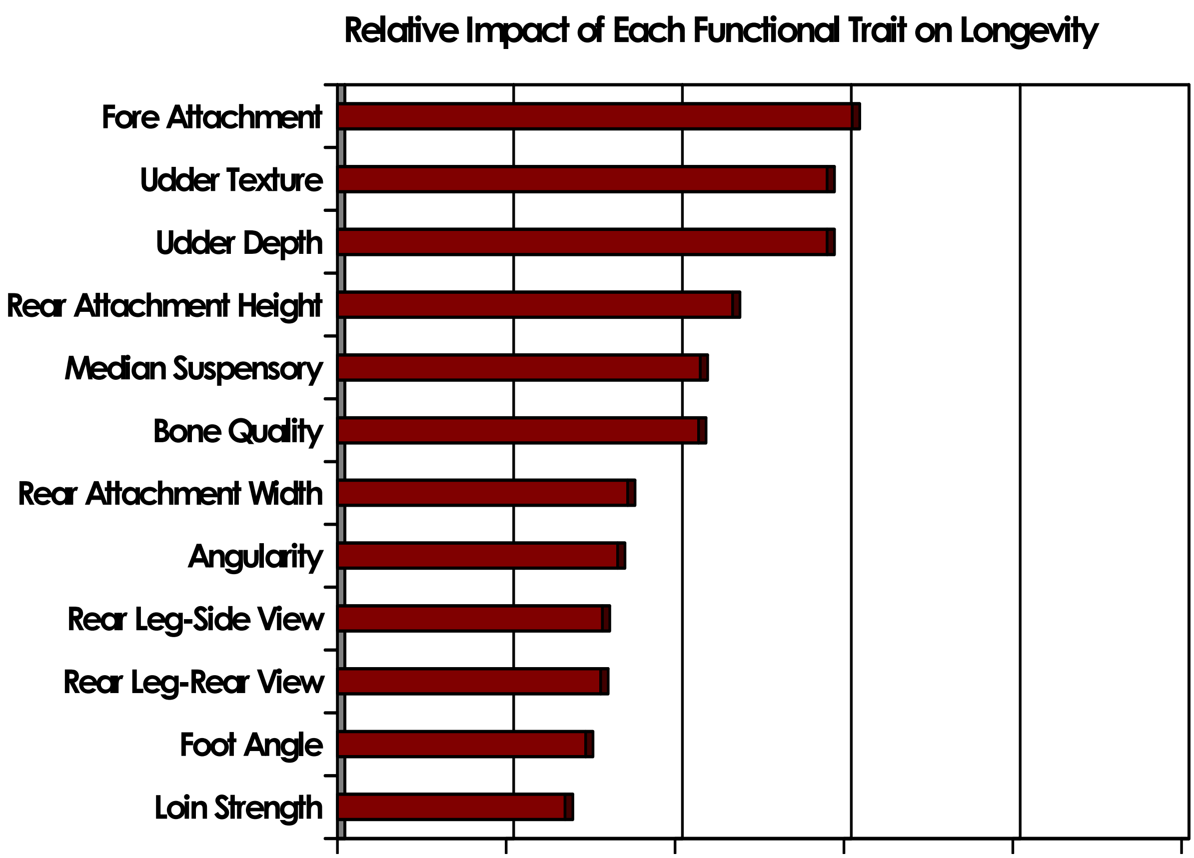


Figure 1. This bar graph is based on actual herd survival data for cows classified as heifers during their first lactation by Holstein Canada between November 1998 and June 1999.

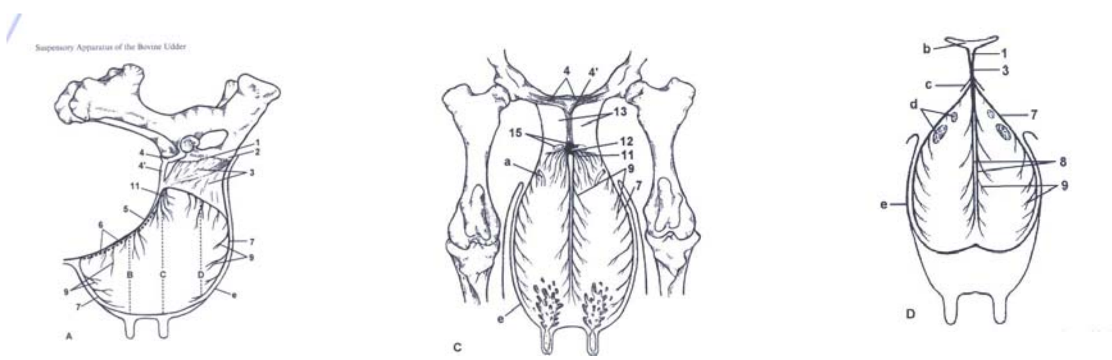
It is useful to begin our discussion on functional conformation by using the four major categories highlighted on our classification scorecard:

