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EFFECT OF SELECTED FACTORS ON LONGEVITY IN CATTLE: A REVIEW

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ABSTRACT

This review presents genetic, phenotypic, environmental and other factors influencing functional longevity in dairy cattle. High yielding cows show a lower risk of culling than low producing cows. Cows with a lower milk yield have an approximately 2.7 times greater risk of culling as compared to cows with an average milk production. Genetic estimation of the length of productive life is possible in both large and small herds. In small herds the genetic effect may be affected by residual effects. Strong relationships with functional longevity in cows have been found for the mammary gland, feet and legs. The udder depth, rear udder and rear udder attachment have the most important effects on the length of productive life. Similarly, cows with a sound conformation of rear legs, the fetlock and feet reach a longer productive life. Age at first calving, herd size, and region of the country have a smaller effect on cow longevity; however, the recommended age of first calving is 24 months or less. The lower age at first calving is associated with lower production in the first lactation. Other traits influencing longevity of cows include calf mortality (average 8% and neonatal mortality of female calves of 3.4%), difficult calving, as well as male or twin births, high and low milk urea nitrogen concentration and lactose percentages, as well as inbreeding, which has a significant effect on reducing longevity of cows. Improved longevity can result in an increased productivity of the herd, because replacement, reproduction and veterinary costs are lowered, while mean milk production of the herd is increased.

Key words: cows, longevity, culling, body conformation traits, economic evaluation.

INTRODUCTION

Longevity is the most important functional trait in selection of cattle worldwide (Jovanovac *et al.,* 2013). The functional traits, such as health, fertility, efficiency of feed utilisation and milkability, are used to summarize the characteristics of animals, which increase the efficiency of production by reducing input costs (Groen *et al.,* 1997). Currently, milk production management focuses increasingly on functional traits, such as longevity, udder health and fertility (Mészáros *et al.,* 2008). Age at first calving (AFC) as well as life span and longevity of cows are important in cattle (Dákay *et al.,* 2006; Hossein-Zadeh, 2011; Zavadilová and Štípková, 2013). The term "longevity" means the duration of life of a cow to her natural death. However, most animals are slaughtered before natural death. Survival is defined as a measure of the fraction of animals, which are still alive at a particular time (Bonetti *et al.,* 2009; Raguž *et al.,* 2011; Oler *et al.,* 2012). Genetic evaluation of longevity is often based on the sire-maternal grandsire (MGS) model (Pfeiffer *et al.,* 2015a; Pfeiffer *et al.,* 2015b). In cattle breeding programs selection is based on different production traits and increasingly - also on functional traits. Estimation of breeding values and phenotypic characteristics is combined in the total merit index (TMI). These values may be estimated by various statistical models (Pfeiffer *et al.,* 2015b). The first method to estimate TMI is a full multivariate animal (MULTI) model based on phenotypic data using actual genetic and phenotypic parameters. The second (yield deviations) and third (deregressed estimated breeding values) methods are based on the approximate multitrait two-step procedure. The fourth method of genetic evaluation is currently being used in Austria and Germany to calculate TMI based on the selection index theory. The relatively low heritability of longevity (h^2 = 0.03-0.1) using a linear model (Oler *et al.,* 2012) and estimates from survival analysis using the Weibull proportional hazard models range from 0.10 to 0.20 (Sewalem *et al.,* 2005; Mészáros *et al.,* 2008; Bonetti *et al.,* 2009; Strapáková *et al.,* 2013), suggesting that genetic improvement of this trait may be a long process. Sasaki (2013) wrote a summary of heritabilities of cow's longevity for these two models, stating that those provided by them or multiple-trait animal models are not conclusive. Evaluation results for the commonly used models differ between countries. Longevity is formally assessed in 24 out of 42 Interbull member states, while breeding values associated with longevity are estimated in Austria, Hungary and the Czech Republic (Interbull, 2015). In Poland the main criterion for selection of males and females is the production–functionality index (PF index). The index includes breeding values of longevity (Polish Federation of Cattle Breeders and Dairy Farmers, 2015). The new formula of PF is as follows:

