

Factors affecting longevity of cows with high share of Polish local breeds' genes*

Krzysztof Adamczyk^{1**}, Jan Szarek¹, Anna Majewska²,
Wojciech Jagusiak³, Zygmunt Gil¹

¹ Institute of Animal Sciences, Department of Cattle Breeding,
University of Agriculture in Krakow, Al. Mickiewicza 24/28, 30-059 Kraków, Poland

² National Research Institute of Animal Production, Department of Animal Genetic
Resources Conservation, Krakowska 1, 32-083 Balice n. Krakow, Poland

³ Department of Genetics and Animal Breeding,
University of Agriculture in Krakow, Al. Mickiewicza 24/28, 30-059 Kraków, Poland

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In comparison to highly productive cows, cows that have lower milk yield (including cows belonging to the so-called local breeds) are usually characterized by higher longevity. However in practice, exploiting the genetic potential for longevity can be easily limited by environmental and economic factors, regardless of the level of milk productivity. The aim of the present study was to analyse longevity of 616 cows with a high percentage of Polish local breed (LB) genes in their genotype. LB cows were most frequently culled at the age of 8-9 years and their lifetime energy-corrected milk yield (LECM) amounted to 17,500-27,600 kg. Average feeding level allowed for average daily energy-corrected milk yield of 11-15 kg during their productive life. However, feeding intensity was higher in larger herds ($p < 0.01$). Moreover, cows culled due to old age in relation to cows culled for other reasons (13.1 and 4.3-8.8 yr old, respectively) showed the greatest differences in LECM (40,857 kg LECM and 9,212-26,223 kg LECM, respectively). In conclusion we pointed out that despite a great genetic potential in terms of functional traits, in practice the productive life of LB cows is relatively too short. It may result both from deliberate excessive herd replacement, and from environmental and economic conditions, especially too low profits from milk sale. Therefore the key importance of a greater number of calves born by LB cows should be more appreciated in practice. As a result breeding of LB cattle might be more efficient in the future.

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**Corresponding rzadamcz@cyfronet.pl

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Cow longevity is usually defined as age at culling. It is determined by milk production intensity and culling reasons, among which particular attention is given to involuntary culling reasons [Sawa and Krężel-Czopek 2009, Heinrichs and Heinrichs 2011, Adamczyk *et al.* 2013, Bruijn *et al.* 2013]. It is commonly believed that decreasing average daily milk yield per lactation and ensuring an optimum level of welfare contributes to cow longevity. Therefore longevity is in a sense a function of the cows' breeding value and conditions at particular stages of their lives, both before the first calving and during the so-called productive life [Oltenacu and Broom 2010, Ahlman *et al.* 2011, Słoniewski 2012a].

However, in practice environmental and economic factors (e.g. a poor housing system, inadequate feeding, heat stress, too low milk prices) play a key role in the survival of a herd and they determine the length of cows' productive life [Groenendaal *et al.* 2004]. The effectiveness of cattle breeding in specialized highly productive herds depends on the direct relationship between profits derived from selling milk and animals, and the incurred costs. On the other hand, in herds with lower milk yields farmers must rely on other sources of income (e.g. subsidies, direct sales) to at least break even. This group of milk producers certainly comprises a majority of breeders of cattle covered by genetic resources conservation programmes (GRCP) in Poland [Spaltabaka 2009, De Vries 2013, Zięta 2013].

In 2014, GRCP covered 7,304 cows kept in 808 herds. This number included 3,025 Polish Red-and-White cows (PRW – 361 herds); 2,288 Polish Red cows (PR – 255 herds); 1,603 Polish Black-and-White cows (PBW – 156 herds) and 388 White-backed cows (WB – 36 herds) [NRIAP, 2015]. Although the populations are relatively small, cattle covered by GRCP have become an inseparable element of landscape in southern (PRW and PR cows), eastern (WB cows) and northern (PBW cows) Poland, representing all values characteristic of local breeds (e.g. excellent health and adaptability, very good fertility) [Litwińczuk *et al.* 2004, Szarek *et al.* 2004, Majewska 2006, NRIAP 2015].

