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Evaluation of the conservation status of the Slavonian-Syrmian Podolian cattle based on pedigree data

IVANKOVIĆ, Ante¹– PEĆINA, Mateja^{1*} – KONJAČIĆ, Miljenko¹ – RAMLJAK, Jelena¹ – KELAVA UGARKOVIĆ, Nikolina¹ – IVKIĆ, Zdenko²

¹ Faculty of Agriculture University of Zagreb, Svetošimunska 25, 10000 Zagreb, Croatia

² Croatian Agency for Agriculture and Food, Vinkovačka cesta 63c, 31000, Osijek, Croatia

*corresponding author: matejapecina@agr.hr

Abstract

Slavonian-Syrmian Podolian cattle is one of the three autochthonous breeds in Croatia. After three decades of implementation of conservation measures, it is still in a critically endangered status. The objective of this work is to determine the population parameters based on pedigree records. The ENDOG v4.8 software package was used to estimate the population parameters. The mean number of complete and equivalent generations is relatively low (1.72; 2.71). The average inbreeding coefficient is relatively high (5.13%), while the mean average relatedness coefficient is of concern in terms of population sustainability (14.56%). The effective number of founders and ancestors of the reference population is low (9, 8) and their ratio (1.12) confirms the bottleneck that the population went through three decades ago. The average generation interval is 6.34 years and ranges from 5.84 (father - son) to 6.76 years (mother - son). The mean age of parents at the birth of offspring was 6.92 years. The population indicators calculated on the basis of pedigree records indicate the vulnerability of the Slavonian-Syrmian Podolian cattle. It is necessary to reduce the level of inbreeding, preserve existing lines and partially refresh the genetic potential of the breed.

Keywords: Slavonian-Syrmian Podolian cattle, pedigree, conservation.

Introduction

Slavonian-Syrmian Podolian cattle (SSPC) is one of three Croatian local cattle breeds. It is a longhorn, resilient breed with a moderate-sized frame (withers height from 125 to 140 cm, body mass from 400 to 600 kg) and a light to dark grey body colour (Figure 1). Until the middle of the 20th century, it was used mainly for field work and as a draft animal, and to a smaller extent for milk and meat production. Due to the modernization of agricultural production and the introduction of allochthonous breeds, local cattle breeds were marginalized and almost became extinct (some cattle breeds are extinct in Croatia). In the nineties of the 20th century, a program was started to protect the SSPC breed. The original population for the protection of the Slavonian-Syrmian Podolian cattle included eighteen adult animals (RAMLJAK et al., 2011). The current SSPC population includes approximately three hundred adult animals (15 bulls and 294 cows) housed on 35 farms (CAAF, 2022). Considering the population size, the SSPC is a critically endangered breed. Local cattle breeds are recognized as an important part of

biodiversity and genetic heritage. Of the total number of breeds of mammalian species used in agriculture, cattle breeds account for 22.90% (FAO, 2019). Although the number of extinct cattle breeds is relatively low (12.8%), a large number of breeds are endangered (21.1%), and for most cattle breeds the endangerment status is unknown (53.8%) (FAO, 2019). Therefore, it is very important to maintain the genetic diversity of the remaining cattle breeds, mostly captured in unselected autochthonous breeds (MEDUGORAC et al., 2009).



Figure 1. Bull and cows of the Slavonian Sarmatian Podolian breed

Small natural populations raise several problems when faced with their conservation: they have lost most of their economic value, they usually show a high inbreeding level which threatens their long-term maintenance, and the conservation of biodiversity that they represent makes them unsuitable for the introduction of individuals in other populations (DUNNER et al., 1998). Monitoring and preservation of genetic diversity is the basis for effective selection and/or conservation programmes (GUTIÉRREZ et al., 2003). Pedigree information is a useful source for conservation programs to analyse the breeding status of a population (JARNECKA et al., 2021), and is important tool to describe genetic variability and its evolution across generations (GUTIÉRREZ et al., 2003). Therefore, the objective of this study was to describe the conservation status of the Slavonian Sarmatian Podolian cattle through pedigree analysis.