PF = 0.4 * Production Index + 0.25 * Conformation Index + 0.15 * Fertility Index+ 0.1 * Breeding Value for Somatic Cell Score +0.1* Breeding Value for Longevity

Longevity of dairy cows is an essential indicator in the assessment of animal health and welfare (Oltenacu and Broom, 2010; Horn *et al.*, 2012; Langford and Stott, 2012; von Keyserlingk *et al.*, 2012). Genetic correlations between functional longevity (FL) and direct health traits were estimated by Pfeiffer *et al.* (2015a). Estimates of genetic correlations between FL and clinical mastitis, early fertility disorders, cystic ovaries and milk fever are moderate to high, with the highest value found between FL and clinical mastitis (r_a = 0.63). Similarly, Govignon-Gion *et al*. (2012) estimated slightly lower genetic correlations of r_a = −0.47 to −0.56 (in their case, negative values were favorable) between FL and clinical mastitis, applying an approximate 2-step approach. Longevity of dairy cows depends primarily on voluntary and involuntary culling by individual farmers (Pirlo *et al.*, 2000; Sewalem *et al.*, 2008; Langford and Stott, 2012). Voluntary culling of cows depends mainly on their productivity, but involuntary culling is caused mostly by sterility, claw disorders and lameness or mastitis. Moreover, cow longevity and length of productive life (LPL) are very important from an economic point of view (Mészáros *et al.*, 2008; Horn *et al.*, 2012; Langford and Stott, 2012; Pritchard *et al.*, 2013; Strapáková *et al.*, 2013). All factors reducing longevity of cows simultaneously result in a reduced production and lower profitability of cattle production (González-Recio and Alenda, 2007; Oltenacu and Broom, 2010). In general selection for increased milk yield is associated with the risk of culling due to reduced reproductive efficiency (González-Recio and Alenda, 2007; Wathes *et al.*, 2008; Oltenacu and Broom, 2010). A significant relationship was shown between reproductive traits and FL in Canadian dairy breeds (Miglior *et al.*, 2006; Sewalem *et al.*, 2008). Cows with poor fertility are at a greater risk of being culled when compared with the reference class cows (Sewalem *et al.*, 2008). The average production of the herd increases with an increase in FL, as most decisions on culling of cows are based on their productivity (Wathes *et al.*, 2008). Selection of cows should take into account longevity, udder health, conformation and reproduction. They are taken into account in many animal breeding programs (Dákay *et al.*, 2006; Miglior *et al.*, 2006; Zavadilová *et al.*, 2009; Strapák *et al.*, 2010). The health condition of the mammary gland, the feet and legs are also strongly related with FL (Sewalem *et al.*, 2005).

The purpose of this paper was to present genetic, phenotypic and environmental factors, influencing FL, which refers to the survival and independent performance of animals, as well as the length of productive life (LPL) mainly in dairy cows.

Genetic evaluation of survival

The Weibull proportional hazard model: Analysis of survival is the main analysis used for the genetic evaluation of cow longevity. The main problems associated with the analysis of survival are connected with censoring or existence of only partial records (Ducrocq, 1994). The class of proportional hazards is the most popular class of survival models (Ducrocq and Casella, 1996). According to those authors, the hazard of an animal is the risk to be culled within a time period, which is described as the product of a baseline hazard function. For survival analysis the following Weibull proportional hazards model is often applied (Raguž *et al.*, 2014):

$\lambda(t) = \lambda 0(t) \exp(ysi + rpj + afck + regl + hsm + sn)$

where:

