Analysis of longevity traits in Holstein Friesian cows

Constantin Găvan[1]

[1]*Agriculture Research and Development Station Șimnic, Craiova, Șoseau Bălcești, no. 54, 200721, Dolj, Romania.*

Abstract

Survival rate (SR) number of parities and length of productive herd life (LPHL) were evaluated for Holstein Friesian cows that calved beginning January 1, 2000 through May 2021 in a research dairy farm. A total of 870 lactation records were examined. Average Survival Rates (SRs) were 75.8% to parity 2, 49.7% to parity 3, 37.3% to parity 4, 18.6% to parity 5, 11% to parity 6, 6.3% to parity 7 and 3.3% to parity 8. A change for a better survival rate of cows over the span, years 2011-2021 compared with 2000-2010 was found to parity 2 and to parity 3 (significant differences). For the rest of parities (to 4, to 5, to 6, to 7 and to 8) the differences were non-significant. Average number of parities over the spam years 2000 to 2015 was 2.81. Linear regression of average of parities on year of first calving was positive (R=0.2786) and this means that was a weak direct relationship between variables. A change in the year of first calving with 1 impacted a change in the number of parities with 0.006. Average productive herd life (months) over the span years 2000 to 2015 was 33.86. Linear regression of average LPHL by year of first calving was positive (R=0.6513) and this means that was a strong direct relationship between variables. A change in the year of first calving with 1, impacted a change in the number of parities with 0.1889. The results of this study can give important information for economic studies on dairy herd management

Keywords: survival rate, number of parities, length of productive life.

1. Introduction

A dairy cow is biological capable of a life span of 20 years [1]. Reduced welfare of dairy cows, as a results of human intervention caused a shortened of life spam during the industrial revolution. Average time in the herds reported in 2008, 2009 years ranges between 4.5 and 5.5 years or 2.5 and 3.5 lactations [2, 3, 4].

The longevity of dairy cows is a complex trait with low heritability value and it is influenced by several inherent and external factors [5, 6, 7].

For breeding longevity traits in dairy cattle it is necessary to select the traits of longevity which determines superior economic performance of dairy herd [8, 9].

Schuster et al., 2020, [10] suggested the following recommendations for defining and calculating specific measures of longevity:

- Survival rates is the proportion of cows that survive to each parity of for designated period of time, and is calculated as the proportion of the cows that survived to each subsequent parity or to a given point in time divided by the number of cows included in the opportunity group.
- Stay ability describes 2 distinct definitions of longevity: the ability to avoid culling and the proportion of cows surviving to a specific point in time. When referring to a cows ability to avoid culling the term stayability should be used, and when referring to the ability to remain in the herd to a specific point in time, the term survivability should be used instead.

* Corresponding author: C. Găvan, scda_simnic@yahoo.com

- Herd life should be used when referring to the entire time an animal spends in the herd and is measured as the number of days between birth and culling or death. If is referring to productive Herd life the term length of productive life should be used.
- Length of productive life should be used in reference to the length of time in the lactating herd calculated as the number of days between first calving and culling or death.

After calving a cow must become to be profitable once she get to a point when the cost during rearing is repaid. This point is specific for each cow and is determined by many factors like age at first calving, milk yield and length of the dry period [11].
In Netherlands rearing costs of a heifer are on average between 1423 euro and 1715 euro [12].
Increasing the length of productive life is a potential option to improve the profitability of the dairy activity [13].
The analysis of longevity in dairy cows has been a top research topic in the recent years, with special attention to the selection of methods precisely determining the relationship between variables [14, 15, 16].
The main purpose of this study was to provide new information about survival rate, number of parities and length of productive life for Holstein Friesian cows from a research farm and to determine if those longevity trait has changed over time (2000 throught 2021).