Thanks to these characteristic traits, cattle belonging to breeds under GRCP have contributed to promoting sustainable animal breeding in Poland and abroad [De Marchi *et al.* 2007, Runowski 2007, Axelsson 2013]. The most important beneficial features of local cattle breeds in Poland comprise features favouring longevity, including very good levels of functional traits. These cattle are characterised by milk yields of 3000-5000 kg milk per 305d-lactation and high milk and beef quality, with good feed conversion rates for farm-prepared feed. On the other hand, breeding local breeds deserves special attention, as the populations are small and the genotype of these animals often contains genes of other breeds [Szarek *et al.* 2004, Król *et al.* 2015, Matwijczuk *et al.* 2015, PFCB 2015].

The aim of the present study was to estimate the effect of herd size, age at first calving and culling reason on longevity of cows with a high share of Polish local breed genes in their genotype.

Material and methods

The study was based on data of 616 cows culled and sold for further breeding¹ in Poland in 2012. The main criterion for including these animals in the research was a verified minimum percentage (51%) of genes of a local breed and inclusion in the Polish Federation of Cattle Breeders and Dairy Farmers recording. Due to the fact that data on the age at first calving were incomplete, analyses and results concerning this aspect are presented on the basis of 445 cows.

Data used for analyses were obtained from the SYMLEK National Milk Recording System and contained information on the average number of cows in herd, age at first calving, lifetime number of milking days, lifetime milk yield, average lifetime fat content in milk, average lifetime protein content, and reason of culling or disposal.

Longevity indicators assumed for this study included age at culling, daily energy-corrected milk yield calculated for the productive life of a cow (DECM) and lifetime energy-corrected milk yield (LECM). LECM was computed according to Sjaunja *et al.* [1990]:

$$\text{LECM} = M \times (383 \times \text{MF} + 242 \times \text{MP} + 783,2) / 3140$$

where:

LECM – average lifetime energy-corrected milk yield (kg);

M – lifetime milk yield (kg);

MF – average milk fat content for cow's productive lifetime (%);

MP – average milk protein content for cow's productive lifetime (%).

DECM was calculated according to a slightly modified formula:

$$\text{DECM} = (M / \text{MD}) \times (383 \times \text{MF} + 242 \times \text{MP} + 783,2) / 3140$$

where:

DECM – average daily energy-corrected milk yield (kg);

M – lifetime milk yield (kg);

MD – number of milking days;

MF – average milk fat content for cow's productive lifetime (%);

MP – average milk protein content for cow's productive lifetime (%).

Distributions of culling age, LECM and DECM were tested for normality within each culling reason using standard tests included in the univariate procedure of the SAS package.

In turn, data were analysed by means of the SAS GLM procedure (SAS, 2008), with analysis of variance performed according to the following unitrait model:

¹According to the definition adopted by the Polish Federation of Cattle Breeders and Dairy Farmers, sale for further breeding denotes sale to another breeder, connected with withdrawing the animal from the active population.

$$Y_{ijklm} = \mu + G_i + H_j + A_k + C_l + \epsilon_{ijklm}$$

where:

Y_{ijklm} – observation (culling age or DECM or LECM);

μ – overall mean;

G_i – i-th effect of genotype (PR, PBW, PRW, WB);

H_j – j-th effect of herd size class (<21 cows, 21-40 cows, >40 cows);

A_k – k-th effect of age at first calving (<25 months, 25-30 months, >30 months);

C_l – l-th effect of culling reason (old age, low milk yield, udder diseases, infertility and reproductive system diseases, infectious diseases, metabolic and gastrointestinal diseases, respiratory system diseases, leg diseases, casualties, other);

ϵ_{ijklm} – residual error.