λ(t) = hazard function (instantaneous probability of culling) for a given cow at time *t*; *λ0(t)* = Weibull baseline hazard function with scale parameter *λ* and shape parameter ρ; *ysi* = random time dependent effect of year /season following a log-gamma distribution; *rpj* = the fixed time dependent effect of relative milk production within herd; *afck* = the fixed time independent effect of age at first calving; *regl* = the fixed time independent effect of region; *hsm* = the fixed time independent effect of herd size; *sn* = random time independent effect of sire. For longevity analysis the Weibull proportional hazard models are used by most authors and these provide heritability estimates for longevity from 0.04 to 0.21 (Sewalem *et al.*, 2005; Mészáros *et al.*, 2008; Bonetti *et al.*, 2009; Sasaki, 2013). Recently FL (all culling reasons, except for productivity) has become increasingly important as a criterion in the selection of dairy cattle (Ducrocq 1987; Szyda *et al.*, 2011). Estimated breeding values (EBV) for FL of Italian Brown Swiss cattle, expressed as the predicted relative risk ratios (RR), range from 0.58 to 1.69 (Bonetti *et al.*, 2009). Highly productive cows in relation to herd-year of parity show a lower risk of culling than low-producing cows. Cows in large herds show lower RR (average 0.95) when compared to cows from small herds (average 1.06). Parity shows a higher risk for cows at first calving and culling is thus broadly dependent on how the cows performed at first lactation. Genetic evaluation of LPL in cows is possible also in small herds, but should be done with caution. The results indicate that in the case of small herds, the confounding between animal genetic effect, contemporary group and residual effects may be large. Hence, it is recommended to evaluate bulls and cows for longevity based on the EVB from the sire-MGS model (Jenko *et al.*, 2013). Relative milk production has the greatest impact on longevity of Simmental cows. Cows with a milk yield of ± 0.2 standard deviations in relation to the average are designated as the reference group. Cows with a higher milk yield (standard deviation of more than 1.5 above the herd mean) have on average 2.4 times lower risk of being culled, while cows with milk yield at standard deviation of 1.5 below the herd mean are 2.7 times more likely to be culled than cows with average milk yields. According to Jovanovac *et al.* (2013), the effect of age at first calving on longevity of cows is smaller. Similarly, the region of country does not significantly affect longevity of cows". Similar results were obtained for the Slovak Pinzgau population (Mészáros *et al.*, 2008). The risk of culling was higher for cows with a low milk production when compared to the other cows in the herd, those which have an older age at first calving, and those coming from smaller herds. The risk ratio was highest at the first half of the first lactation when compared with the second half this lactation. Starting from the second lactation the risk of culling increased. The proportional hazard model in a study of Sasaki *et al.* (2012) included the following effects: region-parity-lactation milk yield stage-class, AFC, the herd-year-season and sire. Heritability on the original scale for DATA1 (records for the period of 1991–2003) and DATA2 (records for the period of 1991–2005) was 0.119 and 0.123, respectively. The regression coefficient of estimated transmitting ability between DATA1 and DATA2 was very close to 1.

Analysis using a linear model: Selection including such traits as loin strength, bone quality, rear udder width, udder texture, udder cleft and final score showed a positive association with longevity and 305-d milk yield in the first lactation, indicating that this factor could contribute to an improvement of these two characteristics in dairy cows in Brazil (Kern *et al.*, 2014). Similarly, in a study by Sewalem *et al.* (2005) the condition of the mammary gland, feet and legs showed a strong relationship with FL in Canadian Jersey and Ayrshire cows. All composite type traits showed a relationship with longevity, indicating that cows classified as excellent survived longer than those classified lower. Among the traits of the mammary gland, traits such as fore attachment, udder texture, and udder depth were the most important ones and strongly associated with the functional survival of cows. An indirect relationship with FL was observed for such traits as udder depth, rump angle, and rear legs side view. Improved traits both through genetics and management have a positive effect on FL of cows. Hence, choosing the right type of traits may effectively predict the functional herd life of cows with the availability of real data concerning longevity in daughters of bulls (Sewalem *et al.*, 2005). Other authors also suggested that udder traits, final scores, and feet and leg scores have a significant impact on FL (Zavadilová *et al.*, 2011). Among those characteristics the linear udder depth, fore udder attachment, and central ligament were most important, with a strong relationship with functional survival of cows. According to Varona *et al.* (2012), early identification of traits correlated with longevity would be very useful in the selection of both beef and dairy cattle. These traits include birth weight and weight at 120 and 210 days, cold carcass weight, conformation, fatness and meat colour, teat morphology - teat thickness, teat length and udder depth, leg morphology - forward and backward legs, as well as milk production and docility. Survival analysis showed a significant relationship between workability traits and longevity in Canadian dairy breeds. Cows classified as very nervous and nervous have a shorter period of functional longevity when compared with cows classified as calm and very calm in all breeds (Holstein, Ayrshire, and Jersey). Milking cows classified as very slow, slow and very quick have a higher risk to be culled when compared to other cows (Sewalem *et al.*, 2010).

