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# Longevity of Holstein-Friesian cows and some factors affecting their productive life – a review

**Kamil Siatka, Anna Sawa, Sylwia Krężel-Czopek*, Mariusz Bogucki**

Department of Animal Breeding, Faculty of Animal Breeding and Biology,
UTP University of Science and Technology, Mazowiecka 28, 85-084 Bydgoszcz, Poland

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**The aim of the work was to discuss the role and importance of longevity in Holstein-Friesian cows and to present the impact of various factors and their interactions on their life expectancy and use. Understanding the determinants of longevity seems to be key to its improvement. The results of many studies show that for many years there has been a worldwide trend towards the decreasing lifespan of dairy cows. It results from the intensification of milk production and from paying inadequate attention to animal welfare issues. Actual herd life depends on breeders, who make decisions based on cow productivity and the general state of health indicating the chance for survival. The existing knowledge has to be continuously updated due to the complexity of issues arising from cow longevity and the need to understand contributing factors, which is important from both a scientific and practical point of view.**

**KEY WORDS: dairy cows / longevity**

Cow's milk currently accounts for more than 86% of global milk production. Out of the many cattle breeds in the world, Holstein-Friesians are preferred due to their high milk yield (obtained especially under intensive management), udder structure and conformation [Knaus 2009, Karslioglu Kara and Koyuncu 2018]. However, long-term breeding work to increase milk yield was paralleled by reduced fertility, increased health problems and culling levels, resulting in a shorter lifespan and productive life of the cows [Karslioglu Kara and Koyuncu 2018]. Although life expectancy of cows is between 15 and 18 years [Cielava *et al*. 2017], in modern

*Corresponding author: krezel@utp.edu.pl

farms they are culled before the fifth or sixth lactation [Cielava *et al*. 2017] and often they do not survive beyond 3 lactations [Ziętara *et al*. 2013, Horvath *et al*. 2017, Adamczyk *et al.* 2018]. All this has contributed to the fact that the cows' productive life and culling reasons have become a major concern, especially since profitability of dairy production depends on both lactational performance and length of productive life, which was reported by many authors [Abou-Bakr 2009, Sadek *et al*. 2009, Sawa and Bogucki 2010, Potocnik *et al*. 2011, Teke and Murat 2013, Meszaros *et al*. 2014, Bogucki 2017, Cielava *et al.* 2017, Horvath *et al*. 2017, Nayeri *et al*. 2017, Sawa and Bogucki 2017]. A long productive life of cows increases their lifetime milk yield and the number of calves born, which has an essential effect on production profitability. From a breeding perspective, a shorter lifespan reduces the generation interval, which increases genetic progress. However, at the same time it has a number of negative consequences, such as reduced population size, changes in herd structure and rising prices for breeding animals. Therefore, the optimum lifespan of a cow should be the composite of breeding and economic results.

**Definition of longevity**

The term "longevity" is used to refer to the expected number of years of life remaining to death. The simple definition of longevity is the ability of a cow to avoid being culled for any reason [Sadek *et al.* 2009, Ahlman *et al.* 2011, Horvath *et al.* 2017], although it can be defined and measured quantitatively in many different ways [Sadek *et al*. 2009]. Most often it is defined as age at culling [Adamczyk *et al*. 2017b], although it can be expressed as the length of productive life, or the time from first calving to culling, age at last calving, the number of started or complete lactations [Sadek *et al*. 2009, Sawa and Bogucki 2010, Potocnik *et al*. 2011, Stanojevic *et al.* 2015, Olechnowicz *et al*. 2016]. Longevity may also be expressed as traits measured over a cow's life, e.g. total milk production or the number of milking days [Sadek *et al.* 2009]. A distinction is also made between true herd life (the ability of a cow to remain in the herd to a specific age) and functional herd life, associated with forced culling [Żarnecki and Jagusiak 2003].