As the effect of age at first calving proved to be statistically non-significant (Tab. 1), eventually the analysis of variance was performed according to the following model:

$$Y_{ijkl} = \mu + G_i + H_j + C_k + \epsilon_{ijkl}$$

where:

Y_{ijkl} – observation (culling age or LECM or DECM);

μ – overall mean;

G_i – i-th effect of genotype (PR, PBW, PRW, WB);

H_j – j-th effect of herd size class (<21 cows, 21-40 cows, >40 cows);

C_k – k-th effect of culling reason (old age, low milk yield, udder diseases, infertility and reproductive system diseases, infectious diseases, metabolic and gastrointestinal diseases, respiratory system diseases, leg diseases, casualties, other);

ϵ_{ijkl} – residual error.

Table 1. The significance (p-values) of associations between cows' longevity and their genotype, herd size, age at first calving and culling reason

Effect	Culling age	DECM	LECM
Genotype	0.4380	<.0001	0.0202
Herd size	0.4348	<.0001	0.4788
Age at first calving	0.0625	0.6136	0.0854
Culling reason	<0.0001	0.1492	<0.0001

DECM – daily energy-corrected milk yield calculated for the productive life of a cow; LECM – lifetime energy-corrected milk yield.

Herd size and age at first calving classes were determined using mean and standard deviation – for herd size the class of 21-40 cows, and for age at first calving the class of 25-30 months were defined as the range of $\pm$ one standard deviation from the mean

value. Culling and disposal reasons were defined according to principles used in the routine recording system in Poland [Śloniewski 2014].

Scheffe's and Tukey's tests were applied to determine statistical significance of differences between means [SAS 2008]. The results obtained by Scheffe's procedure are considered to be relatively reliable; however, the power of the test is small, which sometimes leads to overlooking of these differences which are close to the limit of significance. This is why the application of Scheffe's procedure is often followed by the more powerful Tukey's test.

Results and discussion

The results presented in Table 2 indicate that cows representing particular genotypes most frequently had their first calf at the age of 25-30 months (47-55% of cases). The biggest similarities in this respect exist between PBW and PRW cows. A relatively high percentage (30%) of WB cows calved for the first time later than at 30 months of age, while only 17% of PR cows belonged to this first calving age class.

Table 2. Distribution (%) of cows depending on age at first calving

Age at first calving (months)	WB (n=30)	PR (n=178)	PBW (n=84)	PRW (n=153)	Total (n=445)
<25	23	28	27	27	27
25-30	47	55	48	50	51
>30	30	17	25	23	22

WB – White-backed cows; PR – Polish Red cows; PBW – Polish Black-and-White cows; PRW – Polish Red-and-White cows.

Table 3. Distribution (%) of cows depending on herd size

Age at first calving (months)	WB (n=55)	PR (n=206)	PBW (n=171)	PRW (n=184)	Total (n=616)
<21	44	64	36	55	50
21-40	44	23	40	12	30
>40	12	12	24	33	20

WB – White-backed cows; PR – Polish Red cows; PBW – Polish Black-and-White cows; PRW – Polish Red-and-White cows.

A bigger diversification was observed in terms of herd size (Tab. 3). Generally, the animals were most often raised in small herds (fewer than 20 cows), which is true especially of PR cows, 64% of which were kept in herds of this size. In the herd size class of 21-40 cows, the highest percentage of animals belonged to the WB breed (44%), while in the biggest herds it was the PRW (33%) and PBW (24%) cows.

Only in the case of WB cows sale for further breeding was reported as the reason for disposal (Tab. 4). Taking into account all observations, animals were most

Table 4. Distribution (%) of cows depending on culling/disposal reason

Culling/disposal reason	WB* n=42(55)	PR n=206	PBW n=171	PRW n=184	Total n=616
Sale for further breeding	N/A**(24)	0	0	0	6
Old age	3(2)	1	5	6	3
Low milk yield	9(7)	4	2	1	3
Infertility and reproductive diseases	35(27)	58	32	40	39
Udder diseases	17(13)	8	18	11	13
Metabolic and gastrointestinal diseases	5(4)	11	5	4	6
Legs diseases	12(9)	3	9	10	8
Infectious diseases	0(0)	0	10	0	3
Respiratory system diseases	0(0)	0	0	0	0
Casualties	12(9)	12	8	18	12
Other	7(5)	3	11	10	7

WB – White-backed cows; PR – Polish Red cows; PBW – Polish Black-and-White cows; PRW – Polish Red-and-White cows.

