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Review

Selection for linear traits for legs and feet and its significance for dairy cattle breeding

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Abstract. Selection based on real problems with the legs and feet - the case of lameness, has low efficiency. Linear type traits describing the structural differences in different body parts including those of the legs and feet can be evaluated directly in a large number of animals at an early stage in the life of cows, by not a large number of specialists. Type traits of legs and feet have low to medium heritability values. There is a genetic relationship both among the various linear foot and leg traits and between them and the issues with animal locomotion. The selection for optimal angle of the foot and the rear leg side view, straight rear legs rear/back view, flat and refined bones and proper locomotion – will result in reduced locomotion problems and diseases of the legs and feet in dairy cows. Negative correlation has been found between problems with legs and feet, milk production and reproductive performance. Problems with legs and feet are one of the causes of premature culling and reduced longevity of dairy cows.

Keywords: linear type traits, legs and feet, heritability, correlations, lameness, milk cows

Introduction

Worldwide the ambition of farmers is towards more efficient production of high quality products at competitive prices, which leads to greater demands on the health and productivity of dairy cows. Foot and leg disorders and other problems of the locomotor system are the third most common health problem and reason for culling dairy cows after reproductive problems and mastitis (McDaniel, 1997; Sulayeman and Fromsma, 2012). Health problems with legs and feet lead not only to a negative impact on animal welfare as a result of inflicting pain and suffering of cows (McDaniels, 1997; Garbarino et al., 2004; Van Der Waij et al., 2005), but also result in reduction of the farmer's profit. A reason about that are the increased costs for veterinary treatment (Kossabati and Esslemont, 1997), direct losses from lower productivity and disposal of milk (Warnick et al., 2001; Green et al., 2002) and indirect loss resulting in extending the calving period (Sogstad et al., 2006), reproductive disorders (Hernandez et al., 2001; Melendez et al., 2003; Van Dorp, 2004; Koenig et al., 2005) and reduced period of use of animals (Sprecher et al., 1997; Booth et al., 2004). It is believed that actually culling due to foot and leg problems is greater since part of the culling for reproductive disorders may actually be due to foot and leg problems as a result of which there is no estrus. Even part of the culling for "low productivity" may be actually due to such problems (McDaniel, 1997). Numerically losses from lameness relate to the lowered milk yield of the affected cows comprising 40% of total losses, expenses for treatment – 34% and reduced fertility rate – 26% (Olechnowicz and Jaskowski, 2011).

The incidence of lameness in dairy cattle breeding has increased significantly in recent years. In the dairy herds in the UK it has increased from <10% before 1980 (Russel et al., 1982), to > 20% after 1990 (Clarkson et al., 1996). In the USA lameness in dairy cows is between 21,1% and 23.9% (Cook, 2003). According to Broom (2002) lameness in cows in the USA varies from 35 to 56%, and in England it is 22% (Whay et al., 2002). A study by Green et al., (2002) reveals that over 70% of the cows have had foot and leg problems at least once during the seven-month study. Studies in dairy farms in the Netherlands show that over 70% of the cows have had at least once a foot problem (Somers et al., 2003; van der Waal et al., 2005). For Bulgaria the studies by Vasilev and Yotov (2004) show variation of lameness in dairy cows from 9,37 to 28,12%. Mitev et al. (2012) in a study in three dairy farms recorded lameness from 18 to 28 % for the various farms. According to data by Todorov (2009) worldwide between 2 and 55% of the dairy cows exhibit lameness.

The cases of locomotion problems recur from one lactation into the next one with the same animals. Lyons et al. (1991) found repetitiveness of locomotion disorders 0.55, which is a significantly higher recurrence compared to other health problems (0.09 to 0.33).

Opportunities for selection to reduce foot and leg problems

McDaniel, (1997) indicates two main reasons affecting the resistance to foot and leg problems: (1) metabolic and (2) structural differences in various body parts and more specifically in legs and feet. The basic metabolic factors influencing foot and leg problems are little known except that some of them such as those resulting in laminitis, are extremely important. One of the most common causes for the occurrence of lameness with metabolic origin is subacute ruminal acidosis - SARA. Until practically applicable tests are prepared to enable easy and accurate prediction as to which animals are more susceptible to metabolism-induced lameness, direct assessment of metabolism will have limited use in selection for improvement of locomotion or resistance to foot and leg problems. Obviously, metabolic causes are difficult to record, but conformation differences can be directly assessed (McDaniel, 1997).