- udder conformation,
- feet and leg conformation and the relationship with locomotion,
- dairy strength - thoracic and abdominal body conformation
- rump and loin structure

<u>Udder Conformation</u>

Evaluation of udder conformation and the relative importance placed on each component trait has been modified over the years. Any discussion of udder conformation should include a detailed description of the udder's suspensory apparatus since this attachment to the ventral abdominal wall and the pelvic floor is fundamental to udder health and longevity. Many of the undesirable changes in the udder's exterior characteristics and location can be attributed to a weakness of the suspensory apparatus and these changes are usually irreversible. Normal maturity will cause the suspensory ligaments to stretch but excessive stretching or tearing can cause low, pendulous udders which are more prone to injury and infection.

Historically, the udder was located in a more anterior position and was attached only to the abdominal wall much the same as with deer or elk. Udder shape, location, and strength of attachments are all heritable traits. The heritabilities of these traits were estimated to be between 0.14 to 0.42 (Kistemaker and Huapaya, 2006). Therefore, genetic selection has the ability to alter anatomical structure of the cow's udder. Selection for increased production over the past 250 years has caused the udder to increase in size and mass. As a result, the udder's centre of gravity has shifted caudal or posterior and the suspensory apparatus of the udder has been supplemented with additional suspensory attachment to the pelvic floor by means of the symphysial tendon (represented by "3" in the diagram below). Evaluating fundamental anatomical characteristics such as udder depth and suspensory udder strength has facilitated the development of a functionally sound udder to accommodate the stress of high production.



(Jalakas et al., 1999)

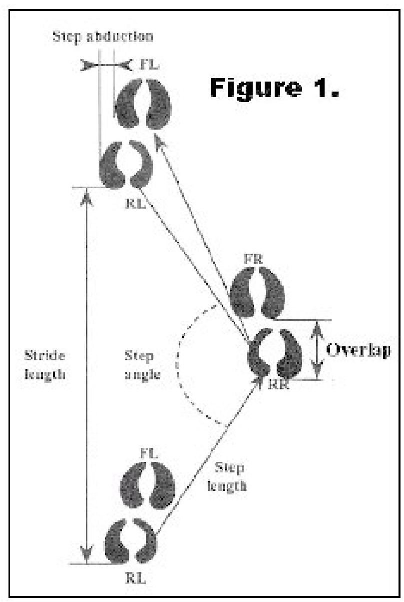
Figure 2. A diagrammatic representation of the suspensory ligaments of the udder.

Several researchers have shown a consistent relationship between udder conformation and udder health and longevity. VanDorp et al., (1998) showed that cows with longer teats were genetically predisposed to a higher incidence of mastitis. In addition, cows may alter their gait if udders are deep and pendulous. Udder traits (especially the height of the udder above the hock) were found to positively influence the length of productive life. Udder depth and milking ease accounted for 84% of the total contribution of type traits to functional longevity (Larroque and Ducrocq, 2001). Recent Canadian data reported that rear teat placement, udder depth, and udder texture were udder traits that had a significant influence on functional survival (Sewalem et al., 2004).

<u>Feet and Leg Conformation</u>

Locomotion is a qualitative evaluation of a cow's ability to walk normally. It measures not only the cow's conformation but also her motion biomechanics including her freedom from lameness and the desirability of the surface upon which she walks. Scoring locomotion directly is the most accurate determination of a cow's feet and leg soundness.