*Values without brackets exclude sale (to be consistent with information on other genotypes) (n=42), values in brackets take into account both culling and sale for further breeding (n=55).

**Non-applicable.

frequently culled due to reproductive system diseases (39%), then – to a considerably smaller extent – due to udder diseases (13%) and casualties (12%). Within particular genetic groups, apart from the above-mentioned reasons, cows were also culled due to leg diseases (WB cows – 12%), metabolic and gastrointestinal diseases (PR cows – 11%) and other reasons (PBW cows – 11%).

On average the analysed cows had a lifespan of 8-9 years (Tab. 5). A statistically significant difference was observed only between PR and PBW cows (7.8 and 8.9 years respectively; $p < 0.05$). Genotypes varied much more in terms of DECM ($p < 0.01$). The lowest milk production intensity was observed in the case of WB cows (10.7 kg ECM/

Table 5. The effect of genotype on culling age of cows, daily ECM and lifetime ECM

Genotype*	N	Culling age (years)		DECM (kg)		LECM (kg)	
		LSM	SE	LSM	SE	LSM	SE
WB	55	8.7	0.6	10.7 ^{ABC}	0.6	17472 ^{Aa}	2449.6
PR	206	7.8 ^a	0.4	12.8 ^{AD}	0.4	23822	1705.3
PBW	171	8.9 ^b	0.4	13.7 ^B	0.4	24885 ^a	1603.1
PRW	184	8.0	0.4	14.7 ^{CD}	0.4	27634 ^A	1717.9

WB – White-backed cows; PR – Polish Red cows; PBW – Polish Black-and-White cows; PRW – Polish Red-and-White cows.

*The longest living cows within the genotypes were the following: PR cow (22.4 years old; 60456 kg LECM); PBW cow (17.4 years old; 82861 kg LECM); WB cow (16.8 years old; 67861 kg LECM); PRW cow (15.6 years old; 34190 kg LECM).

^{aA...} Within columns means bearing the same superscripts differ significantly at: small letters – $p < 0.05$; capitals – $p < 0.01$.

Table 6. The effect of herd size on culling age of cows, daily ECM and lifetime ECM

Herd size (head)	N	Culling age (years)		DECM (kg)		LECM (kg)	
		LSM	SE	LSM	SE	LSM	SE
<21	323	8.7	0.3	11.7 ^{AB}	0.3	22154 ^a	1428.2
21-40	162	8.1	0.4	13.2 ^A	0.4	22020	1710.5
>40	131	8.2	0.4	14.1 ^B	0.4	26186 ^a	1764.3

WB – White-backed cows; PR – Polish Red cows; PBW – Polish Black-and-White cows; PRW – Polish Red-and-White cows.

^{aA...} Within columns means bearing the same superscripts differ significantly at: small letters – $p<0.05$; capitals – $p<0.01$.

day) and the highest one in the case of PRW cows (14.7 kg ECM/day). Cows within particular genotypes did not exceed an average lifetime milk yield of 30,000 kg ECM. WB cows produced the smallest amount of milk during their productive life (17472 kg LECM) and PRW cows the biggest amount (27634 kg LECM) ($p<0.01$). It is also worth mentioning that the longest-living cow belonged to the PR genotype (22.4 years), while a PBW cow had the highest lifetime milk yield (82861 kg ECM).

Herd size did not significantly affect culling age (Tab. 6), but an increase in herd size correlated with increasing milk production intensity: 11.7 kg DECM (herd size <21 cows); 13.2 kg DECM (herd size 21-40 cows); 14.1 kg DECM (herd size >40 cows). Statistically significant differences were observed between the smallest and the medium and largest herds.

