

Inbreeding evaluation in Latvian local cattle breeds

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In this study, inbreeding and effective population size of the Latvian gene conservation cattle breeds Latvian Brown (LB) and Latvian Blue (LZ) were analysed. The study was based on the pedigree data of 319 LB and 712 LZ cows that were alive at the time of data selection. The inbreeding level in LB and LZ has been increasing during the last decade and at the end of the year 2019, it was 2.61% and 5.20% for LB and LZ, respectively. The average increase of inbreeding from 2010 to 2019 was 1.80% for LB and 2.26% for LZ. The proportions of inbred animals with an inbreeding level greater than 10% were 0.60% and 2.14% in LB and LZ, respectively. Effective population size based on the rate of inbreeding decreased and was close or within the minimum range of recommended effective population size. The current study demonstrates that the inbreeding has increased, and the effective population size decreased in both populations. Therefore, the breeding organizations have to monitor and control the rate of inbreeding in LB and LZ populations over time.

Keywords: inbreeding, Latvian Brown, Latvian Blue, native breed

1 Introduction

In Latvia, two local cattle breeds - Latvian Brown (LB) and Latvian Blue (LZ) - are included in the DAD-IS list of the FAO database (FAO, 2019). Latvian Brown has been selected in Latvia for more than 100 years and was accepted as a breed in 1922. In Latvia, the number of LB is decreasing due to substitution by Holstein breed and the conservation of LB started in 2004. The LZ breed is known since the 19th century, but during last century LZ was not selected and kept in private farms because of its grey colour and its adaptation to rough environmental conditions. In the late 80's of the 20th century the number of LZ animals decreased to a minimum and the first LZ conservation programme started in 2004 (Grīslis et al., 2005, Grīslis, 2006).

In Latvia, the proportion of gene conservation breeds has been increasing during the last decade. In 2019, 200 LB and 439 LZ cows were kept. According to the national milk recording, the milk productivity of LZ was 5,202 kg per standard lactation with 4.26% milk fat and 3.35% milk protein content in 2018. For LB cows, an average of 5,302 kg milk per standard lactation with 4.49% and 3.49% milk fat and protein content, respectively, was recorded (LDC, 2019). The fat and protein content in the milk of LB cows is higher than that in LZ cows (Jonkus et al., 2020).

The two breeds included in the genetic conservation programme are under genetic evaluation and Latvia has started to monitor inbreeding. Due to the small population sizes of local cattle breeds, the frequently used mating of related animals affects the level of inbreeding and genetic diversity of these populations (Oldenbroek and van der Waaij, 2015). Most inbreeding studies reported negative consequences or an overall reduction of animal performance (Mc Parland et al., 2007, Mc Parland et al., 2009, Doekes et al., 2019).

In this study, inbreeding and effective population size of the LB and LZ gene conservation cattle breeds were analysed.

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2 Material and methods

For both LB and LZ breeds, pedigree information was provided by the Latvian Agricultural Data Centre. Pedigree data recording for LB and LZ started in 1960 and 1973, respectively. For LB, the reference population included 47 bulls and 319 cows that were alive at the time of data selection. The criteria of data selection for the LB reference population was a percentage of LB genes which needed to be at least 50% and the presence of only Angler and Danish Red breeds in pedigree of the reference animals.

The LZ reference population included 67 bulls and 712 cows being alive at the time of data selection; the minimum LZ gene proportion was 37.5%. Latvian Brown, Holstein, Lithuanian Light Grey and Tyrol Grey breeds are the main breeds for crossbreeding in LZ. For reference animals of both breeds, as many ancestor generations as possible were considered in the pedigree with a maximum of eleven complete generations.