Materials and methods

The database of Slavonian-Sarmatian Podolian cattle includes 1,836 animals born between 1984 and 2022. For each animal in the database, information such as identification number, date of birth, sex, sire, dam, and herd was recorded. In this study, active (alive) animals of both sexes were selected as the reference population (REF 01). Demographic and population parameters are presented for the last two and a half decades. Pedigree analysis was performed using ENDOG v4.8 software (GUTIÉRREZ and GOYACHE, 2005). Pedigree completeness was determined by the mean number of complete generations, the mean number of maximum generations, and the mean number of equivalent generations (BOICHARD et al., 1997). Parameters related to inbreeding (mean inbreeding coefficient (F), mean average relatedness coefficient (AR), effective population size (N_e)), probability of gene origin (effective number of founders (f_e), effective number of ancestors (f_a), effective number of founder herds (f_h)), and generation interval (GI) were assessed. The average relatedness coefficients and individual inbreeding coefficients were calculated based on GUTIÉRREZ and GOYACHE (2005).

Results and discussion

The demographic trend of the Slavonian-Syrmian Podolian cattle population was positive in the last two decades (Figure 2). During the period of the initial implementation of the SSPC protection program (1997 to 2004), all animals were kept in one herd, which limited the development of the population. After 2004, the redistribution of the protected population to several herds was initiated, which resulted in a positive development of the population (annual population growth of 8.79%). The diversity of interests of several breeders (herds) makes the sustainability of breeding endangered breeds more secure. Breeding of SSPC where the population is concentrated in a smaller number of owners or in a narrower breeding area represents a risk for sustainability, due to the potential absence of interest in breeding the local breed (if it is not economically well-affirmed), or because of certain infectious diseases or natural disasters.

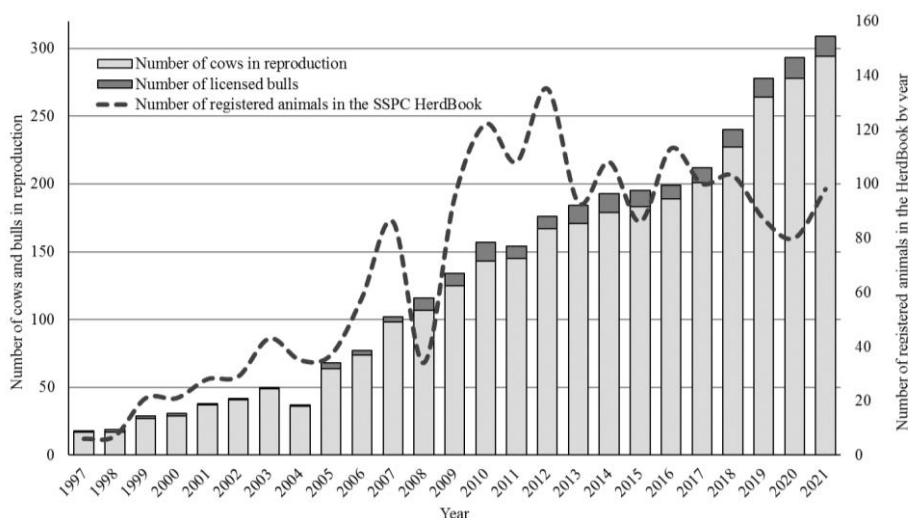


Figure 2. Population trends in the Slavonian-Syrmian Podolian cattle population in the period from 1997 to 2021 (number of licensed and new registered animals in the SSPC HerdBook)

Table 1. Demographic and genetic indices of the Slavonian-Syrmian Podolian cattle

Item	Total
Original dataset (TP; total population)	1,836
Base population (BP; one or more unknown parents)	107
Reference population 1 (REF 01; live animals)	573
Mean inbreeding coefficient (F)	5.13
Mean Average Relatedness coefficient (AR)	14.55
N_e via increase in inbreeding by equivalent generation (N_e)	18.85
Mean number of complete generations (MCG)	1.72
Mean number of equivalent generations (MEG)	2.71
Mean number of maximum generations (MMG)	4.94
Number of founders contributing to reference population	48
Number of ancestors contributing to reference population	46
Effective number of founders for the reference population (f_e)	9
Effective number of ancestors for the reference population (f_a)	8
Effective number of founder herds for the reference population (f_h)	1.9
Effective number of founders/effective number of ancestors ($f_e f_a$)	1.12

An analysis of all pedigree entries revealed 1,729 animals for which both parents were known. The active living population consisted of 573 animals (Table 1). Mean number of complete/equivalent/ maximum generations (1.72 / 2.71 / 4.94) is relatively low, but sufficient for estimation and monitoring of the conservation status of the SSPC population.