In addition to evaluating the magnitude of lameness, locomotion scoring has been initiated in several countries as part of the type classification system. In Canada, locomotion is being evaluated as a research trait in free stall herds. Locomotion evaluation involves observing a cow while walking and identifying important movement and step parameters including foot placement and length of stride as shown in figure 3. Normal locomotion is characterized by a long fluid stride where the rear foot falls into the imprint produced by the front foot on the same side (no abduction or overlap). Undesirable locomotion may result in the rear foot being placed outside the imprint of the front foot as well as a shortened stride length, and a decrease in step angle and walking speed. In the past, scoring of actual locomotion on the total population in Canada has not been practiced since many cows are still housed in tie stall barns. As a result, a selection index for locomotion was developed using the scored feet and leg traits and the genetic and phenotypic relationships between these traits and actual locomotion. The phenotypic correlation between feet and leg traits and locomotion was estimated using recent data collected in free-stall herds. Correlations ranged from 0.21 with Bone Quality to 0.59 for Rear Legs Rear View.



(Telezhenko, 2003)

Figure 3. This diagram represents Holstein Canada's locomotion scoring parameters.

Since the locomotion index was proposed, Holstein Canada has initiated scoring actual locomotion (as a research trait) in free-stall herds in an effort to provide data to validate and further refine the locomotion index. It is anticipated that in the future a selection index for locomotion could be incorporated into the Canadian Lifetime Profit Index.

Studies have shown that 86% of all foot lamenesses involve the hind foot and that 85% of all hind leg lamenesses involve the lateral claw (Blowey, R.W. 1998). The hind legs are connected to the pelvis by a fixed and relatively inflexible ball and socket joint. While standing, the weight should be distributed equally on each hind leg and equally on each claw assuming good level trimming. During motion, the centre of gravity shifts from side to side and the weight bearing by each hind foot varies with the movement (Raven, 1989). The outer hind claw carries more weight and is more heavily stressed and this is consistent with the much greater incidence of lameness associated with the outer claw of the hind feet. The cow has responded to this by developing an outside claw that is larger and thicker in the sole and heel than the inside claw as seen in Figure 4. However, even with these adaptations, the increased stress on the outside claw still results in a significantly greater incidence of lameness.

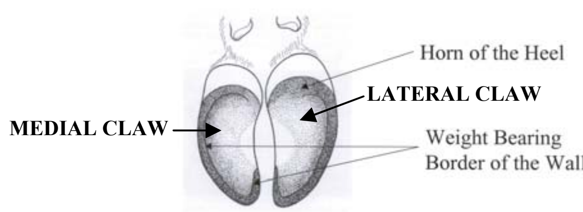


Figure 4. This diagram shows the larger lateral claw on the hind foot. *(Blowey, R.W. 1998)*

Several researchers have shown relationships between feet and leg traits and clinical lameness. Wells et al. (1993) showed that a 10-degree drop in foot angle resulted in an odds ratio of 2.4 to develop clinical lameness. The estimated heritability of feet and leg traits is low, ranging from 0.08 to 0.30 (Kistemaker and Huapaya, 2006), however, the most influential type trait on profit, after adjusting for production, was shown to be Feet and Legs (Perez-Cabal and Alenda, 2002).

This association can be attributed to the positive influence that sound feet and legs can have on reproduction and longevity. A favourable genetic correlation was estimated between Feet and Legs and non-return rate, suggesting that cows with good feet and legs were less likely to return to service (Wall 2005). Melendez (2003) explained that cows having foot and leg problems were less likely to show signs of estrous. Sewalem et al. (2004) reported that cows having extremely coarse bones, extremely shallow heels, low foot angle, and extremely straight or curved legs from the side view had decreased functional longevity.

Dairy Strength - Thoracic and Abdominal Body Conformation

The Canadian Holstein has long been recognized around the world for her capacity, made possible by well sprung, open ribs, and for the unique combination of chest width and body depth that give rise to her characteristic angularity. Although extreme height and size in the show ring has been preferred historically, stature and size have been shown to have negligible or negative effects on longevity (Sewalem et al., 2004). The classification system in Canada has progressed alongside knowledge of relationships between body traits and longevity. As a result, size is no longer evaluated and stature contributes less than 3% to the Final Score. In addition, extreme stature receives a small deduction in the Canadian system. A cow with desirable dairy strength in Canada is characterized by having an angular, open, well-sprung rib, with a wide chest floor and sufficient depth of body to have the capacity to convert large amounts of forage into high quality milk protein.