Selection based on actual foot and leg problems – cases of lameness, has low efficiency. One of the causes for the lower efficiency of direct selection for lameness compared to the indirect one is that as a whole clinical foot and leg problems have low
frequency, especially in younger cows, whereas subclinical cases are not easy to be precisely identified. The accurate recording of lameness requires training of a great number of farmers and veterinarians to identify and record cases on a daily basis. On the other hand, only a few well trained specialists are needed to assess and describe legs and feet and other body parts related to locomotion, once or twice in a great number of young cows, which suffices for efficient selection. Where available, information data of foot and leg problems, can be a useful, but not the main tool for the selection goal (McDaniel, 1997).

The health status of the feet of dairy cows is not included in the breeding programs of various breeding organizations, but it could be improved through indirect selection for linear type traits for legs and feet, which are related to the problems of locomotion (Van Der Waaij et al., 2005). However, this is only possible if the correlations between them are sufficiently high (0.50 – 0.60).

Linear type traits for legs and feet

The concept of linear type traits was introduced in 1976 and the first programs for evaluation of linear type traits have been implemented and tested in 1979 (Lucas et al., 1984). Since 1983 all countries with developed cattle breeding have used the linear type descriptive system to assess conformation traits, which includes several basic linear type traits related to feet, legs and locomotion of dairy cows (Interbull, 2012). In most European countries a scale of 1 to 9 is used, and these are the recommendations of ICAR (2011). Today all breed associations and almost all organizations for artificial insemination use some form of linear type description of breeding evaluation and analysis of the conformation traits in dairy farming.

The basis for reducing lameness through selection for various traits related to feet and legs is the good knowledge of anatomy and biomechanics of normal legs and feet and the relationship between the deviations and various locomotion problems. The most common and the oldest incorporated into breeding schemes linear type traits for legs and feet are the foot angle, set of rear legs – side and rear view. In the last recommendations of ICAR (2011) the linear type traits locomotion, hock development and bone quality are included. In the selection systems for assessment of type in some countries the linear traits foot length or diagonal (the Netherlands) and foot depth (Canada) were included. Practically evaluated are only the traits related to rear legs. Similar traits of the front legs are not included in the different breeding systems for conformation traits assessment, as it is believed that the variation in the structure of the front legs and feet are not crucial to locomotion problems.

The angle at the front of the rear hoof measured from the floor to the hairline at the right hoof (Figure 1). On a scale from 1 to 9 to 1 corresponds a small angle of 15° – 22°, and to 9 – over 65° (WHFF, 2008 and ICAR, 2011). It is assumed that the ideal angle is about 45°. This is a trait that can be affected by trimming hooves, and factors such as bedding, accumulation of manure, etc., can result in inaccurate reporting of the trait. For this reason, the foot angle in the Holstein in Canada is defined as the angle of the hair line above the foot. It is believed that this method of reporting is the least dependent on trimming of hooves or bedding (Atkins and Shannon, 2002). Changing the foot angle results in a shift of the burden on the foot and joints, and, respectively, in injuries and quicker fatigue and pain (Atkins and Shannon, 2002). The angle measured at front of the hock is described in side view (Figure 2). 1 corresponds to an angle of 160° – 158° – straight, and 9 – 136° – 134° sickled (WHFF, 2008 and ICAR, 2011).
The data from the Holstein in Canada show that the curve of the rear legs in the hock varies from 135° to 170°, the ideal angle being 150° – 155°. There is a difference in the requirements for the ideal set for the rear legs in different cattle populations on the same breed – in the classification system of the USA the requirement is for slightly more straight rear legs side view, than in the Canadian one (Atkins and Shannon, 2002).

This trait is used to assess to what extent the rear legs are straight and parallel when viewed from the rear and the degree of inside curve of the hocks and the deviation in the sides of the feet is assessed (Figure 3). This reference point is determined by the vertical line drawn down to the floor from the pin bones. Score 1 is for rear legs almost touching each other in the hock joints, maximum X-shaped set and feet directed strongly sidewards, and score 9 – rear legs placed wide in parallel, the distance between the hocks is greater than that between the middle of the two feet (WHFF, 2008; ICAR, 2011).