A similar value of the mean number of complete/equivalent/maximum generations (1.79 / 2.99 / 5.81) was observed in the population of Istrian cattle (IVANKOVIĆ et al., 2022), because the official protection program was started at the same time. Compared to the values in the SSPC population, the mean number of maximum generations (5.81 vs. 4.94) is higher in the population of Istrian cattle (IC), because the informal IC protection program was started earlier (in 1989 the Breeders association for the protection of Istrian cattle was established), and previously established Istrian cattle HerdBook.

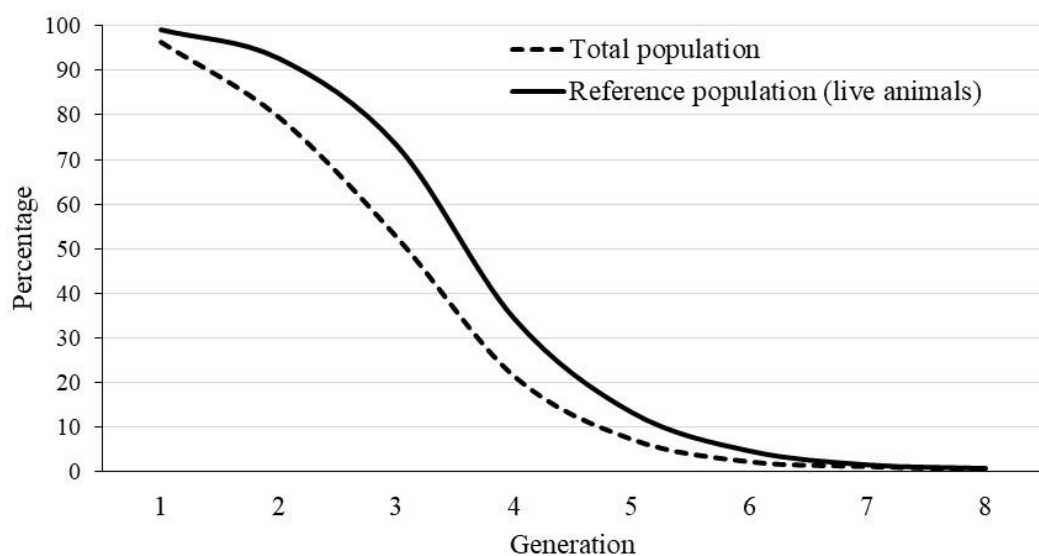


Figure 3. Completeness of total and REF 01 population (in %) in the Slavonian-Syrmian Podolian cattle from 2000 to 2020

The SSPC reference population (REF 01) had a completeness value in the first three generations (99.04%, 92.63%, and 96.66%), whereas completeness dropped to 34.26% in the fourth generation (Figure 3). The entire SSPC population had a lower completeness value in the first four generations (96.33%, 79.51%, 52.61%, and 21.32%). After the ninth generation, the completeness was close to zero.

The mean inbreeding coefficient in the whole population was 5.13%, and the stagnation of the F level during the last decade is noticeable (Figure 4). The AR coefficient in the population was relatively higher (14.55%) and continues to increase, indicating the need for more careful monitoring of the breed. Lower F and AR values and more favourable stagnation tendencies were observed in the population of Istrian cattle (IVANKOVIĆ et al., 2022), which puts the Istrian cattle population in a more favourable position in terms of long-term sustainability compared to the SSPC population.

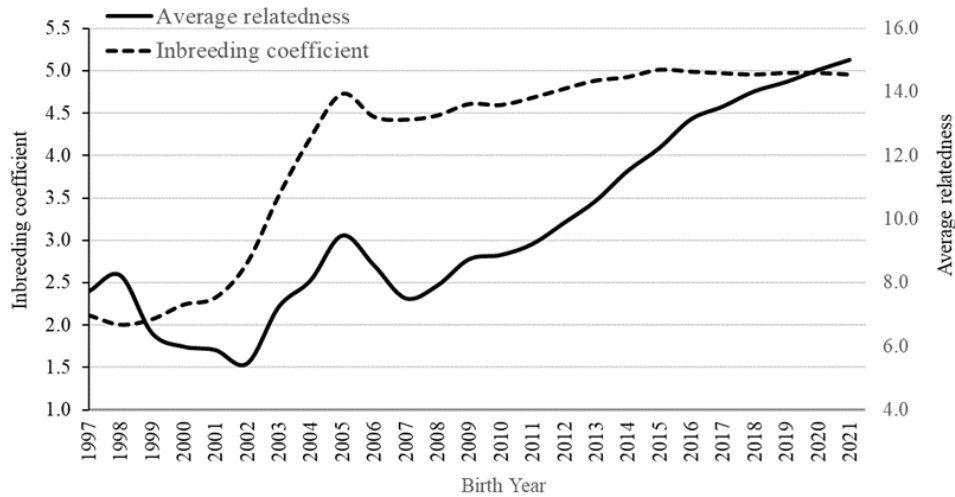


Figure 4. Level of inbreeding coefficient and average relatedness (in %) in the Slavonian-Syrmian Podolian cattle from 2000 to 2020