Studies have demonstrated the relationships between body shape and survival in dairy cows. Cows that were extremely short, small, and narrow-chested had a higher risk of being culled compared to cows intermediate for these traits. A clear relationship between angularity and longevity was observed, indicating that extremely non-angular cows (score of 1) were 2.47 times more likely to be culled than those with intermediate angularity (score of 5). Additionally, extremely angular cows (score of 9) were 1.28 times less likely to be culled than cows that scored 5 (Sewalem et al., 2004).

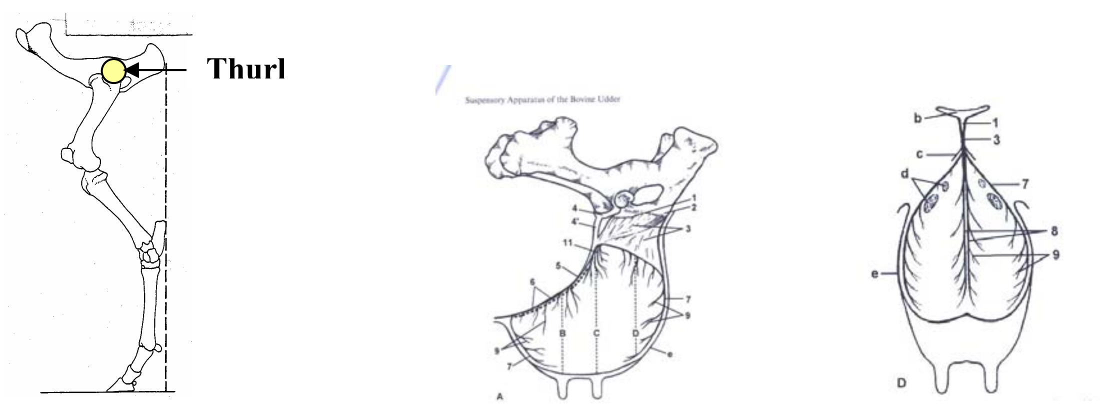
Holstein Canada recently introduced Body Condition Score (BCS) as a research trait. Although this trait currently does not contribute to Final Score, evaluation of daughters will enable calculation of sire proofs for body condition loss and perhaps predict future daughter reproductive performance by incorporating BCS into the daughter fertility index. In addition, the scoring of body condition helps to establish the principle that dairy strength is a functional trait that should be evaluated independent of body condition score. Cows should not receive high scores for dairyness just because they are thin.

Relationships between body condition and reproductive performance are well documented. Cows with high genetic merit for BCS lost less body condition in early lactation, and therefore experienced less severe negative energy balance (Dechow et al., 2002). In addition, Dechow et al. (2002) reported that the genetic correlation between body condition loss and days to first service was 0.68 in first lactation and 0.44 in second lactation, indicating that as body condition loss became more severe, days to first service increased. Kadarmideen and Wegmann (2003) found similar favourable genetic correlations between fertility (days to first service and non-return rate) and BCS. Dechow et al. (2002) noted that selection for yield appears to increase body condition loss by lowering postpartum BCS. Cows that were thinner (lower body condition) had longer calving intervals (Pryce 2000).

Thoracic and abdominal capacity along with dairyness and femininity (angularity) are desirable attributes to facilitate the dairy cow's ability to process large volumes of roughage and sustain high production and desirable reproductive performance.

<u>Rump and Loin Structure</u>

A dairy cow's rump connects several other anatomical structures of significance through the pelvic region. The hind legs articulate with the pelvis at the thurls, the udder attaches to the abdominal wall which in turn attaches to the pelvis by way of the prepubic tendon (represented by "4" in figure 5) and the rear part of the udder attaches directly to the pelvis floor by way of the suspensory ligaments (represented by "7" and "8" in the figure 5 below):



(Jalakas et al., 1999)

Figure 5.

These diagrams show the importance of the rump (pelvis) with regard to the attachment of the hind leg, the body wall, and the udder.

To complete the link, the loin is directly attached to the pelvis at the lumbo-sacral junction. Essentially, the rump and loin structures fasten the cow's abdominal and lumbar regions to her feet and legs and mammary system. Without adequate strength in this area, the productive life of a cow will be seriously compromised

The position of the hook and pin bones define the allowable width of the pelvis to accommodate a desirably high and wide rear udder. A wide, correctly sloped rump is characteristic of pelvic structure that allows for easier passage for the calf at birth and necessary drainage of post-calving fluids in order to help prevent reproductive infections and related fertility problems. Ali and Schaeffer (1984) described the ideal rump phenotype for ease of calving as one having pin bones that are slightly lower than hook bones, a vulva almost vertical when viewed from the side, collectively displaying a long and wide rump with a well-defined pelvic arch. Finally, absence of abnormalities such as advanced anus, advanced tailhead, and recessed tailhead are desired so that fertility is not negatively affected.

