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Table of content

Full research articles

Review

The indicators of endangerment of local breeds – their informativeness

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Abstract

Local breeds of domestic animals represent a unique genetic resource that has a certain economic, sociological and cultural value. Local breeds in revitalization program are under constant surveillance, for which certain indicators to test the state of populations are used. In practice, numerical indicators are most often used, neglecting the importance of other, especially economic and sociological indicators. A multiple assessment of population indicators was done on the example of local breeds. Numerical indicators are fundamental tool for assessing the status of local breeds and are directly related to economic and sociological indicators. Indicators of genetic structure are also an indispensable part of a sustainable program for conservation (and use) of local breeds. Population indicators are more informative if they are considered in a time interval. Although some groups of indicators of the breeds seem to be more important, sustainable conservation programs for local breeds are based on the consideration and monitoring of all available indicators, as they serve to optimize conservation programs.

Keywords: local breeds, population indicators, trends, risks

Introduction

Conservation of farm animal genetic resources (*fAnGR*) is an integral part of national agricultural policy. An affirmative strategic approach in terms of preservation and affirmation of *fAnGR* is present in all European countries as an important determinant of the overall common agricultural policy. An active approach to the preservation of fAnGR in the Republic of Croatia has been present since the mid-1980s, after disappearance of some local breeds. Systematic protection measures have been initiated, especially for endangered local breeds. The results of inventarisation and characterization (*phenotypic, genetic*) of local breeds were the basis of public support for their preservation, promotion and inclusion in the life of rural areas. National program for the conservation of local breeds have been adopted, a central gene bank has been established, as well as systematic monitoring of the local breed populations. After the evaluation and promotion of local breeds, their importance is seen in a broader context (*not exclusively through the unit of animal product*). Local breeds have become an important component of rural life (*landscape management, preservation of rural identity, agritourism, traditional food products, biodiversity, etc.*). *In situ* and *ex situ* (*in vivo* and *in vitro*) conservation programs of local breeds, especially endangered one, are based on available resources, the interest of breeders and consumers, and the involvement of the local and wider community. Long-term sustainable breeding programs of local breeds require well-

designed programs of economic (re)affirmation, and only in the short-term it can be based on enthusiasm and a hobby-emotional approach. In doing so, it is desirable to respect the attitudes of the community and sensitize it, as well as consumer habits with an appropriate way of providing information about the breed, production systems and benefits of local breeds (*food products, the importance of biodiversity, etc*.). In the Republic of Croatia, the active conservation program includes twenty-eight local breeds of cattle, horses, donkeys, sheep, goats, pigs, poultry and bees (IVANKOVIĆ and RAMLJAK, 2017).

Preservation of local breeds requires a polyvalent approach that should take into account population, market, socioeconomic and other breed indicators, their trends and interactions. A long-term sustainable conservation program for local breeds cannot be built with a partial consideration of breed indicators. ALDERSON (2008) suggests that the definition of breed vulnerability should include numerical, geographical, and genetic criteria. CAPUT et al. (2010) emphasize the economic (market) criterion as a very important indicator of the sustainability of each breed. VERRIER et al. (2015) propose to focus on six criteria in assessing the endangered status of the breed, namely: number of breeding females, change in the number of breeding females in the past five years (*mammals*) or generation (*poultry*), effective population size, existence of breeding organizations and technical support, socio-economic context and the proportion of hybrids in the breed. In the national approach to evaluating the level of endangerment of local breeds, numerical population indicators are most often used, while other indicators are mainly neglected. The aim of this paper is to present a polyvalent approach to use different indicators (number and sex structure of the population, genetic structure of the breed, structure of breeders, geographical distribution, and socio-market competitiveness) in Croatia. This approach can serve as a guide in future monitoring of the local breeds.

Material and methods

In the study were used population indicators of twenty-seven local breeds in the Republic of Croatia available in official reports (CAA - Croatian Agricultural Agency; BC - Busha; IC - Istrian cattle; SSP - Slavonian Syrmian Podolian cattle; LIP - Lipizzan; CCH - Croatian Coldblood horse; CPH - Croatian Posavina horse; MH - Murinsulaner horse; LDD - Littoral Dinaric donkey; ID - Istrian donkey; NAD - North Adriatic donkey; PIS - Pag Island sheep; KIS - Krk Island sheep; LS - Licka sheep; DRS - Dubovacka Ruda sheep; RIS - Rab Island sheep; DP - Dalmatian Pramenka; IS - Istrian sheep; CIS- Cres Island sheep; TS - Tzigai sheep; CWG - Croatian white goat; CSG - Croatian spotted goat; IG - Istrian goat; BSP - Black Slavonian pig; TP - Turopolje pig; BSPP - Banija Spotted pig, CH - Croatian hen; ZT - Zagorje turkey). Population indicators were used to calculate the indices and associated trends of the studied local breeds.