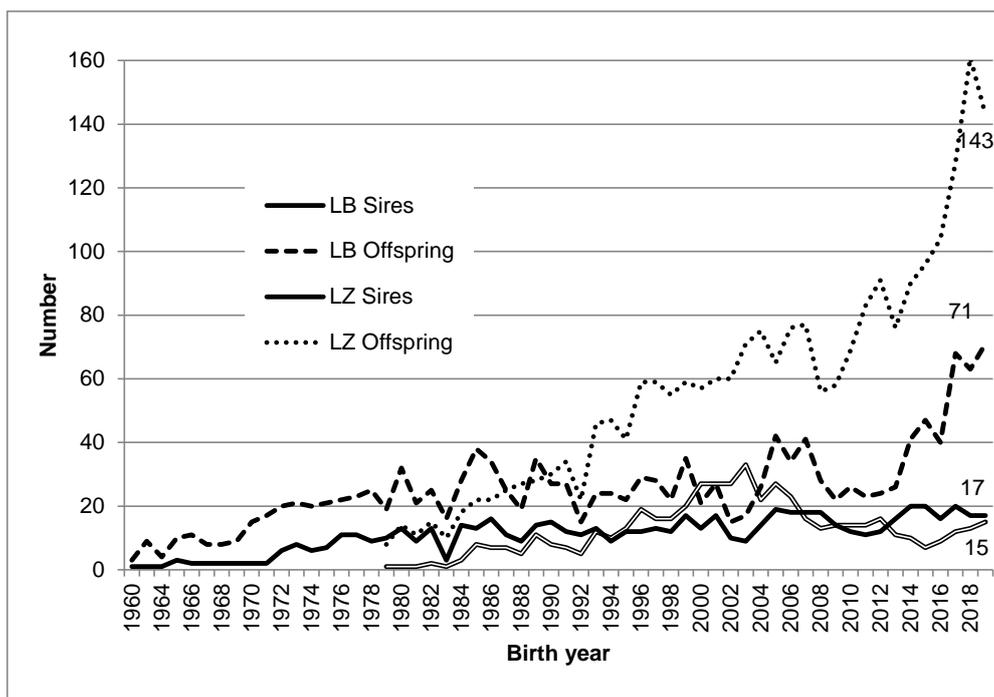


Figure1 Number of sires in reproduction by year of birth of offspring for LB and LZ

Figure 1 shows the number of animals included in the analysis. The increase in both breeds has started in 2010. In 2019, 71 LB and 143 LZ offspring were sired by 17 and 15 bulls, respectively. During the last 10 years, the number of AI sires remained almost constant for the analysed breeds.

The software package POPREP (Groeneveld et al., 2009) was used to compute diversity parameters on pedigree data. The pedigree completeness, level of inbreeding, and effective population size (N_e) based on the rate of inbreeding (1) and on the number of parents (3) were analysed:

$$N_e = \frac{1}{2 \Delta F} \quad (1)$$

where ΔF is the rate of inbreeding per generation with

$$\Delta F = \frac{F_t - F_{t-1}}{1 - F_{t-1}} \quad (2)$$

where F_t and F_{t-1} are the average inbreeding coefficients at t and $t-1$ generations;

$$N_e = \frac{4N_m \times N_f}{N_m + N_f} \times 0.7 \quad (3)$$

where N_m is the number of male parents and N_f is the number of female parents.

3 Results and discussion

3.1 Pedigree completeness and inbreeding level in LB and LZ populations

The LB and LZ pedigrees were tested for pedigree completeness (Table 1). Results show that there is no substantial difference between breeds in the average pedigree completeness for animals born within the last 10 years. The pedigree completeness for LB in the previous period was better than that for LZ. This can be explained by a long history of animal recording of LB and by a relatively short period of LZ registration as a breed.

Table 1 Average pedigree completeness for LB and LZ populations

Generations	LB pedigree completeness, %	LZ pedigree completeness, %
1 generation deep	100.0	100.0
2 generations deep	99.9	99.5
3 generations deep	98.8	97.1
4 generations deep	96.8	91.3
5 generations deep	89.9	81.7
6 generations deep	80.0	70.8

The level of inbreeding in the LB and LZ cattle populations is presented in Figure 2 and Figure 3, respectively. The comparison indicated that LZ animals born from 2000 to 2019 had higher inbreeding level than LB animals. The estimated inbreeding level in LZ was on average 1.15% higher than the inbreeding in LB. In 2019, the difference between the two populations reached the highest value (2.59%). The inbreeding level in LB and LZ has been increasing during the last decade, and at the end of the year 2019 it was 2.61% and 5.20% for LB and LZ, respectively (Figure 2 and Figure 3). Over years, the inbreeding level has increased from 0.23 to 1.22% for LB sires and from 0.80 to 1.22% for LB dams. Higher values of inbreeding were observed for LZ sires and LZ dams and the trend in inbreeding during the last five years was 1.23 – 3.58% and 1.77 – 2.46%, respectively.