**Survival of cows to next lactation**

For many years there has been a worldwide trend towards the decreasing lifespan of dairy cows [Varisella *et al.* 2007a]. Horvath *et al*. [2017] reported that in Hungary most cows (26%) were culled at first lactation, while the proportion of cows culled at subsequent lactations gradually decreased and those culled at sixth and further lactations accounted for only 7%. Similar results were presented by Ziętara *et al.* [2013], who found in the Polish Holstein-Friesian breed that culling rate was highest (23.2%) in primiparous cows and consistently decreased with subsequent lactations. Studies performed in Serbia [Stanojevic *et al.* 2015] showed that almost 55% of the

cows were culled during the first two lactations, whereas in subsequent lactations culling percentage decreased, but only 0.7% of the cows survived eight lactations. Similar findings were presented by Sadek *et al*. [2009], who reported, based on studies conducted in Egypt, that about 70% of the cows were culled during the first three lactations, and this proportion declined with age from 11.63% in the fourth lactation to 4.44% in the sixth. According to the data reported by Olechnowicz *et al*. [2016], in UK herds the mean culling level is 22-25%, with as much as 41% of the cows being culled until the end of the third lactation and 54% after the fourth production period. For comparison, in the USA 37% primiparous cows are culled, 83% of the cows are removed from the herd during the first three lactations, whereas in Portugal only 15% of the cows reach the fourth lactation.

**Consequences of the short productive life of cows**

A general problem around the world is the relatively short productive period of cows. For example, Holstein-Friesian cows have an average of only 3.5 lactations in Great Britain and 2.8 lactations in the USA [Orpin and Esslemont 2010]. In Poland the average productive life of cows in recent years has been around 3 lactations [PFHBiPM 2018]. Considering the results of a study [Bogucki 2017] concerning milk production in successive production cycles, in which milk yield was shown to increase to 3-4 lactations, it may be concluded that cows should not be culled earlier. This improves their welfare and fertility, thus reducing veterinary and AI costs [Sadek *et al*. 2009, Meszaros *et al*. 2014]. Abou-Bakr [2009] reported that in dairy cows their cost of rearing are reimbursed within one to three years of production, while Horvath *et al.* [2017] stated that Holstein-Friesian cows should be milked for at least 27 months. Ziętara *et al.* [2013] concluded that for economic reasons the optimum milk production period is 5 to 8 lactations. Potocnik *et al.* [2011] found that lengthening the productive life of cows from three to four lactations causes the average milk yield per lactation and annual profit to increase by 11-13%. In turn, Karslioglu Kara and Koyuncu [2018] found that lifetime milk yield of Holstein-Friesian cows increases with each lactation because their culling level decreases with age, firstly due to low productivity, and secondly due to the increasing proportion of older, high-yielding cows. Shortening the productive life of the cows necessitates earlier replacement of the herd while reducing the possibility of heifer selection [Pawlina *et al.* 2015].

**Potential for extending the productive life of cows**

Olechnowicz *et al*. [2016] reported that the cow's lifespan and length of productive life is of key importance from the economic perspective, because all factors contributing to a decrease in longevity at the same time adversely affect livestock production and its profitability. Because the potential for extending the productive life of cows is of special interest for breeders, breeders of Holstein-Friesian cattle around

the world tend to attach more importance to functional traits, including longevity, at the cost of production characteristics [Egger-Danner et al. 2015]. The low heritability of longevity ($h^2$ = 0.03-0.26) suggests that its genetic improvement may take time [Varisella et al. 2007a, Pytlewski et al. 2010, Sawa and Bogucki 2010, Strapakova *et al*. 2014, Pawlina *et al.* 2015, Olechnowicz *et al*. 2016]. It may be potentially helpful to use the increasingly common genomic selection, which due to the marked decrease in the generation interval enables genetic progress to be considerably accelerated [Boichard and Brochard 2012, Nayeri *et al*. 2017]. It is widely accepted that the crossing of Holstein-Friesian cows with other dairy breeds generally increases the lifespan of animals, especially in the F1 generation due to heterosis [Freyer *et al.* 2008, Buckley *et al*. 2014].