The number of founders in the SSPC was 48 while the effective number of founders was 9 or 18.75%. The effective number of ancestors was 8 or 17.39% of the total ancestors (46). The f_e/f_a ratio of 1.12 indicates a balanced use of breeding animals. Observed value of the f_e/f_a ratio in the population of Istrian cattle was lower (1.03; IVANKOVIĆ et al., 2022). BOICHARD et al. (1997) observe that f_e/f_a ratio close to 1 indicates lack of *bottlenecks* in the population.

The average generation interval was 6.34 ± 3.12 years and ranged from 5.84 ± 3.43 (sire-son) to 6.76 ± 2.98 (dam-son), with a longer average generation interval for dams than for sires (Table 2). CAROLINO and GAMA (2008) observed mean generation intervals of 6.0 and 6.8 years for the sire and dam pathways, respectively, in the "Alentejana" cattle breed in Portugal. In the Mertolenga cattle breed, the generation interval was 6.4 years for the sires and 7.1 years for the dams (CAROLINO et al., 2020). In the Spanish local cattle breeds "Berrenda en Negro" and "Berrenda en Colorado" GI were 6.50 and 6.92 years, respectively (GONZÁLEZ-CANO et al., 2022). The estimates of the average age of the parents at the birth of their offspring were generally higher in the maternal pathway (7.32 ± 4.00 , dam - son ; 6.99 ± 3.86 , dam - daughter) compared to the paternal pathway (6.81 ± 3.19 , sire - son; 6.58 ± 2.98 , sire - daughter).

Table 2. Average age of parents at the birth of their offspring and generation interval (years) for the Slavonian Syrmian Podolian cattle

Pathway	Average age		Generation interval	
	n	Mean \pm SD	n	Mean \pm SD
Sire — son	830	6.81 \pm 3.186 ^a	28	5.84 \pm 3.427
Sire — daughter	900	6.58 \pm 2.981 ^A	363	6.05 \pm 2.545 ^a
Dam — son	869	7.32 \pm 3.999 ^{B,b}	29	6.76 \pm 2.979
Dam — daughter	938	6.99 \pm 3.865	382	6.63 \pm 3.551 ^b
Overall	3537	6.92 \pm 3.549	802	6.34 \pm 3.118

a, A, b, B - different superscript letters in the columns show significant differences (lowercase letters $p < 0.05$; capitals $p < 0.01$)

Considering all the pathways, the average age of the parents at the birth of their offspring was equal to 6.92 ± 3.55 years. Significant differences were found in the generation interval on the 'sire – daughter vs. dam – daughter' ($p < 0.05$), and in the average age of parents at the birth of offspring on the pathways 'sire – son vs. dam – son' ($p < 0.05$) and 'sire – daughter vs. dam – son' ($p < 0.01$).

As for the number of animals, the trend of the population is positive, as well as the increase in the number of herds to 35 (in 2021) and the stabilization of the average size of herds to nine adult animals per farm. The sex ratio in the population (cows/bulls) is 17.1 : 1 and is slightly higher than in the population of Istrian cattle.

Conclusion and recommendation

The Slavonian-Syrmian Podolian cattle population is subject to a systematic conservation program. In the last decade, the level of inbreeding stagnated in the last five years. Although BOICHARD et al. (1997) indicated that the F trend has some limitations, especially when pedigree completeness is low, the observed level of inbreeding requires careful monitoring of the population. The f_e/f_a ratio in the population indicates that there is no obvious bottleneck in the population. We assume that this is a consequence of the higher proportion of natural matings in practice. The shallow depth, i.e., number of generations, of the SSPC pedigree is real, but all information on relationships among breeding animals is essential for optimizing conservation strategies. These results can be used as a guide for further implementation of effective conservation programs for endangered SSPC breed.

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