Age at first calving and longevity: Among the many factors influencing replacement of cows in the herd AFC is particularly important, as indicated by many authors (Hossein-Zadh, 2011; Raguž *et al.*, 2011; Zavadilová and Štípková, 2013). From the economic point of view, AFC at 24 months or less is recommended (Pirlo *et al.*, 2000; Nilforooshan and Edriss, 2004). However, a younger age of calving is associated with lower production in the first lactation (Nilforooshan and Edriss, 2004). The AFC has a significant effect on milk yield in the first 100 days of the first lactation. Cows with AFC ≥751 days produce more milk during the first 100 days of the first lactation when compared with cows with AFC ≤699 days, respectively: in a study by Krpálková *et al.* (2014) it was 3,046 kg and 2,917 kg. The average lifetime milk yield (LP) was the lowest for cows with AFC of more than 24.5 months of age. Many cattle breeds, especially beef cattle, calve for the first time at a mean age > 24 months (Dákay *et al.*, 2006). The Hungarian Grey cows have delayed AFC (3.51 years) when compared to the other beef breeds. The average AFC in cows of all breeds included in the study by those authors (Hungarian Grey, Charolaise, Limousine, Angus, Limousine crossbred, Hereford and Hereford crossbred) was 2.59 ± 0.65 years. In recent years, the importance of genetic trends in selection for AFC has decreased. The results obtained by Hossein-Zadeh (2011) show decreasing genetic trends for AFC (fat percentage and protein percentage over the years); however, that author observed increasing genetic trends for milk yield, mature-equivalent milk yield, fat yield, mature-equivalent fat yield, protein yield and mature-equivalent protein yield over the years. At the same time he found a decreasing phenotypic trend for AFC; however, phenotypic trends were positive for the yield and composition of milk over the years. On the other hand, according to that author the reduction of genetic and phenotypic trends for AFC was mainly due to the increased number of heifers entering the herd. Moreover, AFC declines may represent early maturity, or intense selection for high performance. The AFC levels of Holstein and Simmental breeds indicate that RR has the lowest variability when compared with other factors. The values of RR ranged from 0.927 to 1.025 in Simmental cows and 0.980 to 1.068 in Holstein cows, showing a low effect on the culling risk (Raguž *et al.,* 2011). Cows calving at an older AFC show low fertility at the first lactation and a shorter productive life. A negative relationship was observed between the analysed traits of fertility and longevity in cows (Zavadilová and Štípková, 2013). One of the reasons for the increased LPL (by about 1 year) is a lower AFC (Sawa and Bogucki, 2010). In that study cows, which calved for the first time in 2000 (24.4 months) in comparison to cows which calved for first time in 1988 (25.9 months) had longer LPL. Those authors suggested that AFC and first lactation milk yield were significantly correlated with longevity. AFC is an important trait to be considered in breeding heifers, because it may have an impact on subsequent productivity (Wathes *et al.,* 2008). It is important to take into account the welfare of heifers and their production life. The main factor influencing AFC is the growth rate of heifers, which is affected by genetic and environmental factors. Through genetic selection we obtain animals that grow fast and that can calve at 22 months without negative consequences for their production and longevity. However, some studies indicate that the effect of AFC on longevity is not significant (Jenko *et al.*, 2013).