An alternative solution is to search for non-genetic factors that affect longevity. Olechnowicz *et al*. [2016] and Adamczyk *et al.* [2017a] reported that a cow's lifespan depends on age at first calving, cause of removal from the herd, milk quality (urea content, somatic cell count), rate of inbreeding, herd size and parturition process. It is also taken into account that a cow's conformation is associated with production and non-production traits, and thus with production efficiency [Zavadilová and Štípková 2012]. The findings of Zavadilová and Štípková [2012] pointed to a relationship between conformation traits and productive lifespan, with such traits as capacity, body conformation, body depth and rump width being most strongly correlated (r = -0.21 to -0.26) with the productive lifespan. Other studies conducted in the Czech Republic [Vacek *et al*. 2006] showed that most of the body traits showed a slightly positive relationship to herd life, indicating that larger cows live longer. Cows with a well-attached fore udder, a highly attached rear udder, a strong central ligament, close front teat placement and moderately long teats showed the longest functional productive life (P<0.05-0.001). Litwińczuk *et al.* [2016], who looked for possible associations of lactation persistency with lifespan and milk production efficiency, showed that the cows that lived longest (over 6 years) and produced the most milk (nearly 28,000 kg) were those yielding over 30 kg at peak lactation with a moderate decrease in yield, i.e. 40%.

**Age of cows at first calving vs. longevity**

Sawa and Bogucki [2010] and Teke and Murat [2013] showed that cow longevity tended to improve as the date of first calving was delayed (r = $0.06^{xx}$ and $0.13^{xx}$). In turn, Bogucki [2017], Strapakova *et al*. [2014] and Bayram *et al.* [2009], taking into account the non-significant coefficients of correlation, concluded that age at first calving has no influence on longevity. According to Haworth *et al*. [2008], age at first calving has no effect on the lifetime number of calvings and milking days, whereas in terms of productive lifetime the authors considered calvings at 24-36 months as desirable. In turn, Adamczyk *et al.* [2017a] reported that age at first calving causes significant differences both in lifetime energy-corrected milk yield and in lifetime energy-corrected milk yield per milking day: cows that first calved at the age of >

2.6 years exhibited much lower milk yields (20 783 kg and 19.7 kg/day) compared to cows that calved at the age of 2.0-2.6 and <2.0 years (24387 kg and 20.7 kg/day; 24184 kg and 20.5 kg/day, respectively). Korean researchers [Mu-Kyung *et al*. 2016] found that cows that first calved at an older age achieved higher first 305-day lactation yields, while the analysis of the effect on longevity showed that first calvings at the age of 24–28 months were most beneficial, with earlier calving cows (<24 months) characterized by a lower lifetime number of milking days (1045.7 vs 1143.1) and lifetime milk yield (31791.6 kg vs 34171.8 kg). These studies also demonstrated that age at first calving had a significant effect on culling risk during the first and second lactation, but this risk tended to increase for cows that first calved at a younger age.

It should be remembered that milk yield is dependent on the development of the mammary gland, most of which takes place before first calving. Early commencement of the first milking may lead to a lower first lactation yield as a result of suboptimal development of the mammary gland [Haworth *et al*. 2008]. Hutchison *et al.* [2017] demonstrated that the optimal age at first calving in terms of first lactation yield and lifetime production varies with herd management characteristics, suggesting that the optimal first lactation yield may differ from herd to herd. Likewise, Meyer *et al*. [2018] were of an opinion that universal recommendations for age at first calving may be incorrect for all dairy farms, because the recommendation might not represent management goals or capabilities of a particular production system or farm.