2. Materials and methods

Data for this report were lactations records from Agricultural Research and Development Station (ARDS) Șimnic-Craiova, Romania, enrolled in the National Association Dairy Herd Improvement Program. The research dairy farm is located in the South-West region (Oltenia, 182 m above sea level, 44°19' N, 23°8' E). The initial dairy herd was imported from Denmark (1977-1978) as Danish Black and White (DBW) dairy cattle. Today the most genes from the original DBW cattle have been replaced by Holstein-Friesian genes, and the herd is enrolled in Dairy Herd Improvement testing.
For this report only records of cows that calved between 2000 and 2021were used.
Survival rate (SR) subsequent calving was evaluated (percentage) as the number of cows that calved a second, third, fourth, fifth, sixth, seventh and eighth time divided by the total number of cows that calved for the first time.
Mortality and culling rate were evaluated as the number of cows that died or culled after the first calving to the end of 8th parity divided by total number of cows included in the first calving in each year (2000 to 2021).
Length of productive life (LPL) was defined as the time a cow was in the herd and was evaluated as the number of days between first calving date and culling or death date.
For parity 8, cows were assumed to have survived for 1 year (365.26 days).
All data were entered into Microsoft Excel computer program 2007. Stata version 14 was used to summarize the data, and descriptive statistic was used to express the results.
A linear regression model was used to describe the relationship between the dependent variables (parity number or LPL) and independent variables (year of first calving), and to estimate the effect of each independent variable on the dependent variables. For this analysis an online calculator was used (www.statskindom.com/linear-regression-calculator) [17].

3. Results

Survival rates (SR) (%) of the cows by year of first calving are presented in table 1 for parities 2nd through 8th.
For survival to parity 2 the average survival rate was 75.8% for cows with first parity between 2000 throught 2021 (table 1).
The survival rate to parity 2nd seems to have changed over time. For cows with first parity between 2000 throught 2009 the average SR to parity 2 was lower than for cows with first parity between 2010 throught 2021 (73.3% vs. 77.5%) a difference of +4.2%; p value 0.0058 (table 2) and this means some improvement of SR during recent years (2010-2021).
Average survival rate to parity 3 was 49.7% (table 1). Also the average survival rate to parity seems to have changed over time. The average survival rate to parity 3 was lower for cows with first calving between 2000 to 2010 than for cows with first calving between 2011 to 2020; a difference of +3.02%, 95 CI 1.40-7.05, p value =

0.0208 (table 2). This means a change for better survival rate of cows to parity 3.

For survival to parity 4 the average survival rate was 37.3 (table 1) with variation from 36.7% (2000-2009) to 37.99% (2010-2019).

The difference between averages SR of cows with first calving between 2000 to 2009 was small (1.28%) and not significant (p value = 0.337).

Table 1. Survival rates to parities 2nd through 8th by year of first calving

Year of first calving	to 2nd %	to 3rd %	to 4th %	to 5th %	to 6th %	to 7th %	7th to 8th %
2000	73.6	55.2	39.4	18.4	13.1	5.2	2.6
2001	72.5	50	40	20.2	12.5	7.5	5
2002	73.1	46.3	34.1	17	12.2	7.3	4.8
2003	71.8	46.1	33.3	15.4	10.2	7.7	2.5
2004	71	47.3	34.2	15.8	10.5	7.9	2.6
2005	70	47.5	35	17.5	7.5	5	2.5
2006	71.8	48.7	35.9	17.9	10.2	5.1	2.6
2007	76.9	51.3	38.4	20.5	12.8	7.7	5.1
2008	78.9	50	36.8	18.4	10.5	5.3	2.6
2009	77.5	45	40	22.5	10	5	2.5
2010	73.2	43.9	31.7	17.1	7.3	4.9	2.4
2011	83.8	51.3	35.1	16.2	8.1	5.4	2.7
2012	84.2	52.6	42.1	23.7	13.1	7.9	5.3
2013	77.5	50	37.5	17.5	10	5	2.5
2014	75	47.5	40	20	12.5	7.5	5
2015	79.5	53.8	35.9	15.4	7.7	5.1	2.6
2016	73.2	48.8	36.6	19.5	14.6	7.3	
2017	77.5	52.5	40	20	15		
2018	75	50.5	40	20			
2019	76.9	53.8	41				
2020	76.2	52.4					
2021	78						
Average	75.8	49.7	37.3	18.6	11	6.3	3.3
S.E.*	0.8	0.7	0.6	0.5	0.5	0.3	0.3

* =Standard error

The average SR to parity 5 for cows with first parity between 2000 to 2018 was 18.6% (table 1). The average SR for cows with first calving between 2000 to 2009 was 18.36% and the average SR for cows with first calving between 2010 to 2018 was 18.82%. the difference between the 2 average SRs was small (0.46%) and not significant (p value = 0.677) (table 2).