There is a strong relation between the rear legs rear view and the health status and condition of the feet. Normally legs should be straight from the back facilitating the smooth locomotion, "straight-ahead locomotion" with the external feet maintaining the body weight. Injured external foot corium causes increased sensitivity and pain and cows try to compensate by shifting the weight on the internal feet. As a result, feet are placed aside and the hocks inwards. Cows with such a setup move their legs like shovels and they are not normally straight and with smooth locomotion (Atkins and Shannon, 2002). The development of bones in the rear leg metatarsus is recorded, taking into account the flatness, smoothness, and width of bones (Figure 4). Score 9 are ideal bones – extremely smooth, flat and well developed bones and tendons, and score 1 – thick and broad bones (WHFF, 2008; ICAR, 2011). The quality of the bone structure is an indicator of good condition and blood circulation in the legs without swelling in the joints. There is a high positive correlation between bone quality, the dairy type and milk yield (Atkins and Shannon, 2002).

Gordon and Shannon (2002) indicate that bone quality is an indication of good physical condition and good development of the legs. Cows with flat and refined bones have better locomotion resulting from the reduction in bone mass and reduced area of contact, particularly in the hock, which can reduce leg problems. The hock is described viewed from the rear and the side (Figure 5). It is recorded how flat and with dry forms the joint is, presence of edema and infusions in it. Score 1 conforms to thick hocks with significant swellings on them, score 9 – flat, smooth bones of the joint, without swellings and infusions on them (WHFF, 2008; ICAR, 2011).

The setting of legs and feet in locomotion, length and direction of the step is recorded (Figure 6). Score 1 corresponds to the presence of lameness due to injury or disease of the feet, score 9 is not recorded or has very slight ad- or abduction in locomotion, long strides (WHFF, 2008; ICAR, 2011).

The reference point for this trait is the distance from the hairline of the heel to the floor (Figure 7). Depth of not less than 4 cm is assumed to be ideal and corresponds to score 9. Canada is one of the few countries assessing the heel depth as well, the other countries agree that it is enough to take into account the foot angle and this is related to the depth as well. Since the heel depth is

![Figure 3. Rear legs rear view](image)

![Figure 4. Bone structure](image)
incorporated in system of linear description of the Holstein in Canada and the breeding assessments of bulls have shown very low correlation between the foot angle and the heel depth, the Canadian Holstein Association continues to describe and assess the heel depth. Bedding and soiling with manure can hamper the reading of the trait heel depth (Atkins and Shannon, 2002).

The length of the diagonal connecting the beginning of the hair line in the rear of the foot and its tip is recorded (Figure 8). The length of the foot or its diagonal is a trait that is seldom included in the evaluation system, recorded in the Netherlands, for example. Although studies have shown a certain association between problems with feet and foot length (Choi and McDaniel, 1993), most breeding organizations tend not to include it because it is influenced largely by hoof trimming. All studies show that cows with shorter foot diagonal at first lactation have longer productive life.

**Heritability of foot and leg traits**

Studies show that the type traits associated with legs and feet have genetic components of variation significantly greater than zero and are low to moderately heritable. Toghiani (2011) obtained very low heritability values for the linear foot and leg traits, 0.075 for rear legs side view, and 0.13 for foot angle, respectively. For the Czech-Moravian Association of Holstein breeding Nemcova et al. (2011) found values for heritability of the linear foot and leg traits, respectively: rear legs rear view – 0.10, for rear legs side view – 0.16, for foot angle – 0.10 and for bone structure – 0.28. Low heritability values are indicated by De Groot et al. (2002), for rear legs rear view – 0.12, rear legs side view – 0.11 and foot angle – 0.04, respectively. Slightly higher heritability values of the foot and leg traits for the Holstein have been received in Turkey by Tapki and Guzey (2013), respectively for rear legs rear view – 0.22, for rear legs side view –
0.20, for heel depth – 0.16 and locomotion – 0.12. Bone quality/structure, which is a new trait in the classification system of the United Kingdom, has moderate heritability values 0.23 (Onyiro, 2009). Similar are the results given by Fatehi et al. (2003), from 0.24 to 0.29, respectively, for bone quality/structure in different housing systems. Van Dorp et al. (2004) established heritability value 0.30 for bone quality in Canadian Holstein cows. The resulting heritability for bone quality (0.23) shows that selection for flat and refined bones in dairy cows may have moderate success (Onyiro, 2009). Heritability of the trait heel depth for the Holstein population in Canada is similar to the others relating to the foot – 0.10. Heritability for the linear type trait foot angle is about 0.10 on average with deviation up to 0.15 and it is lower than that for the foot length/diagonal. The linear type trait foot length (diagonal) has higher heritability – of about 0.19 (Groen et al. 1994) and has higher values when measured (from 0.23 to 0.41). Heritability values for all foot and leg traits are similar and not higher than 0.22 (Visscher and Goddard, 1995). This means that most linear type traits for legs and feet for the individual cows do not have great contribution to selection. Still, heritability around 0.10 is sufficient to obtain a reliable estimate of the breeding value of bulls, given trait may lead to a change in an adverse direction of another trait.