Sex ratio was calculated based on the number of reproductively active breeding animals. The average herd size was calculated based on the total number of breeders and the total number of reproductively active individuals. The geographical distribution of breeds is expressed by the number of geographical administrative regions (there are a total of 21 administrative regions in the Republic of Croatia) in which there are five or more reproductively active individuals of a certain breed. The index "breeding organizations and institutional support" was calculated based on the indexation (0.65, 0.35) of reference data: a) breeding associations (established independent breeding association that performs breeding and protection of the breed / established independent breeding association that entrusts breeding activities to "professional services" / there is no breeding association), b) institutional supports (local, regional, national). In the calculation of the economic index of the breed, the following indicators were evaluated (from 0 to 1): a) activity / market visibility, b) number of products

offered on the market, c) degree of product finalization, d) market value / product price, e) marketing activity, f) consumer interest (indexation value for a) to f) as follows: 0.15, 0.20, 0.15, 0.15, 0.15, 0.20). In the calculation of the sociological index of breeds, the following indicators were assessed (from 0 to 1): a) familiarity of the local community with the breed, b) interest of the local community in preserving the breed, c) involvement of the local breed in local events, d) recognition of local breed values (indexation value for a) to d) as follows: 0.25, 0.25, 0.25, 0.25).

Results and discussion

Numerical population indicators provide a basic insight into the biological condition of local populations and are indispensable in their evaluation. An example of numerical population indicators can be seen in Table 1. Although important measures have been taken over the past

Table 1. Numerical indicators of the state of local breed populations in Croatia for 2018 (CAA, 2019; * estimated)

	Breeds	Size of population	No. adult animals	Breeding male	[(a)]Breeding female (a)	[(b)]Effective pop. size	Sex ratio ♀ : ♂
Cattle	BC	*2100	1423	114	1309	419.47	*11.48*
	IC	*1400	969	50	919	189.68	*18.38*
	SSP	*320	240	13	227	49.18	*17.46*
Horse	LIP	2112	687	88	599	306.91	*6.81*
	CCH	7052	3034	296	2738	1068.49	*9.25*
	CPH	5085	2338	138	2200	519.42	*15.94*
	MH	37	19	1	18	3.79	*18.00*
Donkey	LDD	2439	982	264	718	772.11	*2.72*
	ID	600	239	44	195	143.60	*4.43*
	NAD	106	52	10	42	32.31	*4.20*
Sheep	PIS	*30000	4415	123	4292	478.29	*34.89*
	KIS	*18000	458	14	444	54.29	*31.71*
	LS	*30000	10249	450	9799	1720.97	*21.78*
	DRS	897	745	47	698	176.14	*14.85*
	RIS	*8500	685	44	641	164.69	*14.57*
	DP	280000*	10032	318	9714	1231.68	*30.55*
	IS	1484	1168	86	1082	318.67	*12.58*
	CIS	*15000	929	44	885	167.66	*20.11*
	TS	1325	1029	23	1006	89.94	*43.74*
Goat	CWG	*5000	213	15	198	55.77	*13.20*
	CSG	*25000	1524	92	1432	345.78	*15.57*
	IG	*50	37	4	33	14.27	*8.25*
Pig	BSP	2463	2463	201	2262	738.39	*11.25*
	TP	170	170	22	148	76.61	*6.73*
	BSPP	124	124	28	96	86.71	*3.43*
Polutry	CH	4878	4878	459	4419	1663.24	*9.63*
	ZT	*1990	*1990	*220	1770	782.71	*18.09*

three decades to stabilize the existing populations of local breeds, it is evident that some breeds are still in critical vulnerability (SSP, NAD, MH, DRS, IG, TP, BSPP; Table 1).

Numerical indicators, if viewed in a time interval, indicate certain trends. Table 2 shows the number of some local breeds in the period 2001-2018.

Table 2. Number of breeding individuals of local breeds in the Republic of Croatia (CAA, 2002 -2019)

Breed	2001	2003	2005	2007	2009	2011	2013	2015	2018
BC		8	116	141	221	341	507	758	1423
IC	211	325	368	437	531	663	761	834	969
SSP	38	50	68	102	134	154	184	195	240
MH	31	29	25	21	28	41	51	34	34
DRS	157	178	231	305	450	602	665	627	745
IS	1233	1457	1982	1885	1829	1865	2332	1427	1168
BSP	263	408	685	669	716	1005	959	1496	2463
TP	50	105	143	193	156	159	153	162	170
ZT	1118	2013	1940	2151	2501	2860	2958	1809	1770

Since numerical indicators alone do not provide a complete answer to the causes that determine the effectiveness of local breed protection programs, it is necessary to consider geographical, economic, and social indicators (Table 3; ALDERSON, 2008; CAPUT et al., 2010; VERRIER et al., 2015).