The average SR across al years was 11% to parity 6, 6.3% to parity 7 and 3.3% to parity 8 (table 1). This parities were the lowest for survival rate, and the average SRs of cows with first calving between 2000 to 2008 were higher than cows with first calving between 2009 to 2015 (table 2).

The average number of parities by year of first calving was 2.81 with variation from 2.67 to 3.02. Average number of parities has decreased from 2.94 in the year 2000 to 2.64 in the year 2009 and then increased to 2.87 in the year 2015 (table 3).

Linear regression of average of parities on year of first calving was positive (R=0.2786), and the slope (b1 = 0.006353, CI 0.0062-0.01891) defined how a change in the year of first calving impacted a change in the number of parities (table 4). The average productive herd life (months) by year of first calving was 33.86 months with variation from 32.03 to 36.84 months. Average productive herd life has declined from 33.06 months in the year 2000 to 32.03 months in the year 2002 than increase to 32.87 months in the year 2003, to 33.79 months in the year 2004 declined to 32.91 months in the year 2005, and to 32.92 in the year 2006. In the year 2007 the average productive herd life increased to 34.62 months and then decreased to 32.23 months in the year 2011.

In the years 2012 and 2013 average of productive herd life was 36.84 months and 36.68 months respectively, and then declined to 34.76 month in the year 2014 and to 34.26 months in the year 2015.

Linear regression of average productive herd life on year of first calving was positive (R=0.6513) and this means that was a strong direct relationship between the 2 variables.

Table 2. Average survival rates by parity subgroups (a and b), and the difference between them

Parity (category)	Years of first calving	Average survival rate		Difference		95% CI	t – statistic	p-value
		%	SD	%	SE			
1 to 2 (a)	2000-2010	73.66	2.86					
1 to 2 (b)	2011-2021	77.89	3.46	+4.20	1.35	1.40-7.05	3.125	0.0053
2 to 3 (a)	2000-2010	48.3	3.21					
2 to 3 (b)	2011-2020	51.32	2.10	+3.02	1.19	0.51-5.5	2.520	0.0208
3 to 4 (a)	2000-2009	36.71	2.58					
3 to 4 (b)	2010-2019	37.99	3.2	+1.28	1.30	-1.45-4.01	0.985	0.337
4 to 5 (a)	2000-2009	18.36	2.19					
4 to 5 (b)	2010-2018	18.82	2.54	+0.46	1.08	-1.83-2.75	0.424	0.677
5 to 6 (a)	2000-2008	11.05	1.78					
5 to 6 (b)	2009-2017	10.92	2.97	-0.13	1.15	-2.57-2.31	-0.113	0.911
6 to 7 (a)	2000-2007	6.67	1.32					
6 to 7 (b)	2008-2016	5.93	1.24	-0.74	0.62	-2.06-0.58	-1.192	0.252
7 to 8 (a)	2000-2007	3.46	1.25					
7 to 8 (b)	2008-2015	3.20	1.21	-0.26	0.61	-1.58-1.06	-0.423	0.679

SD = standard deviation
SE = standard error
CI = confidence interval

Table 3. Average number of parities, and average of productive herd life by year of first calving

Year of first calving	Average number of parities	Average productive herd life (months)
2000	2.94	33.06
2001	2.81	32.84
2002	2.69	32.03
2003	2.67	32.87
2004	2.76	33.79
2005	2.72	32.91
2006	2.79	32.92
2007	2.86	34.62
2008	2.89	33.81
2009	2.64	34.54
2010	2.67	32.61
2011	2.89	33.23
2012	3.02	36.84
2013	2.87	36.68
2014	2.81	34.76
2015	2.87	34.26
Average	2.89	33.86
SE	0.03	0.3

The slope (b1 = 0.1889) (confidence interval 0.06277-0.3151) means that an increase of year of first calving by 1, the value of average productive herd life increases by 0.1889.