Correlations among the linear type traits for legs and feet

Among the linear type traits related to animal locomotion, there is both phenotypic and genetic correlation. A serious study and understanding of the correlations among them is necessary, which will contribute to proper targeting of selection. Genetic correlations between the various linear type traits for legs and feet are low to moderately high. Nemcova et al. (2011) found that the correlation between the foot angle and the rear legs side view is –0.67. This means that cows with more straight hocks (elephant setup) show a clear tendency for steeper feet as well and vice versa. The genetic correlation between the foot angle and rear legs rear view is 0.39. genetic correlation between bone quality and chest width is -0.52, and with the body depth it is -0.18. These correlations indicate that cows with broad and deep body have thicker, coarser bone system. Cows with definitely angular milky forms have more refined bone system, the genetic correlation being 0.67 (Nemcova et al., angle). and shorter foot diagonal would lead to a reduction in the incidence of foot and leg problems. Similar relationships were observed for the length of the foot.

High and negative genetic correlations (above -0.50) between the foot angle and rear legs rear view is 0.39. correlation between the foot angle and the sole ulcer is –0.29, and with the body depth it is -0.18. These correlations indicate that cows with broad and deep body have thicker, coarser bone system. Cows with definitely angular milky forms have more refined bone system, the genetic correlation being 0.67 (Nemcova et al., angle). and shorter foot diagonal would lead to a reduction in the incidence of foot and leg problems. Similar relationships were observed for the length of the foot.

Onyiro (2009) pointed out that the genetic correlation between locomotion and the set of the rear legs is negative, indicating that the sickled rear legs are associated with locomotion problems. The results of the analysis indicate moderate genetic correlations between bone quality, locomotion and the overall assessment of legs and feet. This means that selection for good/sound/ locomotion will result in improvement in the bone quality, and vice versa. Van Dorp et al. (2004) obtained moderate genetic correlation (0.25) between bone quality and locomotion. Onyiro (2009) found no significant genetic correlation between bone quality and reed legs side view and foot angle. This is surprising because these two traits may have moderate genetic correlation with locomotion, which in turn has high genetic correlation with bone quality. A possible explanation for this is the existence of a non-linear relationship with these two traits – with them the optimal values are from the middle of the scale, while with locomotion – in one end – towards score.

Genetic parameters, especially correlations, must be calculated for each breed and country in order to avoid influencing genetic evaluations due to improper (co) variance of the components (Toghianni, 2011). Selection in a certain direction for a given trait may lead to a change in an adverse direction of another one.

Correlations between foot and leg traits and locomotion problems

For the correct targeting of selection towards reducing locomotion problems and foot and leg problems it is necessary to know very well the relationships between them and the linear foot and leg traits. Genetic correlations between foot measurements and foot disorders are moderate (Boelling and Pollott, 1997). At a greater foot angle the rates of incidence of laminitis, digital dermatitis and sole injuries are reduced. Boettcher et al. (1997) found that cows with steep feet have fewer cases of clinical lameness. The genetic correlation between the foot angle and the sole ulcer is –0.29, suggesting that animals with steeper feet are less susceptible to sole ulcer. Similar relationships were observed for the length of the foot. Correlations between foot angle and hyperplasia interdigitalis are positive, but of lower values. Selection for steeper feet (greater foot angle) and shorter foot diagonal would lead to a reduction in the incidence of foot and leg problems. High genetic correlation has been found between lameness and the locomotion trait (Boelling and Pollott, 1998a, b; Stott et al., 2005).