The number of breeders and the size of the herd is one of the basic preconditions for sustainable programs of using local breeds. In Table 3 different relations of herd size within the species can be noticed, which is caused by the geographical position but also by the way of their utilization. For example, the average herd size of Lika sheep is significantly higher than Pag sheep because Lika sheep are raised in a geographically less congested area and mainly for meat, while Pag sheep are raised on a geographically limited island primarily and for milk production. Indicators of the geographical distribution of local breeds (Table 3) are related to the economic efficiency of the breeds. Economically more vital breeds are often spread to areas where they were not originally bred. For example, after the development of a program for the production of quality beef of Istrian cattle, its breeding has expanded to five more counties. However, the breeding of local breeds is mostly kept in the original breeding area in which, in addition to the economic price, the existential value of the breeds is also preserved. A particularly important indicator of the sustainability of local breed protection programs is the organization of breeders through the breeding association and their focused approach to social, social and economic issues. Sustainable (independent) breeding associations form the basis for the realization of economic programs, joint effective market performance, cooperation with scientific and professional institutions, etc. One of the weaknesses of the program for preserving local breeds is generally small number of independent breeding associations.

When the number of breeders is observed in the time period (Table 4), upward or downward trends are additionally observed. For example, there is an evident increase in the number of breeders of local cattle breeds, although at the same time the average herd size is not growing (BC ↑, IC ↑, SSP ↓).

Table 3. Socio-economic indicators of breeding of local breeds in the Republic of Croatia for 2018 (CAA, 2019; * estimated)

	Breeds	Number of breeders	∅ size of herd/flock	Geogr. distr. (no. of County)	Breeders association	Economic competitiveness	Social importance
Cattle	BC	141	10.09	13	0.750	0.400	0.663
	IC	146	6.64	8	0.838	0.960	0.938
	SSP	38	6.32	7	0.588	0.195	0.375
Horse	LIP	760	0.90	19	0.878	0.715	0.938
	CCH	1.110	2.73	21	0.913	0.380	0.738
	CPH	618	3.78	14	0.913	0.395	0.800
	MH	20	0.95	1	0.413	0.110	0.625
Donkey	LDD	740	1.33	20	0.250	0.420	0.763
	ID	148	1.61	8	0.500	0.595	0.850
	NAD	39	1.33	3	0.150	0.100	0.300
Sheep	PIS	51	86.57	1	0.500	0.970	1.000
	KIS	5	91.60	1	0.413	0.505	0.500
	LS	52	197.10	6	0.500	0.785	0.688
	DRS	26	28.65	2	0.500	0.310	0.625
	RIS	22	31.14	1	0.413	0.440	0.500
	DP	105	95.54	3	0.500	0.735	0.875
	IS	17	68.71	2	0.500	0.755	0.938
	CIS	9	103.22	1	0.413	0.455	0.563
	TS	12	85.75	4	0.500	0.615	0.625
Goat	CWG	8	26.63	2	0.413	0.495	0.438
	CSG	21	72.57	5	0.413	0.440	0.438
	IG	4	9.25	1	0.500	0.155	0.750
Pig	BSP	261	9.44	11	0.663	0.835	0.938
	TP	18	9.44	3	0.663	0.275	0.813
	BSPP	20	6.20	1	0.500	0.460	0.500
Poultry	CH	192	25.41	19	0.588	0.790	0.688
	ZT	110	16.09	9	0.750	0.935	0.938

In terms of preserving the genetic material of local breeds, indicators of genetic structure are very important (number of male and female lines, inbreeding level, genetic diversity within the population, etc.). The depth and completeness of the pedigree are the basic breeding preconditions of modern breeding-conversational work.

Table 4 Number of local breeds breeders and average herd size from 2001 to 2018 (CAA, 2002 -2019)

	Number of registered breeders					Breeding individuals/breeder				
Breed	2001	2005	2009	2013	2018	2001	2005	2009	2013	2018
BC		32	48	81	141		3.56	4.60	6.26	10.09
IC	76	103	131	167	146	2.78	3.57	4.05	4.56	6.64
SSP	1	3	10	15	38	38.00	9.67	13.40	12.27	6.32
MH			20	33	20			1.40	1.55	0.95
DRS	18	17	27	32	26	8.72	13.59	16.67	20.78	28.65
IS	20	33	39	35	17	68.15	60.06	46.90	66.63	68.71
BSP	26			113	261				8.49	9.44
TP	5			15	18				10.20	9.44
ZT	274	207	224	156	110	4.08	9.28	11.17	18.96	16.09

Conclusion and recommendation

Comprehensive conservation programs of local breeds contain a breeding, economic and social component. Namely, the breeding component without economic and social policy is unsustainable for a long time period. Therefore, in monitoring the status of endangered breeds, all population indicators (breeding, economic, social) should be considered in order for the conservation program of local breeds to be balanced and sustainable. Breeders, the economy and the whole community have achieved the benefit of breeding local breeds (as well as the responsibility for its preservation).