**Age at first calving vs longevity**

Many authors [Borkowska and Januś 2009, Sawa and Krężel-Czopek 2009, Orpin and Esslemont 2010, Pytlewski *et al.* 2010, Sawa and Bogucki 2017] have shown that the length of productive life and lifespan of cows depend on their first lactation milk yield. Considering the short lifespan of cows it can be stated that high first lactation yield has a positive effect on longevity. Sawa and Bogucki [2017] showed, however, that excessive milk yield of primiparous cows (>11000 kg) shortens the lifespan and the productive life, while it also reduces the number of calvings. This situation is particularly evident in herds with low production levels, which may result from failure to adjust living conditions to the high production level of primiparous cows. Similar trends were described in earlier studies, which stressed that efforts to maximize first lactation yield may significantly shorten the productive life of the cows. According to Sawa and Krężel-Czopek [2009], the cows' productive life decreased with first lactation yield >7000 kg milk, whereas a later study by Ziętara *et al*. [2013] reported this level to be >9000 kg milk. Borkowska and Januś [2009] demonstrated that a high first lactation yield may adversely affect the health of young, developing cows and may result in their earlier removal from the herd. Pytlewski *et al.* [2010] found the longest lifespan (5.53 years) for cows with the lowest first lactation milk yield below 7000 kg FCM and for animals with productivity within the range of 7001-8500 kg FCM (5.46 years). These two groups of cows differed in terms of lifespan from the

other populations of animals. A study by Strapakova *et al*. [2014] showed that culling risk for cows with lower yields than the herd average was higher than for cows whose milk yield was one standard deviation higher than the average. Culling risk decreased with increasing milk yield of the cows.

According to Sawa and Krężel-Czopek [2009], it is possible to predict lifetime yield of cows based on their first lactation ($r = 0.44^{**}$). These results are consistent with observations by Sadek *et al*. [2009], who reported that the coefficients of phenotypic correlation as well as genetic correlation between first lactation yield and lifetime yield were moderately high and positive at $0.30^{xx}$ and $0.45^{xx}$, respectively. In turn, Teke and Murat [2013] estimated the correlation coefficients between first lactation yield and lifetime yield to be $r = 0.12^{xx}$. According to Sawa and Krężel-Czopek [2009], the optimal level of milk yield from the perspective of lifetime milk production of the cows varies depending on the production level of their herd, which serves as a measure of the quality of rearing conditions. In low producing herds, best production efficiency is shown by cows that yielded 6001-7000 kg milk as primiparous cows, while in higher yielding primiparous cows, decreases in lifetime milk production and fertility are to be expected. In herds with medium and high producing cows, lifetime milk yield of the cows increases with increasing first lactation yield, whereas fertility deteriorates. In a study by Sadek *et al*. [2009] the coefficients of phenotypic and genetic correlation between first lactation yield and longevity traits (number of completed lactations, length of productive life measured in months, age at culling in years, number of months in lactation) ranged from $0.10^{xx}$ to $0.25^{xx}$ and from $0.20^{xx}$ to $0.37^{xx}$, respectively. According to Bogucki [2017], the correlation coefficients between milk yield of primiparous cows and lifespan, and between milk yield of primiparous cows and lifetime production, depending on culling reason, range from $0.08^{xx}$ to $0.32^{xx}$ and from $0.34^{xx}$ to $0.64^{xx}$, respectively.

Haworth *et al*. [2008] reported that daily yield of primiparous cows had no effect on the number of lifetime calvings and lifetime days of milking, but affected lifetime milk yield. The authors demonstrated that lifetime yield increased with increasing daily yield of primiparous cows from <15 to 25-30 kg milk, but when the yield exceeded 30 kg/day, this caused a large reduction in lifetime milk yield. They considered the level of 25-30 kg milk as optimal daily yield for Australian Holstein-Friesian cows in terms of lifetime milk yield and lifespan.