Reasons for culling of cows and longevity: Longevity depends on voluntary and involuntary culling by individual farmers (Sewalem *et al.,* 2008). In English dairy farms the average annual culling rate is about 22 to 25% (Esslemont and Kossaibati, 1997; Whitaker *et al.*, 2000; Bell *et al.*, 2010). The reported average total annual culling rate in 50 dairy herds in England was 23.8 %. Among the culled animals 41% were culled at the end of the third lactation, and 54% at the end of their fourth lactation. The most important reason for culling was poor fertility (36.5 % of disposals), followed by management considerations (11.5 %) and mastitis (10.1 %) (Esslemont and Kossaibati, 1997). Over half of the cows were culled before their fourth parity, at the rate ranging from 54 to 59 % (Esslemont and Kossaibati, 1997; Bell *et al.,* 2010). Culling of cows is significantly associated with the need for assisted calving, abortion and mastitis. Older cows are more likely to be culled, usually they have a smaller number of milking days and a greater number of days from calving to conception. Reasons for culling are also associated with conception failure. Newer data suggest that 59 % of cows were culled before their fourth parity (Bell *et al.*, 2010). However, the results published recently suggest that the main reasons for culling in Austrian Fleckvieh cattle are fertility disorders (22.9%) and udder diseases (13.5%) (Pfeiffer *et al.,* 2015a). Similarly results are reported by Koeck *et al.* (2015), who found in their study that about 25% of the analysed cows were culled due to reproductive problems, and the same percentage is culled annually due to a reproductive disease, while around 15 percent of cows are culled because of udder disease. Involuntary culling is also associated with injuries, poor health or infertility (Langford and Stott, 2012). In the United States the age of culling in cows has significantly decreased, with about 37% of cows in large herds being culled in their first parity and 83% within the first three parities (De Vries *et al.,* 2010). Also in the United States Hare *et al.* (2006) conducted a study on large numbers of cattle (data concerning 13.8 million cows) of different breeds (Ayrshire, Brown Swiss, Guernsey, Holstein and Jersey). On average, in the years 1980 - 2005 cows were culled in their 3 parities with a productive herd life of about 2 yr and 8 mo. These indicators and survival rates have decreased, apparently because of more intense culling primarily due to management decisions by producers rather than genetics. Similarly, high rates of cow culling were reported by authors from Portugal, with only 15% of first calvers reaching their fourth lactation (Rocha *et al.,* 2010). According to those authors, one of the factors that cause reduced fertility of cows to be taken into account is an increase of milk production from 6537 kg to 8590 kg (305 days) from 1996 to 2002. On the other hand, cows with higher milk production levels within the herd have about 30% higher RR to be culled than the average producing cows (Raguž *et al.*, 2011). It follows that a large number of animals at a young age are culled in the early stages of its production life. It should be added that from 13 to 16% potential born heifers entering the herd die before their first calving because of the mortality of calves and conception failure as heifers (Esslemont and Kossaibati, 1997; Brickell *et al.*, 2009). Similarly, across 109 herds in Sweden, 22% heifers died, were culled (10%), or were sold off live (7%) before their first calving (Hultgren *et al.*, 2008). The most common reason for culling of cows in Swedish organic herds was a poor state of udder health (26.7%), followed by low fertility (23.6%). In conventional Swedish cow herds the two main reasons for culling amounted to be 20.6% and 25.9%, respectively. The third most common reason for culling cows in both systems is low milk production (8.3% in organic herds and 8.8% in conventional herds), with the difference in the percentage of cows culled for this reason being non-significant between the two systems. Problems with limbs ranked fourth as the cause of culling, with the difference being slight, but significant between organic and conventional cow herds (5.0% vs. 5.9%). In contrast, other health characteristics did not differ between the animal management systems. The overall cow culling pattern in both systems was the same. The main reasons for culling of cows differed in subsequent lactations. In the first lactation the main reason for culling, regardless of the management system or breed, was low fertility (Ahlman *et al.