For making practical selection decisions correlations are favorable. Wells et al. (1993) found a similar phenotypic relationship between foot angle and clinical lameness. The authors found that bulls that transmit more straight legs – rear view, have fewer daughters with foot and leg diseases. Phenotypic evaluations of certain studies have shown that cows with a little bit above the
middle range of the rear leg - side view scale are the most desirable (McDaniel, 1995). Cows with steeper foot angle and straighter legs have far better locomotion based on a study by Van Dorp et al. (2004). Boettcher et al. (1998) found that cows with lower foot angle, sickled set and broad rump have more cases of clinical lameness. According to Koenig et al. (2005) bulls that transmit to progeny straight legs - side view; have fewer daughters with foot and leg problems.

In Bulgaria Miteva et al. (2012) found significant correlation between lameness assessment and rear legs – rear view set. In cows with parallel rear legs no lamotion problems have been recorded, while in those with clear X-shaped set over 30% have varying degree of lameness.

Relationship between foot and leg traits and milk production

In many countries selection programs in dairy farming are primarily focused on milk production, and less attention is paid to the conformation traits. Given the high percentage of lameness due to foot and leg problems, the correlation between lameness and milk production is of great economic importance. Many authors have studied the impact of lameness on milk production and obtained mixed results. Some of these studies show that high-producing cows are exposed to a greater risk of lameness (Barkema et al., 1994; Green et al., 2002). However, Grohn et al. (1995) claimed it was not necessarily that high-producing cows were more susceptible to lameness provided that feeding and rearing conformed to their biological needs. Other studies have shown that cows with lameness have lower productivity than those which are not affected by these problems (Warnick et al., 2001; Hernandez et al., 2002, Mite et al., 2011; Sulayeman and Fromsa 2012) and also less than their potential (Green et al., 2002). Rajala-Schultz et al. (1999) assessed milk loss between 1,5 and 2,8 kg/day for the first two weeks after lameness was found.

The results showing higher milk yield in cows with lameness raise the question among researchers whether this is not because higher productivity is associated with the occurrence of lameness. This relationship was studied by a number of authors (Deluyker et al., 1991; Barkema et al., 1994). Their studies support the possibility that the high milk yield is a risk factor for the disease. Other studies have shown higher levels of lameness in herds with higher milk yield, but recent studies have not found such a relationship (Whitaker et al., 2001; Haskell et al., 2006). This could mean that high milk yield alone cannot lead to lameness.

Several studies also suggest that highly productive cows are at higher risk of lameness due to the metabolic stress of the high milk yield (Barkema et al., 1994; Warnick et al., 2001). In an effort to achieve maximum productivity, some farmers feed with higher grain, lower fibre diets that maximize energy intake during early lactation. Overdose of proteins coupled with an insufficient amount of crude fiber can lead to occurrence of subacute ruminal acidosis (SARA). It is a disorder of ruminal fermentation that is characterized by extended periods of depressed ruminal pH below 5.5–5.6 and leads to various digestive and systemic disorders. In the long term, dairy herds experiencing SARA usually exhibit secondary signs of the disease, usually 3–6 months after an appearance of SARA. These secondary signs include laminitis, weight loss and poor body condition despite adequate energy intake, and unexplained abscesses. Undiagnosed, the secondary health effects of SARA can lead to high herd culling rates. SARA should be investigated as a cause, if the secondary signs are occurring for no apparent reason.

Ingvartsen et al. (2003) found unfavorable genetic correlation between milk yield and lameness (0,24 to 0,48). Although it is known that an increase in milk yield was associated with increased frequency of lameness, significant achievements to alleviate this problem have not been made yet (Defra, 2007). De Groot et al. (2002) found that genetic correlations between foot and leg traits and milk yield ranged from 0,107 (for the rear legs – rear view) to 0,83 (for the rear legs – side view) and had significantly higher values compared to those pointed by Misztal et al. (1992) and Short and Lawlor (1992). According to Cassell (1996) the genetic correlations found between productive traits and linear ones about the foot suggest that selection for high milk yield would not affect the foot angle, but increasing the fat content would lead to smaller foot angle. Milk yield and fat content are controlled by many similar genes. Possibly, selection for increase of productivity would result in higher incidence of certain undesirable foot angle genes. The length of the foot will increase genetically with selection for high productivity and the depth will decrease slightly. All these relationships are undesirable.