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Inbreeding of the Hungarian Simmental population

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Abstract

The aim of the current research were the analysis of the inbreeding of Hungarian Simmental population and to discover the possible relationships between inbreeding and standard lactation yield, total lactation yield, number of milking days and persistence.
Inbreeding was used in conjunction with selection to increase uniformity in breeds of cattle. The inbreeding although a useful tool to improve populations, but usually leads to economic losses. One of the consequences of inbreeding is inbreeding depression, the reduction of the mean phenotypic value, mainly for characters connected with reproductive capacity or fitness. The used database contained the performance of 11476 cows, born after 1997. Their pedigree data contained 26190 animals.
Based on our results, the inbreeding was negligible in this population, because the average inbreeding was only 0.5% and the inbreeding coefficient of 48 animals was higher than 10%. The estimate of the inbreeding of cattle born after 1997 showed 0.01% annual increase in the average inbreeding coefficient. Based on our analysis of significant effect of some factors on standard lactation milk and number of milking days, 1% increase in the inbreeding resulted 14.6 kg decrease in standard lactation yield and 1.1 increase in the number of milking days.

Keywords: Hungarian Simmental cow, inbreeding, milk yield

Introduction

Inbreeding was used in conjunction with selection to increase uniformity in breeds of cattle (RHOAD, 1949). The inbreeding although a useful tool to improve populations, but usually leads to economic losses (BARCZAK et al., 2009). One of the consequences of inbreeding is inbreeding depression, the reduction of the mean phenotypic value, mainly for characters connected with reproductive capacity or fitness (MIGLIOR et al., 1992).
There are numerous previous studies, that inbreeding negatively affects milk production, fertility and survival. The effects of inbreeding on productive traits have been examined for dairy cattle. PARLAND et al. (2007) reported, 12.5% inbred had milk, fat, and protein yields decreased by 61.8, 5.3, and 1.2 kg, respectively; fat and protein concentrations reduced by 0.05 and 0.01%, respectively; and somatic cell scores increased by 0.03. Based on HERMAS et al. (1987) results, the impact of inbreeding on production traits were -23.8 kg of milk, -1.25 kg of fat, and 0.002% for fat percentage. Evaluated of the effect of inbreeding on reproductive traits, that inbreeding depressed reproductive performance. Age at first calving decreased 3.7

day per 1% increase in inbreeding. According to THOMPSON et al. (2000) lactation milk yield by inbreeding were 35 kg per percentage inbreeding level >0.01 but increased to 55 kg per percentage inbreeding level from 0.07 to 0.10. Somatic cell score was not influenced by inbreeding. Inbreeding had the greatest effect on production at ages <22 month and early in lactation. Based on MÁRKUS et al. (2013), lactation milk production decreased by 10.4 kg, open days and the lactation length increased by 0.8 and 0.6 days respectively by 1% increase of the inbreeding coefficient.

YOUNG-SEYKORA (1996) estimate of inbreeding for registered Holstein females. Based on their results, inbreeding was estimated at 0.5% for 1970, 0.3% for 1976, 1.6% for 1982, and 2.1% for 1990. HERMAS et al. (1987) explained the inbreeding ranged from 0 to 25.3% and averaged 4.1%. VON KROSIGH-LUSH (1956) reported, the inbreeding ranged from zero to 34% and averaged 7.4%.

The aim of this study were the analysis of the inbreeding of Hungarian Simmental population and to discover the possible relationships between inbreeding and standard lactation yield, total lactation yield, number of milking days and persistence.

Material and methods

The results were collected by the Association of Hungarian Simmental Breeder's. The filtered database contained the results of 11476 cows, born after 1997. Their pedigree data contained animals.

The pedigree data was analyzed with Pedigree Viewer software (KINGHORN, 1994). The annual changing of the inbreeding was estimated with SAS PROC REG (SAS Institute Inc., 2002).

The relationships between standard lactation yield, total lactation yield, number of milking days, persistence and inbreeding coefficient was also analyzed. The following model was used to evaluate the effects:

$$y_{ijkl} = Lactation_i + Herd_j + BirthYear_k + Sire_l + F_x + e_{ijkl},$$

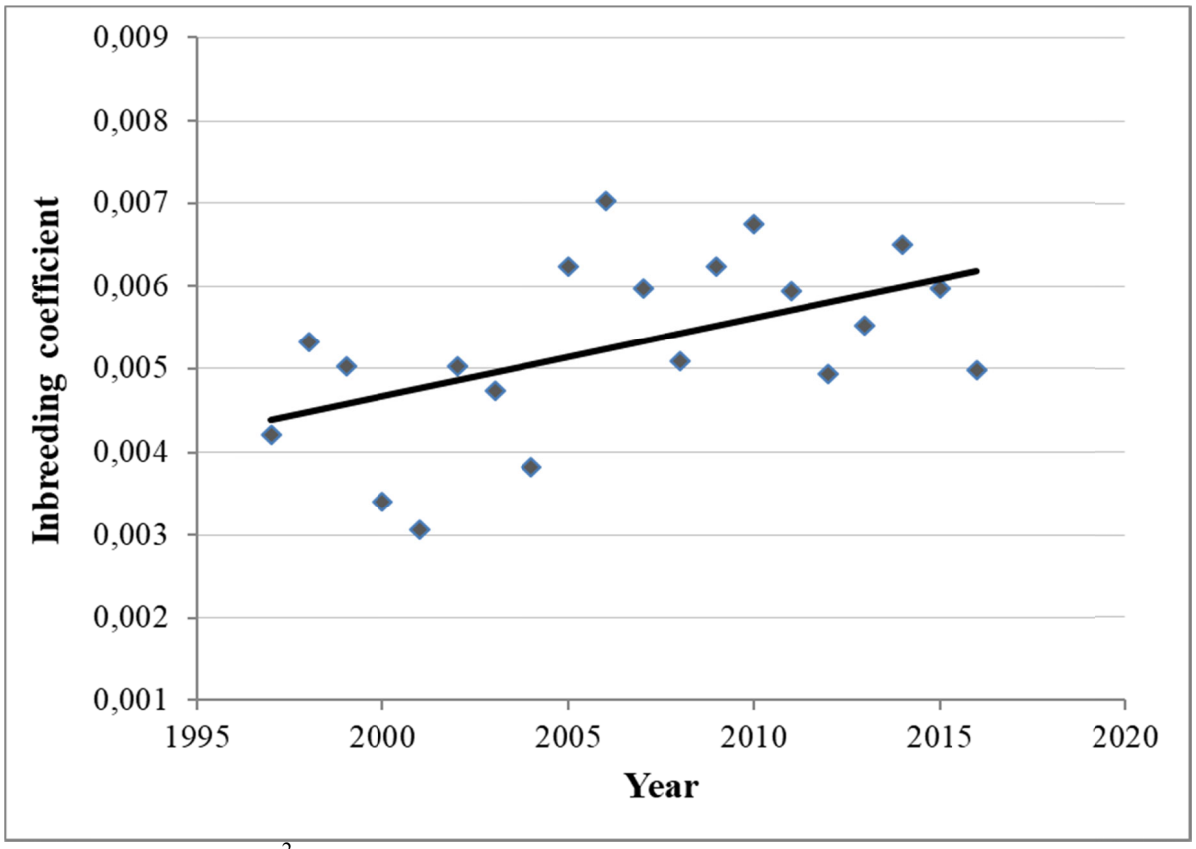
where:

- y_{ijkl} is the dependent variable (standard lactation yield, total lactation yield, number of milking days and persistence)
- fix effects - $Lactation_i$ the lactation number of cows, $Herd_i$ the herd of the cow, $BirthYear_k$ the birth year the cow
- random effect of the $Sire_l$
- F_x is the inbreeding coefficient as covariate
- e_{ijk} is the residual

The level of significance for each fixed effect was determined using SAS PROC GLM (SAS Institute Inc.,2002).

Results and discussion

In this population there were 7165 inbred animals. The inbreeding coefficient of 1628 cattle was higher than 1%. The inbreeding coefficient of 48 animals was higher than 10%. The highest inbreeding coefficient was 26.6%, but the average inbreeding was only 0.5%. The average inbreeding of the inbred animals was 1.1%. Our findings were lower compared to MARKUS et al. (2013) results for the Hungarian Holstein-Friesian population (the highest inbreeding was 37.5% and 95.4% of inbred animals had less than 5% inbreeding level). HERMAS et al. (1987) explained the average inbreeding of 4.1% for a Guernsey population which is also higher than our results.



$y=0.0001x - 0.1843$ $R^2=0.2655$

Figure 1. The annual changing of the inbreeding coefficient

The annual changing of the inbreeding coefficient is presented in *Figure 1*. The estimate of the inbreeding of cattle born after 1997 showed 0.01% annual increase in the average inbreeding coefficient ($y = 0.0001x - 0.1843$, $R^2 = 0.2655$). In contrast, according to MÁRKUS et al. (2013) the inbreeding coefficient increased by 0.1%.

Significant effects of some factors (lactation number, herd, birth year, sire, inbreeding level) on standard and total lactation yield, number of milking days and persistence are shown in *Table 1*.