*, 2011). The rate of culling for Polish Holstein-Friesian cows was about 31 % throughout the analysed period from 2002 to 2007 and was relatively high, which may indicate intense selection in herds (Pytlewski *et al.*, 2010). The largest number of animals was culled due to infertility and diseases associated with reproduction (40.7%). In this group of animals the most common problems of cows were connected with infertility (71.7%), followed by retention of placenta with complications (7.1%), inguinal ligament damaged (6.2%), milk fever (4.8%), intrauterine adhesions and tumours (3.4%) and metritis (2.8%). Other Polish authors reported that longevity of Polish Holstein-Friesian high-yielding cows culled in 2007-2011 showed a downward trend (age at culling in 2006 was 6.40, while in 2011 it was 5.43) (Oler *et al.*, 2012). The culling rate for cows was 32.0 %. The authors stressed an alarming trend for increased culling of young cows, especially in the first lactation. The percentage of voluntary culling decisions increased during 2006–2007 from about 2% to 6% in the subsequent years. High-yielding cows (average yield of almost 11,000 kg milk) were culled most commonly due to infertility and reproductive disorders (35.9 %), diseases of the hoof and lameness (15.1%), diseases of the udder (13.1%), and metabolic and gastrointestinal diseases (12.9%). The dynamics of reason-specific culling depends on the genetic group, stage of lactation, parity, milk yield and the characteristics of the herd (Pinedo *et al.*, 2014). According to those authors, early lactation is a particularly critical period for "died," "any sickness," and "injury-sick" culling categories. The risk of culling increases on subsequent days after calving due to unsuccessful reproduction, whereas for Holstein cows it is due to low productivity (Pinedo *et al.*, 2014). The main factor in the reduction of longevity in cows is poor fertility, both in the case of heifers and lactating cows (Wathes *et al.*, 2008). Culling of cows increases with parity number. The risk of culling of cows in their sixth parity increases threefold when compared with their first parity. In their study De Vries *et al.* (2010) reported the average LPL of cows calving in 1 to 6 parities to be 907, 697, 553, 469, 423, and 399 days, respectively. The first peak daily hazard for culling is about 30 days after calving, and the next is in late lactation (280 milking days) for older cows. For cows after their first parity hazards for culling peak earlier (about 10 days after calving) and they have a lower risk of culling than older cows. Pregnant cows have a 3 to 7 times lower risk of culling than open cows. In the years 2001 - 2006 in the eastern part of the United States the use of the synchronized breeding program increased from 21.9% to 41.4%. However, cows included in this breeding program have a slightly lower risk of culling when compared with cows not included in this program (De Vries *et al.*, 2010). Cows culled due to infertility problems live longer (5.2 years) and have a longer productive life and milking life, amounting to 1136 and 922 days, respectively, when compared with cows culled due to intrauterine tumours and adhesions taken together (3.2 years, 423, and 410 days, respectively) (Pytlewski *et al.*, 2010). Lifetime productivity of culled cows indicates that cows culled due to metritis had a higher lifetime milk production (24 762 kg milk yield and 816.1 kg protein yield). In turn, cows eliminated from the herd due to infertility produced the largest amounts of fat corrected milk (23 563 kg) and fat (960.9 kg). Reproductive traits have a significant relationship with FL in Canadian dairy breeds (Sewalem *et al.*, 2008). It should be added that cows calving with the help of surgery, as well as heifers with stillbirths or large calves had shorter longevity when compared with the reference class. LPL is a combination of good fertility and longevity of cows (Wathes *et al.*, 2008). Cows after parturition often suffer from bacterial contamination of the uterine lumen, which leads to infection and uterine disease, potentially causing infertility (Sheldon *et al.*, 2008).