Relationship between foot and leg traits and reproductive performance

Foot and leg problems influence the reproductive performance of dairy cows. Culling due to reproductive causes may be associated with lower detection of estrus due to foot and leg problems. Sprecher et al. (1997) show that lameness with a score above 2 on a scale from 1 to 5, correlated with a longer interval from calving to first insemination and fertilization, requires more inseminations for fertilization, and is a prerequisite for culling 8.4 times more.

Weaver (1988) stated that lameness could be a possible cause for reduced fertility as lame cows spent more time lying down, have lower manifestation of oestrus and have nutritional problems. Collick et al. (1989) found that lameness occurring within 120 days after calving is related to the extension of the interval of days open. Garbarino et al. (2004 ) studied the effect of lameness on ovarian activity in postpartum in Holstein cows and found that lame cows had 3,5 times greater odds of delayed cyclicity. Based on their research, they suggest that delayed ovarian cyclicity in lame cows will be reduced by 71% if lameness was eliminated.

Onyiro (2009) found that in general, genetic correlations between linear foot and leg traits with NR56 are low, with the exception of that between bone quality and NR56 (0,36). Correlations indicate that the straight hocks, steep feet, higher overall score for legs and feet, and flatter and refined bones are associated with better fertility. The studies by Cassell (1996) suggest that not all values for the foot and leg traits are unidirectional and desired effect on various economically significant traits. For example, steep and short feet are associated with shorter interval of days open, longer survival up to 5 years and higher culling age – they are all desired. But deep heels are associated with longer interval of days open and longer life as well.

Berry et al. (2004) found that cows with straighter hocks and steep feet have lower fertility rate at first insemination. Unfavorable correlations between locomotion and fertility indicate that the increase of the incidence of lameness is associated with longer time to first insemination and lower fertility rate at first insemination. Peeler et al. (1994) found that if a cow became lame in the period before inseminating, it is less likely to detect oestrus. Therefore, assessment of locomotion after the first insemination cannot have such an influence on the period to first insemination, as assessment afterwards.

Relationship between foot and leg traits and duration of...
productive life of dairy cows

Although traits related to productivity and fertility are of paramount economic importance, functional traits such as longevity and health are of great interest for milk producers in order to improve the profitability of the herd. Besides all this, the exclusive emphasis on selection for milk yield has a negative effect on conformation traits, which has an effect on the overall condition of animals. Research on livestock are increasingly aimed at identifying new selection criteria that would contribute to the genetic improvement of economically important traits of low heritability (such as longevity or health). A possible solution is to apply indirect selection of these characteristics through selection for linear type traits (Bouška et al., 2006).

Direct selection for reducing involuntary culling has limited options because it leads to extension of the generation interval and has low heritability values, therefore selection based on correlated traits that can be recorded as early as first lactation is preferable. Several studies suggest that there is a relationship between the type or physical characteristics of the exterior and the duration of productive life or lifetime productivity (Rogers et al., 1988). Information about the conformation traits can be used as relatively early estimate for the duration of use. Some conformation traits are associated with longevity and are recorded at the beginning of the productive life of cows. The breeding goal in dairy farming is to increase the profit from animal per unit of time. Profit is a function of productivity and time for which a cow remains in the herd. Thus, the profit can be calculated only when the cow is culled and selection for more profitable animals must be able to be reported at an earlier age (Perez-Cabal and Alenda, 2002). Foot and leg problems are one of the causes of involuntary culling of dairy cows. Cases of lameness are associated with higher levels of culling (Oltenacu and Broom, 2010). Uribe et al. (1995) found that heritability for the so-called “culling due to leg problems” is 0.15. In fact, foot and leg problems can be a cause of culling for many of the cows culled due to low productivity and disorders in reproduction. Results from several studies show that moderately straight legs in side view are associated with longer life. Straighter hocks also lead to problems. Dadpasand et al. (2008) reported that deviations in rear legs side view and foot angle increased the risk of culling. However, rear legs set–side view, has half less correlation with the duration of productive life as compared with the foot angle (McDaniel, 1997).