Table 1. Significant effects of some factors on standard and total lactation milk, number of milking days and persistence

Factors	Lactation number	Herd	Birth year	Sire	Inbreeding coefficient	R^2
Standard lactation yield	***	***	***	***	*	0.39
Total lactation yield	***	***	***	***	n. s.	0.25
Number of milking days	***	***	***	***	**	0.08
Persistence	***	***	***	***	n. s.	0.14

n. s.: P>0,05 * P<0,05 ** P<0,01 *** P<0,001

It can be seen, that the lactation number, the herd, the birth year and the sire were significant effects on every trait. The inbreeding coefficient was significant impact on standard lactation yield and number of milking days (*Table 1*). Based on MÁRKUS et al. (2013) results, the effect of the inbreeding coefficient was estimated for the open days, lactation length and the 305 day lactation yield.

Based on our research, 1% increase in the inbreeding resulted 14.6 kg decrease in standard lactation yield and 1.1 increase in the number of milking days. In this topic there are some researches that were published in literature. MÁRKUS et al. (2013) reported, that the lactation yield decreased by 10.4 kg and the lactation length increased by 0.6 days respectively by 1% increase in Holstein-Friesian population. PARLAND et al. (2007) reported, 12.5% inbred had milk, fat, and protein yields decreased by 61.8, 5.3, and 1.2 kg, respectively. According to HERMAS et al. (1987) the impact of inbreeding on production traits were -23.8 kg of milk, and -1.25 kg of fat.

Conclusion and recommendation

The inbreeding was negligible in this population as the average inbreeding was 0.5% and the inbreeding coefficient of only 48 animals was higher than 10%.
The estimated inbreeding of cattle born after 1997 showed 0.01% annual increase in the average inbreeding coefficient.
The significant effect of some factors on standard lactation milk and number of milking days, 1% increase in the inbreeding resulted 14.6 kg decrease in standard lactation yield and 1.1 increase in the number of milking days.

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Comparative skull geometry of recently lived Hungarian Rackas

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Abstract

At the start of this research, an aim was to gather information that enabled to make comparisons between the Hungarian Racka that are alive today and their ancestors. The importance of this breed throughout history and its influence on Hungarian identity even today is undeniable. Foremost in our research was the magnificent and unique Racka horns and the associated skull parameters.
The data gathered and computed has documented both horn and skull measurements of 21 Hungarian Racka for the period of 1900 to 1960s. The control Merino sheep skulls present from the 1960s were used as a comparison for the skull measurements.
Interestingly, the majority of the skull measurements were similar for the Racka and Merino sheep. However, the Racka sheep skulls from the 1960s time frame had a greater breadth than those of the 1910s and Merinos from the 1960s. The Merinos also had a longer facial length than the Rackas.
Concerning the horn measurements there was little variation between the parameters from 1910 to 1960. In order to improve the strength and reliability of such measurements, it is important to gather more information on Racka skulls and horns. Measurements from a larger timescale incorporating samples from today and samples from before the 20th century if possible to allow to document any changes over a wider timeframe.
It is therefore vital that the conservation of Hungarian Racka breed continues and that genetic variability is maintained. Current and future data will reflect the impact of breeding selection on this breed and any changes to their distinctive horns.

Keywords: Hungarian Racka, craniometry, horncore

Introduction

Settlements in Hungary from as early as the 1st to the 4th century AD have evidence of sheep once being present. Graves are the main source of such evidence and remains of sheep with large horns, small horns and no horns at all have been discovered.
The name of the Racka sheep was given to breeds of sheep with similar shape and co-existence in Europe's Southern and Central regions. They are belonging to the large Zackel-sheep group and most probably have their origins in Middle Asia.

There are two colour varieties of the Hungarian Racka sheep (*Ovis aries strepsiceros hungaricus*) as named by Linneus – black or white. Sheep with a white fleece also have a tan coloured face and legs. The Hungarian Racka has uniform horns in V shape. The horns are also characteristically corkscrew in shape (DRAGANESCU, 2007 and 2013). However, that breed has been lived in other extinct variants in the past (GÁSPÁRDY, 2010).
Both males and females have horns, sometimes with the same animal having one normal horn and one signature corkscrew horn (RYDER, 1983). During Medieval time, the sheep in Hungary had horns with an open coil, similar to the Argali, the corkscrew horn reaching this area in the sixteenth century. The Racka was of great importance to the Hungarian people at that time. They were used for meat, milk and wool production (BARTOSIEWICZ, 2006).
During Medieval times in Europe, wool was more important than meat. The hairy coat of the Racka was particularly suited to making sleeveless woollen cloaks (*guba*) for shepherds. Lambskins were often used to make caps and collars. In the eighteenth century, Merino sheep were imported for their fleece characteristics and this influenced the lifestyle of both shepherd and sheep. It is said that the introduction of Merinos destroyed the old pastoral life and flocks become less nomadic and more attacked to large pastures (*puszta*).
Flocks of Hungrian Racka can now be found at the Hortobágy National Park and private farms and cared by hobby breeders (BODÓ, 1985).
The horn (*cornu*) of the sheep is comprised of three main parts. These are: the base (*basis cornus*), the body (*corpus cornus*) and the apex (*apex cornus*). The *os cornu*, which fuses to the frontal bone, provides the origin for the rigid cornual process. The cornual process also has a porous surface and is the skeletal component of the horn. The horn is covered by a heavily cornified layer of epidermis which forms the horn sheath. The horn sheath is composed of a hairless and glandless modification of the common integument (KÖNIG and LIEBICH, 2014).
The corneal processes usually project caudally and laterally from the skull. They vary in shape from rounded to spirally twisted (Racka) or curved (e.g. Merino). The diameter and length of the processes increase with age. In hornless breeds there may be a slight roughening of the bone where the corneal process would develop (MAY, 1970).