The higher first lactation yield in a study by Pytlewski *et al.* [2010] was associated with a shorter lifespan and length of productive life of the cows. Furthermore, first lactation yield caused no differences in the lifetime yield of the cows. In addition, cows with higher first lactation yield were characterized by higher yield per day of life, higher yield per day of productive life and higher yield per day of milk production (milking period).

**Reasons for culling dairy cows**

Culling of cows is an important issue from both a breeding and economic perspective. In practice, environmental and economic factors (e.g. poor housing conditions, improper nutrition, heat stress, excessively low price) play a key role in herd survival and determine the productive lifespan of cows [Adamczyk *et al*. 2017b]. It is accepted that the culling level of cows depends on herd management methods [Strapakova *et al*. 2014]. The overall herd culling rate is a measure of intensity of selection, as well as environmental and feeding conditions. It indicates the rate of generation turnover of a herd. The analysis of cow culling patterns is of vital importance from a breeding and economic point of view. There are multiple reasons for culling. Culling for low milk production (regardless of health, temperament, old age or sale to another herd) is known as voluntary (unforced, intentional) culling, whereas culling due to disease and/or low fertility is referred to as involuntary (forced, unintentional) culling [Sadek *et al.* 2009, Orpin and Esslemont 2010, Olechnowicz and Jaśkowski 2011]. When culling is voluntary, the herd manager may decide to maximise profits, reduce costs, or improve the herd [Orpin and Esslemont 2010, Olechnowicz and Jaśkowski 2011]. Unfortunately, research results show that the distribution of culling reasons is unfavourable because as much as 90% of the cows are removed from the herd for reasons unintended by the breeder [Orpin and Esslemont 2010, Pawlina 2015]. In this situation improvement of the animals is difficult and thus cattle evaluation and selection programs now include secondary traits such as fertility, conformation or resistance to mastitis, which in the selection indices are assigned a rank of 40-50% [Pytlewski *et al*. 2010]. However, this should be paralleled by improvements in animal management conditions [Pytlewski *et al*. 2010, Stanojevic *et al*. 2015].

Detailed analysis of culling reasons and levels is increasingly being used as a tool for proactive health planning in dairy herds [Orpin and Esslemont 2010]. The herd life of cows depends on the breeder's decisions based on their health status, because the genetic correlations between functional longevity and a number of diseases (clinical mastitis, fertility disorders, ovarian cysts, downer cow syndrome) range from moderate to strong (r = 0.47 to 0.56) [Olechnowicz *et al*. 2016].

To extend the productive life of cows, attention should be focused on activities aimed at improving fertility in females, because reproductive problems are the main (up to 45%) reason for removal of the cows from the herd [Morek-Kopeć and Żarnecki 2009, Sawa and Bogucki 2009, Horvath *et al*. 2017]. Ziętara *et al*. [2013], Adamczyk *et al.* [2018], Morek-Kopeć and Żarnecki [2009], based on SYMLEK data for 1 441 446 cows culled in the years 1995-2007, found an upward trend for culling due to infertility and diseases of the reproductive system. Sawa and Bogucki [2017] showed that increasing the first lactation yield was paralleled by increased levels of culling due to infertility. This results from high nutrient requirements that are difficult to meet, but also from the fact that the supplied nutrients are in the first place used for maintenance requirement and for milk production. As observed by Strucken *et al.* [2012], milk yield competes here with fertility.

In summary, it is concluded that longevity, as the most important functional trait (and analysis of the factors determining it), has been investigated by many international research centres engaged in cattle studies. The results of this research demonstrate that longevity is tremendously important in terms of breeding and production, as it is associated with productivity, anatomy and health of the cows. Improving the life efficiency of cows depends not only on their high lactation performance, but also on good fertility, health and longevity. Because the reasons for culling and its consequences are complex, it is not easy to make an optimal decision concerning removal of a cow from the herd. It is suggested that such decisions should be supported by specially designed analytical and simulation models [Demeter *et al*. 2011].

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