Generally, rear legs set – rear view is more strongly correlated with the longevity than that of the rear leg – side view, as shown by numerous studies (McDaniel, 1995; Boettcher et al., 1997). Assessments of breeding bulls transmitting straighter rear legs – rear view, i.e. parallel (without X-shape) are positively associated with higher longevity of their daughters. The analyses show that the rear leg set - rear view is of almost the same significance as the foot angle to predict longevity. The relationship between the length of the foot diagonal with survival has been the subject of study by de Jong (1994) as well, who found that cows with the longest foot diagonal had the shortest duration of productive life. The greatest duration of use is in those with medium length of the foot diagonal. The culling rate in cows with the shortest diagonals is higher than in those with intermediate values for length of the diagonal.

McDaniel (1997) found that the greater foot angle is positively correlated both with higher survival and the trait rear legs – rear view. Choi and McDaniel (1993) found that the genetic correlation between the foot angle and the culling age is 0.87, which is a confirmation of the statement that after reproductive problems, low productivity and mastitis, leg problems and locomotion are the most important reasons for involuntary culling of dairy cows. Dekkers et al. (1994) found that the trait bone quality had moderate genetic correlation with longevity. Gordon and Shannon (2002) suggest that bone quality is an indication of good physical condition and good development of the legs, and has high positive genetic correlation with the traits dairy type and milk yield. According to Onyiro (2009) longevity has high genetic correlations with bone quality (0.50), locomotion (0.66), and the total foot and leg score (0.69), which suggests that flat and fine bones, good locomotion and the overall good foot and leg condition are associated with increased longevity. The foot angle is moderately correlated with longevity; which means that cows with a steeper foot angle have greater longevity. The correlation between rear leg set – side view and life expectancy is –0.32, indicating that the sickled set of the rear legs is associated with reduced lifespan. Sawa et al. (2013) found that lifetime productivity has the highest correlation with the linear traits of the udder (0.22), followed by foot and leg traits (0.13). Selection to improve foot and leg traits will not solve the problems with them completely, but selection for animals with shorter foot diagonal, steeper feet, optimum hock angle from side view and more parallel rear leg set from rear view will improve locomotion of animals and reduce problems with them in herds (McDaniel, 1997).

Conclusion

Selection based on actual foot and leg problems – cases of lameness, has low efficiency due to the fact that as a whole clinical problems with legs and feet have low incidence, especially in younger cows, and subclinical cases are not easy for correct identification and require special training and daily reporting. For indirect selection of linear traits only a few well trained specialists are needed to assess and describe legs, feet and other body parts related to locomotion, once or twice in a great number of young cows, which is sufficient for efficient selection. Regardless of the low hereditary coefficients, heredity of about 0.10 is sufficient to achieve reliable estimate of the breeding value of bulls with a large number of assessed descendants. Genetic correlations of linear foot and leg traits to lameness and foot and leg diseases in dairy cows show that it is possible to apply indirect selection to improve foot and leg health, and thus reduce the incidence of lameness and its negative impact on the efficiency of dairy cattle breeding. The selection of animals with optimum foot and hock angle from side view, parallel rear legs from rear view, flat and refined bones and good, sound gait will improve locomotion of animals and reduce foot and leg problems in dairy herds. Direct selection for reducing involuntary culling due to lameness has limited options because it leads to an extension of the generation interval and has low heritability levels, so selection based on correlated traits that can be recorded as early as first lactation is preferable from an economic point of view as well.

Reference


Miteva, T., Gergovska, M., Miteva, T. and Penev, T., 2011. Influence of lameness on dairy milk yield, lactation curve and body condition score during lactation in Black-and White cows. Bulgarian Journal of
Agricultural Science, 17, 704-711.
Tapk I and Guzev Y, 2013. Genetic and Phenotypic Correlations between Linear Type Traits and Milk Production Yields of Turkish Holstein Dairy Cows. Greener Journal of Agricultural Sciences, 3, 11, 755-761.
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Papers shall be submitted at the editorial office typed on standard typing pages (A4, 30 lines per page, 62 characters per line). The editors recommend up to 15 pages for full research paper (including abstract references, tables, figures and other appendices).

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The title needs to be as concise and informative about the nature of research. It should be written with small letter /bold, 14/ without any abbreviations.

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**Discussion:** The objective of this section is to indicate the scientific significance of the study. By comparing the results and conclusions of other scientists the contribution of the study for expanding or modifying existing knowledge is pointed out clearly and convincingly to the reader.

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