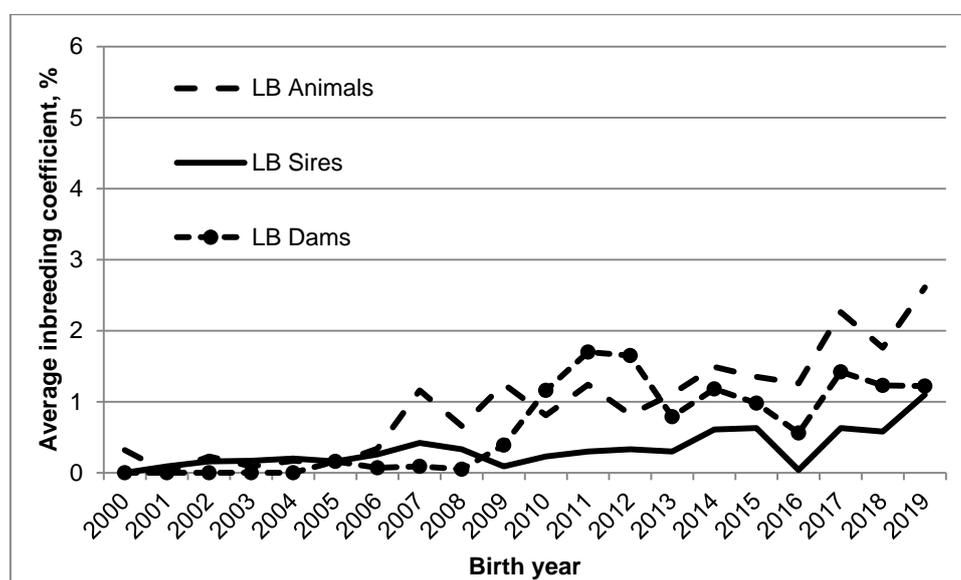


Figure 2 Inbreeding trend of animals and parents in LB populations by birth year

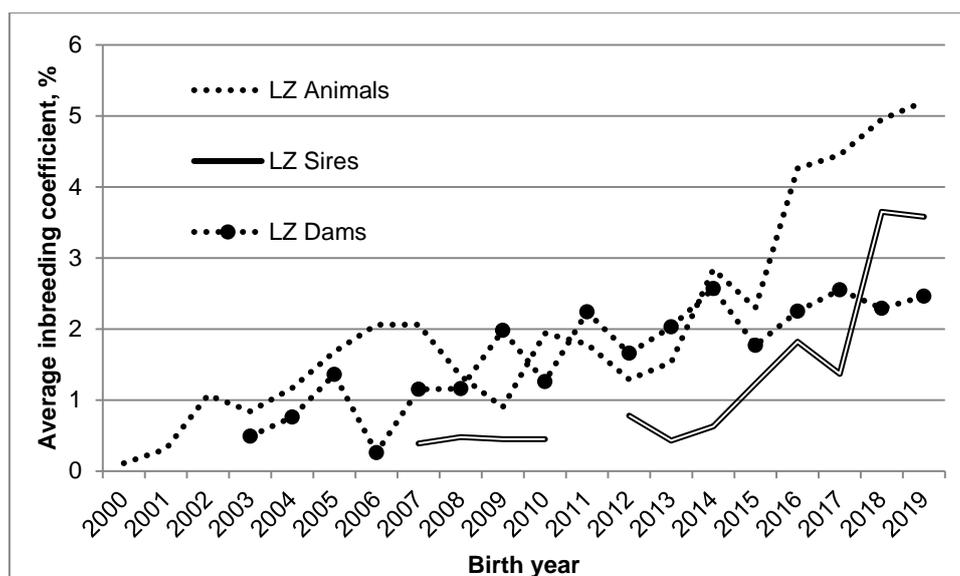


Figure 3 Inbreeding trend of animals and parents in LZ populations by birth year

For 757 LZ animals, Gr̄isliš et al. (2005) computed an average inbreeding coefficient of 1% and the average inbreeding coefficient of inbred cows was 12.3%. In a later investigation the inbreeding level of 1,288 LZ animals born from 2006 to 2013 averaged 1.71%, and 40% of the inbred LZ cows had an inbreeding coefficient higher than 3% (Gr̄isliš and Simkeviča, 2018).