Higher pin bones are associated with an undesirable tilt to the vaginal canal causing it to lie at an inward sloping angle rather than lying flat. With this type of angle, the reproductive tract is more prone to infection since it lies deep within the abdominal cavity and the vagina is unable to drain effectively (Astis 2002). During parturition, the natural exit path for a calf is at a downward angle. Higher pins have a genetic association with inefficient longer calving intervals (Wall 2005). Research shows that animals with higher pin bones and narrower rumps are more likely to have difficult calvings (Cue 1990). In addition, cows with high and narrow pin bones had an increased genetic predisposition to retained placentas (VanDorp et al., 1998). VanDorp also showed that cows with lower scoring rumps were genetically prone to a higher incidence of lameness. In addition to its positive affect on reproduction, researchers have reported a strong link between a sloped wide rump structure and increased longevity. Animals with intermediate rump angles (slope of 1-2 inches from hook to pin) had a longer productive life (lower rate of culling) than animals with extremely low or extremely high pin bones in relation to hip bones (Pérez-Cabal and Alenda, 2002). Sewalem et al. (2004) showed that the relative risk of involuntary culling was lowest at intermediate rump angles.

Although there is no doubt that the show ring provides an unequaled venue to showcase excellence in conformation, we must recognize that all dairymen do not view superior conformation with the same priority and, in addition, several researchers have been discrediting the value of conformation in relation to longevity or productive life. Their criticism has focused on issues such as cows being too large, too frail, and having a reduced reproductive performance. For too long we have not responded to the critics who condemn conformation evaluation and we have not challenged their misguided views that claim superiority for a smaller, thicker, crossbred cow with the alleged benefit of hybrid vigor.

When we look at the conformation traits showing the greatest correlation with longevity, there is no doubt that the udder traits and the feet and leg traits are at the top of the list. Few critics debate this issue since the desirable type traits used in the judging and classification system for these two categories are fundamental for a cow to achieve longevity. Most of the rump traits are also accepted as being required for good functionality, however, it is more of a challenge with Dairy Strength. Although breeders around the world describe strength as a fundamental component of longevity, research has left us with some results that are both difficult to accept and difficult to explain.

The traits that are evaluated in the dairy strength category include angularity, stature, height at front end, chest width, and body depth. The trait of angularity is also referred to as dairy form or dairyness and is scored quite differently in different countries around the world. It is important to recognize that if high angularity scores are associated with thin cows, as is the case in a significant number of countries, there will be a large negative correlation with this trait and longevity. In Canada we have argued that angularity should be scored independent of body condition and should represent a structural evaluation that combines strength with the dairy character that identifies the will to milk. By focusing on these structural traits including spring and openness of rib, Canada has been able to develop an angularity evaluation that has a positive influence on longevity.

Stature and height at the front end are also controversial traits since excessive height is also associated with reduced longevity. The important point to recognize here is that stature does not tell the whole story since it is, in effect, a combination of body depth and length of leg. Stature in Canada has increased by 2 inches in the past 10 years and this rate of increase is not sustainable. However, it is critical that attempts to control this rapid increase in stature does not come at the expense of body capacity which is essential to achieve high dry matter intake and efficient, economical milk production.

At the present time excessive chest width and body depth both have negative correlations with herd life. The negative correlation with excessive chest width can be partially explained by the fact that this characteristic can be associated with a coarse, “woody” cow. In the case of body depth, it may relate to increased body weight associated with excessive body depth. This may result in added strain to the feet & legs from the cow having to carry a greater mass over her lifetime. For a trait such as body depth, we must also recognize that this trait can be difficult to assess on young fresh heifers and accurately predict the development that will occur over time.

In conclusion, I think dairymen must recognize that the functional conformation we have today can't be taken for granted and it will deteriorate rapidly if it does not receive priority in our genetic selection programs. We need to build on the past 100 years of breeding success and use the new genetic selection tools in combination with selection for functional conformation selection to develop the most desirable dairy cow for our modern confined management environment.

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