Other traits influencing longevity

Mortality of female calves and calving difficulties: In England perinatal mortality on dairy farms averages 8% for Holstein-Friesian calves, and about 15% of calves born to heifers do not reach first calving (Brickell *et al.*, 2009). For this reason there are significant restrictions in the choice of heifers to the herd. The mean calf mortality rate reported in the above-mentioned study was 3.4% between 1 and 6 months of age. Most calvings did not require assistance (85%), some help was needed only in 15% of calvings. The main risk factors for maternal mortality were calving assistance, twinning, and age of the cows. Heifer losses between 6 months of age and the start of the breeding period averaged 3.5% (ranging from 0% to 18.5% depending on the farm), while post-service losses averaged 4.2% (ranging from 0% to 21.1%). The total number of live born heifers that fail to calve for the first time amounted to 14.4% (Brickell *et al.*, 2009). Other authors (López de Maturana *et al.*, 2007) stated that calving difficulties significantly reduce longevity of cows by in average as 10% and increase herd amortization costs by 10%, hence the need for more heifers in the herd for replacement. Calving difficulty is more frequent in primiparous than in multiparous cows. The risk of culling increases in cows with difficult calvings, as well as cows which gave birth to males or twins, and those that had a short period from calving to first insemination, or had an increased number of days to conception (De Vries *et al.*, 2010).

Concentration of milk urea nitrogen and somatic cell counts: In Canadian dairy breeds (Holstein and Ayrshires) the concentration of milk urea nitrogen increases over parities, whereas lactose percentage decreases in later parities. The survival analysis showed that in these breeds a significant relationship is found between lactose percentage and milk urea nitrogen concentration in the first lactation and longevity (Miglior *et al.,* 2006). According to those authors, cows with high and low milk urea nitrogen concentrations and lactose percentages have a greater risk to be culled when compared to the average of the group. In Holstein cows linear associations are found between a decreasing risk of culling and an increasing milk urea nitrogen concentration. The relationship between the concentration of lactose and survival is small in Holstein and Ayrshire breeds by parities; however, a lower risk of culling is observed at a high lactose percentage. Although a negative relationship was found between somatic cell counts (SCC) in the first month of lactation during the first parity and longevity (survival over a 5-y period) for cows in Irish dairy herds, this effect turns out to be small (Archer *et al.,* 2013).

Inbreeding: In Canadian dairy cows there is a gradually increasing level of inbreeding and it seems that this trend will continue (Sewalem *et al.,* 2006). The results show that inbreeding has a significant relationship with FL in Holsteins, Ayrshires, and Jersey; however, there is a relatively low risk of being culled for cows with less than 12.5% inbreeding rate. The increase in inbreeding coefficients above 12.5% (from 12.5% to 18.2%) in Holstein cows results in their being 1.25 times more likely to be culled than non-inbreed cows (Sewalem *et al.,* 2006).

Body conformation traits: One of the principles in selection for longevity in dairy cows is to use correlated traits, which show the potential value in younger age and promote survival in the herd (Strapák *et al.,* 2010). The main and partial body conformation traits of dairy cows considered to be important are legs and udder conformation. The LPL is considerably affected by udder and legs. Those authors concluded that udder depth, rear udder and rear udder attachment have the most important effects on the LPL. Similarly, cows with a sound conformation of their rear legs, the fetlock and the feet have a longer productive life. Genetic correlations are reduced after the introduction of FL to the analysis. Fore udder length, rear udder attachment and the central ligament are positively correlated with actual longevity. The depth of the udder is a potential indicator of cow FL (Strapák *et al.,* 2010). The estimated correlations may be time-dependent and should be verified in defined intervals (Zavadilová *et al.,* 2009). Studies confirmed the impact of important udder traits, final scores, and feet and legs on FL. Among these features the linear udder depth, fore udder attachment, and central ligament are most important, with a strong relationship with functional survival of cows. The Czech Holstein cows are angular with a high dairy form and these qualities would seem disadvantageous in terms of longevity. The management and environmental conditions are suitable rather for dual-purpose production than for specialized dairy breeds. Body condition score (BCS) is very important in the context of survival presented in our previous statements. The selection index for FL may be based on the information on longevity of daughters, udder traits, final scores, and feet and legs traits, but it is necessary to take into account the linearity of the relationship between longevity and type traits. From the point of linearity, dairy form, udder, udder depth, fore udder attachment, central ligament, and locomotion appear more suitable (Zavadilová *et al.,* 2009). Newer studies suggest direct genetic correlations between FL and conformation traits. Pfeiffer *et al.* (2014) found correlations between longevity and feet and legs, and udder to be 0.39 and 0.40, respectively. Small and negative genetic correlations were recorded between longevity and hip width, body depth, and muscularity.