Data presented in Table 7 demonstrate that the difference concerning culling reason was usually strictly connected with removing cows from herds due to their age

Table 7. The effect of culling reason on culling age of cows, daily ECM and lifetime ECM

Culling reason	N	Culling age (years)		DECM (kg)		LECM (kg)	
		LSM	SE	LSM	SE	LSM	SE
OA	22	13.1 ^{ABCDEF}	0.7	11.7	0.7	40857 ^{ABCDEF}	3299.5
LM	18	4.3 ^{AJ}	0.8	14.4	0.8	9212 ^{AH}	3622.6
UD	74	8.2 ^{BI}	0.4	12.1 ^a	0.4	23046 ^{Bb}	1827.1
IRD	262	7.8 ^{CJ}	0.2	13.7 ^a	0.3	19983 ^C	1099.4
ID	18	8.1 ^D	0.9	12.2	0.9	13264 ^D	3931.2
MGD	38	7.9 ^{Ea}	0.6	13.9	0.6	21599 ^E	2561.9
LD	46	8.8 ^{FK}	0.5	13.3	0.5	26223 ^{Hac}	2296.0
CA	76	7.0 ^G	0.4	12.9	0.4	16787 ^{Fc}	1835.4
O	47	7.9 ^{HL}	0.5	12.0	0.5	21642 ^G	2283.8

OA – old age, LM – low milk yield, UD – udder diseases, IRD – infertility and reproduction diseases, ID – infectious diseases, MGD – metabolic and gastrointestinal diseases, LD – leg diseases, CA – casualties, O – other.

^{aA...} Within columns means bearing the same superscripts differ significantly at: small letters – $p<0.05$; capitals – $p<0.01$.

(13.1 years), as compared with other reasons (4.3-8.8 years). The only exception were two cows culled at the age of 11 years due to respiratory system diseases. Among the 22 cows culled due to their age, PBW and PRW cows constituted a majority (87%). Definitely the earliest culling decisions were attributed to low productivity (4.3 years), although such decisions were not frequent (18 observations).

Cows culled due to their age had the highest average lifetime milk yield (40857 kg ECM). A statistically significant difference ($p < 0.05$; $p < 0.01$) was observed in this respect in comparison with most other culling reasons. In turn, milk production intensity was generally at a similar level (12-14 kg DECM), regardless of culling reason. The only statistically significant difference ($p < 0.05$) was found when comparing cows culled due to udder diseases (12.1 kg DECM) with cows culled due to reproductive system diseases (13.7 kg ECM).

The results for respiratory system diseases were not included because of the very small number of observations (2 cows).

Polish GRCP requirements for heifers concerning age at first conception are 14-15 months (not less than 13) for PR and WB breeds and 15-16 months (not less than 14) for PBW and PRW breeds [NRIAP 2015]. However, our research demonstrated (cf. Table 2) that first conceptions, regardless of genotype, occurred at a later age (from 72% of cases for the PR breed to 77% of cases for the WB breed). It seems that this can be largely attributable to the method of feeding heifers, which was based on roughages, while concentrates were used only in small amounts, or not at all. That is why heifers reached reproductive maturity at a later age.

Several authors claim that age at first calving can have a significant effect on dairy cow longevity, which concerns both highly productive cows (> 7000 kg milk per 305d-lactation) and animals whose milk yield is lower [Meyer *et al.* 2004, Hultgren and Svensson 2009, Sawa and Bogucki 2010, Do *et al.* 2013, Zavadilová and Štípková 2013, Cielava *et al.* 2014]. In their opinion the productive life of cows which had their first calf earlier (< 24 months) can be longer than that of cows which were older at the time of first calving (especially those over 30 months of age). Although our findings do not confirm this conclusion in relation to Polish local breeds, with regard to average age at culling and LECM the differences between the compared factors were *close to* the margin of statistical significance ($p = 0.0625$ and $p = 0.0854$, respectively) (cf. Tab. 1).