Investigations into the horn characteristics of the Hungarian Racka have been carried out in recent times. JAKAB (2010) found the horn length 8.2 and 6.5 cm for white and black Racka lambs at 45 days of age, respectively. While, it was similar (about 36.6 cm) for both colour variants at 3 years of age. He investigated the distance between horns for Hungarian Racka and Gyimesi Racka (or Turcana), and revealed that the difference was larger than 2.5 cm between the two breeds. Reason for that the Gyimesi Racka is carrying its broadly arched horn horizontally.
NAGY (2012) studied a group of 100 Racka sheep, consisting of 40 rams and 60 ewes. The average horn length of the black rams and ewes (42.25 cm and 27.50 cm respectively) was longer than those of the white rams and ewes (42.20 cm and 23.67 cm).
The black rams and ewes also had more twists per horn (3.5 and 2.92) than their white counterparts (3.35 and 2.8). In contrast, the angle between the horns was lager in the white rams (111.15˚) and ewes (67.20˚) with the black rams measuring 108.30˚ and the black ewes 64.80˚. According to this study, it is the black variety of the Racka breed that has longer horns with more twist per turn than the white Racka. However, it is the white Racka which has the largest angle between their horns.
GÁSPÁRDY (2011) painted a comprehensive, historical picture of the shape and development of the Zackel type sheep breeds' horn.

Generally the skull is referred to as two parts – the face and the cranium which are made up of the facial bones and the cranial bones respectively. The mandible and hyoid bones are usually included in the facial bones. The ethmoid and frontal bones do however form part of the nasal cavity and can be therefore considered partly bones of the face.
Paired bones of the skull can also be called flat bones because they have a thin but expanded form. All of the facial bones are paired bones. Paired bones develop from membranous material whereas unpaired bones develop from cartilage. An example of some unpaired bones includes the occipital, sphenoid and ethmoid bones.
In foetal and new-born animals, the position and individual shape of the skull bones can be seen. This early in life, the bones are loosely united with connective tissue or cartilage. As the animal grows and becomes older there is ossification of this soft tissue or cartilage. When it is completely ossified, growth is complete. These junction lines are called sutures and can be seen in the adult sheep skull (MAY, 1970).

The aim of this study is to investigate the relationship between skull and horn geometry of Hungarian Racka sheep. In this study we examine some important measurements of the skull and horn. We want to compare the skulls from the early 20th century with those from the 60s. Our aim is to focus on the skull measurements related to the horn conformation. We also want to evaluate the connection between the number of the horn core twists and the horn twists.

Material and method

The Museum of Hungarian Agriculture (Magyar Mezőgazdasági Múzeum) has its own unique zoological repository including an archaeological animal bone collection called Matolcsi (after János Matolcsi, director of museum 1957-68). This collection was started before World War One and this is where we conducted measurements on a number of Racka skulls.
The measurements were taken during May, 2014. We used a digital vernier calliper, to receive the exact size of the skulls. For the non-linear distances (for example horn circumference) we used tape-measure.
We used reference points from the Driesch's book "A Guide to the Measurement of Animal Bones from Archaeological Sites" (DRIESCH, 1976) as a guide when taking measurements of the different skulls.
On the course of our visits we took 80 measurements altogether. However, we are giving account in this paper about only those measurements of the skull, which are the most important from the aspect of the horn conformation.

We estimated the age on the basis of teeth development. The measurements were examined and analysed based on their relation to the age. At a certain point we could verify the relationship with the different ages. We defined the coefficient of determination to establish the connection between the age and the size.
The raw data was corrected to 4 years of age with linear regression equation, allowing a comparison of the skulls by sample sources irrespectively of age.
With the age-adjusted data we examined the influence of the different sources, where the skulls are originated from. We created two groups of skulls: one for the Racka skulls in the MATOLCSI Collection (denoted as Racka 1960-ies), and the second group was created by use of skull descriptions from more previous references (HITSCHMANN, 1913; GALAMBOS, 1928; denoted as Racka 1910-ies). Merino skulls in the Matolcsi Collection too (denoted as Merino 1960-ies) was considered as control group.