Economic evaluation and improved longevity: Longevity of dairy cows is an indicator of health, animal welfare and a sustainable system of milk production. In a study concerning economic evaluation of longevity, as a result of advanced longevity of cows, replacement costs explicitly declined and dropped by 74% when comparing animals with one and five completed lactations. Annual costs increase with an increase in milk production, but decrease with rising longevity. Through an increased longevity profits increase on average up to the 6th lactation, and for the 50 best animals up to the 5th lactation (Horn *et al.,* 2012). The elimination of the main causes of involuntary culling significantly improves animal welfare as well as increases profits of the farm (Rushen and de Passillé, 2013). Good housing conditions for cows and management practices to control health problems may lead to a reduced involuntary culling rate. Factors decreasing longevity are connected with mortality and diseases of calves, which have a negative impact on subsequent productivity of cows. There are main risk factors in indoor housing, causing lameness, injury, and illness in dairy cows. Knowing the standards of animal welfare and at a greater use of benchmarking of farm performance, it is hoped that an increased knowledge in this field will lead to improved animal welfare and will reduce involuntary culling rates (Rushen and de Passillé, 2013). Producers of dairy cattle in three regions of North America (British Columbia, California, and the northeastern United States) developed a program that can be used to better address their management goals, including gait score, leg injuries, and lying time (von Keyserlingk *et al.,* 2012). Studies by Polish authors (Sawa and Bogucki, 2010) showed that longevity improved in Polish Holstein-Friesian cows in the years from 1988 to 2000 and the lifespan and LPL increased up to about 1 year in herds of maximum 20 cows, and in herds with the lowest production level by about 0.85 years. If the first calving was before 24 months of age production life increased by about 1 year, and in herds producing 4 000 - 7 000 kg of milk as first calvers it was by about 0.5 years. According to Liwińczuk *et al*. (2016), lactation persistency had a significant effect on length of life and efficiency of milk production in Polish Holstein-Friesian cows. Cows which lived longest that are for about 6 years produced the most milk (nearly 28,000 kg) with the milk yield over 30 kg at peak lactation and moderate decrease in yield, i.e. 40%. In primiparous cows yield at peak lactation as well as the course of lactation were found to significantly affect length of life and lifetime yield at these cows. The LPL was shorter by 0.3 years in cows culled for low milk production. Improved longevity can result in increased productivity of the herd, because replacement, reproduction and veterinary costs are lowered, and the mean milk production of the herd is increased (Sewalem *et al.,* 2005). Improving nutrition and management of calves increases the lifetime efficiency of animals and also improves animal welfare and profitability (Van Amburgh and Soberon, 2013). By improving management of calves and heifers we can obtain positive economic results for adult animals.

Conclusion: The relatively low heritability for longevity, ranging from 0.04 to 0.21, suggests that genetic improvement of this trait will be a long process. However, it is an important criterion for selection of dairy cattle. Parity and milk production have a considerable effect on longevity. Other parameters having smaller effects on longevity of cows include age at first calving, herd size, and region of the country. From the economic point of view, the AFC of 24 month or less is recommended. The traits of the mammary gland and feet and legs show a strong relationship with FL in cows. The average total annual culling rate is from 20.6 to 32 %. The most important reason for culling is poor fertility, with management problems ranking second, followed by poor udder health. Over 50% half of cows are culled before their fourth parity. Culling of cows is significantly associated with assisted calvings and abortions, twin births and age of the cows. Calving difficulties significantly reduce longevity of cows on average by 10% and increase herd amortization costs by 10%. Many authors highlight the alarming trend of increased culling of young cows, especially in the first lactation. The elimination of the main causes for involuntary culling significantly improves animal welfare, while also increasing farm profits. High productive life is a combination of good fertility and longevity of cows. The authors of this study based on literature review conclude that the management of the herd of dairy cows has a significant impact on the longevity of cows.

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