Local cattle breeds in Europe are usually maintained in small herds and generally they are historically or traditionally associated with a specific region of the country [Saether and Vangen 2001, Michna 2005, Peters *et al.* 2009, Hiemstra *et al.* 2010, Danchin-Burge *et al.* 2012]. Data collected by Sosin-Bzducha and Majewska [2014] indicate that in Poland in the years 2013-2014 cows covered by GRCP were far more frequently kept in herds smaller than 20 animals. According to Majewska [2014], the average size of herd covered by GRCP in Poland in October 2015 was 9.7 animals. In comparison to 2014, the average herd size increased by 0.7 and varied considerably depending on the region of the country. For example, in the Małopolskie province, where the number of local breed herds was highest for PR cows (180 herds, 1621

cows) and PRW cows (291 herds, 2612 cows), the average herd size was similar to the national average. In turn, in north-eastern Poland, where farms are generally bigger, an average herd covered by GRCP numbered 21 PR cows, 15 WB cows and 18 PBW cows. The most numerous PRW cow herds were recorded in the Opolskie province (17 cows on average) and the Dolnośląskie province (13 cows on average). These observations are confirmed by the results of the present study concerning PR cows, found mainly in the region of Małopolska. As compared to other genotypes, these animals were most frequently (64% of observations) kept in small herds (<21 cows). Likewise, a majority (55%) of PRW cows analysed in this study were kept in the smallest herds. For WB and PBW cows the average herd size was over 21 cows.

Sosin-Bzducha [2012] analyzed the main culling reasons for PRW cows covered by GRCP in the years 2008-2011. She found that as many as 48% of cows were removed from herds on account of infertility and reproductive system diseases. Moreover, casualties were one of the most frequent culling reasons (21%). Our study demonstrated that in 2012 a slightly smaller proportion of PRW cows were culled due to these reasons (the numbers decreased by 8% and 3% respectively, cf. Table 5). Generally, in the last decade problems with reproduction constituted a major reason for culling of local breed cows [Borkowska and Januś 2006, Majewska 2014].

Moreover, the results of our study and research conducted by Borkowska and Januś [2006] confirm a consistent interest of breeders in selling WB cows for further breeding. This can probably be attributed to the growing popularity of the WB breed, which thanks to its distinctive coat colour has become in a sense “an ornament” of several small farms.

Longevity of local breed cows should be their main asset, especially for organic farms. According to Słoniewski [2012b], these cows should be used for at least 6-8 years, whereas Sosin-Bzducha [2012] and Majewska [2014] estimate the average culling age of PRW and WB cows to be about 8-9 years. The results of our research indicate that generally cows with a lifespan exceeding 10 years and lifetime milk yield over 60,000 kg LECM could be found within the analysed genotypes (only a PRW cow in its lifetime lasting 15.6 years produced just 34,190 kg ECM). Therefore it seems that the reason for early culling of local breed cows is not the breeding value of these animals, but failure to provide them with adequate conditions to maximize the length of their productive life. It is particularly important with regard to cows belonging to small populations covered by GRCP, in which breeders should strive to increase the number of calves born during a cow's productive life.

In the recent years longevity of local breed cows in Poland has been systematically increasing [PFCB 2013, PFCB 2015]. In 2014 cows were culled at a later age than two years before (the average age at culling of WB, PR, PBW and PRW cows was 7.4 years, 8.6 years, 9.2 years and 9.2 years, respectively). Both in 2012 and in 2014 lifetime milk yield was on the whole at a similar level, with the exception of WB cows, which lifetime milk yield in 2014 was by over 3900 kg higher than two years before.

In conclusion, it must be emphasized that owners of cattle belonging to breeds covered by genetic resources conservation programmes in Poland constitute a small, but very important group of breeders, whose main aim is to preserve animal biodiversity. Although generally local breeds are kept in small herds in a maintenance and feeding system based on roughages, we can observe a considerable diversification in this respect, depending on the genotype and the region of the country. Unfortunately, despite a great genetic potential in terms of functional traits, in practice the productive life of local breed cows in Poland is too short. It is difficult to attribute it to a single reason. It may result from certain breeding decisions on the farm level (e.g. deliberate excessive herd replacement) as well as external factors (environmental and economic conditions). Prolonging the productive life leads a greater number of calves born by the cow, which in the case of small populations is of key importance. Therefore it might be worthwhile to show greater appreciation for this aspect of breeding work with Polish local breed cows.

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