The proportion of non-inbred animals in LB and LZ was 68.32% and 53.63%, respectively (Table 2). A total of 1,512 LB animals were analysed and from those, 479 animals (31.68%) were inbred. The largest proportion of inbred LB animals (29.83%) had inbreeding coefficients up to 5%. However, a few animals with inbreeding coefficient higher than 10% were also found.

As expected, the number of inbred LZ animals was higher than that of LB; indeed, 46.37% of LZ animals were inbred. The proportions of LZ inbred animals with inbreeding coefficients up to 5% and above 10% were 38.07% and 2.14%, respectively.

Angler and Danish Red breeds have been used to develop and improve the LB breed. Studies on inbreeding have been performed in small local and in large populations, like German Angler and Danish Red. Addo et al. (2017) reported that 64% of the individuals in German Angler cattle were inbred; the average inbreeding estimates were higher for the German Angler breed than the Red-and-White dual purpose breed, and reached 1.39% for all and 2.19% for inbred animals. In the study of Sørensen et al. (2005) the inbreeding level in Danish Red breed population has increased over from 2001 to 2003 with the rate of inbreeding per generation being 1.07%. These studies illustrate the increase of inbreeding in Red cattle populations.

Table 2 Distribution of LB and LZ animals based on the coefficient of inbreeding

Coefficient of inbreeding, %	LB animals		LZ animals	
	number - <i>n</i>	proportion, %	number - <i>n</i>	proportion, %
0 (non-inbred)	1,033	68.32	2,030	53.63
up to 5 %	451	29.83	1,441	38.07
6 – 10 %	19	1.26	233	6.16
11 – 15 %	6	0.40	45	1.19
16 – 20 %	-	-	21	0.55
21 – 25 %	1	0.07	10	0.26
26 – 30 %	2	0.13	5	0.13
Total	1,512	100.00	3,785	100.00

The number of inbred animals increased over time. The maximum inbreeding coefficients were 25.69% for LB in 2019 and 28.50% for LZ in 2016. Crossbreeding is being used to improve the productivity of cows and also to control inbreeding level.

3.2 Effective population size

In the last periods, the generation interval has increased for LB (Table 3). This tendency can be explained by changes in the AI bulls' age. Since 2010, the average age of the active AI bulls ranged between 13.3 and 24.6 years.

Table 3 Generation interval, rate of inbreeding per generation, and effective population size of LB and LZ cattle

Breed	Period	GI male/female	ΔF %	Ne (eq. 1)	Ne (eq. 3)
LB	2005*-2009	12.6/6.2	0.14	518	254
	2010*-2014	14.0/5.0	0.23	219	239
	2015*-2019	20.8/6.2	0.47	112	186
LZ	2005*-2009	6.6/4.5	0.93	56	238
	2010*-2014	5.7/5.3	0.64	86	130
	2015*-2019	7.3/5.1	0.67	79	69

GI – Generation interval in year marked by *; ΔF – Rate of inbreeding per generation; Ne – Effective population size.

The rate of inbreeding per generation has increased from 0.14 to 0.47% for LB and has decreased from 0.93 to 0.67% for LZ. However, during the last five years the number of used sires for LZ was 34 – 20 and for LB 89 – 68. As a result, the effective population size decreased and was close or within the minimum range (50-100) of recommended effective population size (Mäki-Tanila et al., 2010). In the investigation of Zutere et al. (2006) the effective population size for LZ was only 18 while it was 200 for LB. Due to a small number of Ne, the increase of inbreeding can be expected.

4 Conclusions

The average inbreeding level was higher for the LZ than the LB breed and has increased over the last 20 years. It has reached 5.20% for LZ and 2.61% for LB animals born in 2019. Crossbreeding was used to remove and control the level of inbreeding in the LB and LZ populations. The present study shows that the number of animals of local Latvian cattle breeds has significantly decreased in recent years. As usually observed in small gene conservation breeds a steady increase of inbreeding was observed for both breeds. Levels of inbreeding and the effective population size decreased in both populations, which could be explained by the use of a limited number of bulls. Breeding organizations have to optimize mating plans and to control the rate of inbreeding in the LZ and LB populations.

Acknowledgments

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