Linear coefficient of mean productive herd life was higher than linear coefficient of mean number of parities (R = 0.65 vs. R = 0.28) and increased the R^2 significantly (R^2 = 0.42 vs 0.078).

Parity composition of dairy herd was 33.3% for parity 1, 25% for parity 2, 16.7% for parity 3, 12.5% for parity 4, 5.8% for parity 5, 3.4% for parity 6, 2.5% for parity 7 and 0.8% for parity 8, and was a reflection of the number of cows that are replaced each year as a result of culling [18].

Table 4. Results of linear regression analysis of mean number of parities (a), and mean productive herd life (b) on year of first calving.

	Regression ANOVA	Source	DF*	Sum of square	Mean square	F statistic	P value
		Regression	1	0.01372	0.01372	1.1782	0.2961
		Residual	14	0.1631	0.01165		
		Total	15	0.1768	0.01179		
a	Linear regression reported in APA style	R^2 = 0.078, F = 1.18, p = 0.296 β = 0.0064 p = 0.296 α = 2.7 p<0.001, slope b1 = 0.06353 CI**(0.062-0.0989)					
	Regression (ANOVA)	Source	DF	Sum of square	Mean square	F statistic	P value
		Regression	1	12.1357	12.1357	10.3161	0.006271
		Residual	14	16.4694	1.1764		
		Total	15	28.6051	1.907		
b	Linear regression reported in APA style	R^2 = 0.42, F = 10.32, p = 0.006, β = 0.19 p = 0.006 α = 32.25 p<0.001, slope b1 = 0.1889 CI(0.063-0.3151)					

*DF = degrees of freedom
**CI = confidence interval

4. Discussion

Survival rate are dependent on many economic factors. For a long-term breeding strategies in dairy cows, it is necessary to evaluate the changes over time of longevity traits, and then using simple methods, to calculate the economic value of herd life. In this study we estimated the survival rate, number of parties and length of productive life in a herd of Holstein Friesian cows with first calving between 2000 and 2021. The survival rate to parity 2 was 75.8% and higher value were reported by Nieuwhov et al. (1988) [19] (77.2%) in US, Pipino et al. (2023) [20] (89%) in Argentina. Smaller value was reported by Hare et al. (2006) [18] (73.3) in US. Dallago et al., 2021, [21] observed the different status of dairy cow longevity in high milk – producing countries: QLPL significantly decreased over years (ranging from 0.9 to 3.04 years; Ireland and Poland), a LPL not changed (average 3.25, 3.24, 3.14 years; U.S., Germany and Netherland respectively) and a LPL increased over time (increase of 1.85 years in New Zeeland). After the milk yield trait, LPL is the second most economically important trait in dairy cows [22].

Short longevity shows that cows are not expressing their maximum potential for milk production and profitability. Also if more cows in first and second lactation are culled (increased culling rate) will decrease cow longevity and reduces the profitability of the herd. In the initial third of the first lactation cows are culled due to low milk production and mil ability while in the second lactation cows are culled due to the incidence of metabolic and other diseases [23].

Higher risk of culling due to failure to reproduce is observed in the final third of lactation for cows in the first and second lactation.

A greater proportion of mature cows as a results of increased longevity would reduce the number of replacement heifers, because mature cows have a relatively higher milk yield compared to young animals. This approach is relevant under a supply management system where profitability is associated with increased efficiency of using the resources available rather than increasing milk production.

The commercialization of extra heifers should be an additional source of income.

5. Conclusions

Using the recommended methodology to measure longevity of dairy cows, our study shows that Holstein Friesian cow longevity has increased over time between 2000 trought 2021.
The results of this study can give important information for economic studies on dairy herd management.

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