Since the Racka breed is known for its famous and unique twisted horns, we wanted to demonstrate the relationship between the twist of the horncore and its length, and the twist of corneous matter of the horns. In order to do this the number of twists was also counted (Figure 1). Linear regression analysis was performed to show the relationship between them (see more in LEDWITH, 2014).
All our research is based on female sheep. Analyses were performed by use of the Statistica program (StatSoft, 2013).

Figure 1. A skull to present the twist of horncore and horn

Results and discussion

Table 1 shows the results we got on the skull measurements. There were no remarkable deviations in them with except of the facial length, in which the Rackas were proven to have a shorter facial length – irrespectively of the period from which the skull was recovered – than the Merino.
On the contrary to this, in the case of the measurement "greatest breadth of the skull" the 1960s Merino and the 1910s Racka appeared to be identical and broader than Racka skulls from the 1960s.
The similarities seen in the Rackas' measurements from different eras seems reassuming and signals toward the uniformity of the breed – based at least on our samples – during the first half of the 20th century. Surprisingly, similarities were found to a large extent between the Rackas and the Merino. This result may be explainable by our limited sample number.

Table 1: Cranial measurements adjusted for 4 years of age, according to sources

Measurement (p-value)	Racka 1960-ies n=18		Merino 1960-ies n=6		Racka 1910-ies n=5	
	Mean	SD	Mean	SD	Mean	SD
profile length (0.678)	226.4	8.11	229.3	11.05	230.4	14.46
frontal length (0.413)	81.2	6.93	86.6	9.67	83.2	2.84
sutura coronalis-horns distance (0.302)	53.77	10.6	59.00	0.25	-	
facial length (0.032)	160.8[a]	6.78	175.4[b]	17.88	161.2[a]	13.26
greatest length of the nasals (0.207)	80.15	6.23	83.58	5.97	86.22	10.55
short lateral facial length (0.146)	132.5	5.8	138.97	3.02	135.2	11.18
greatest breadth across the premaxillae (0.798)	43.47	2.56	43.56	2.78	42.63	2.58
greatest breadth of the skull (0.020)	110.7[a]	4.1	116.3[b]	5.05	116.2[b]	6.87
least breadth between the orbits (0.423)	75.79	3.07	77.45	1.86	77.69	5.23
facial breadth (0.304)	70.66	3.34	73.29	4.71	69.78	5.57
neurocranium length (0.474)	118.9	7.02	124.3	2.08	119.9	7.56
greatest length of the lacrimal (0.671)	39.63	6.23	39.5	2.53	42.1	4.2
dental length (0.624)	67.88	11.7	73.5	5.67	67.64	9.23
greatest breadth of the foramen magnum (0.142)	19.73	1.88	22.16	1.54	20.29	2.13
nasion-horncore mean distance (0.490)	76.56	7.06	75.17	6.11	84.53	0.00
length of the mandible (0.355)	172.3	7.36	178.5	3.79	171.2	13.35

a, b – different superscript letters show significant difference ($p<0.05$)

Horn measurements are displayed in Table 2. As with the results of the skull measurements, there was similarity in horn measurements for Racka sheep living during the beginning and middle of the last century. A single statistically proven difference was observed in the trait "breadth between the medial borders of horncore bases". In this case however, a difference of 6 mm is probably not serious. Here we can suggest it could have been caused by measuring mistake since all the other horn parameters taken of the Rackas from the 1910 period and Rackas from the 1960 period were quite similar.

The very rare born polled males were excluded from the breeding program. With this selection the variability of the breed is narrowing, which is disadvantageous for the genetic preservation work. In study of Jakab (2010) it was also concluded that for the females the distance between the horns is decreasing with the age. In his up-to-date work the horn angularity adjusted for 3 years of age in females was 70-76˚, a result which is in agreement with our results based on the past.

Table 2: Horn related measurements adjusted for 4 years of age according to sources

Measurement (p-value)	Racka 1960-ies n=18		Racka 1910-ies n=4	
	Mean	SD	Mean	SD
breadth between the lateral borders of horncore bases (0.824)	82.57	4.50	82.04	1.47
breadth between the medial borders of horncore bases (0.045)	36.47[a]	4.26	30.06[b]	10.39
horncore basal circumference (0.517)	80.19	13.87	85.68	7.06
twist of the horncore (0.509)	0.73	0.22	0.62	0.17
length of the horncore (front) (0.848)	112.4	26.83	116.2	17.31
twist of the horn (0.387)	1.43	0.32	1.28	0.19
distance between horn tips (0.643)	380.1	62.89	364.7	28.67
horn length mean (0.803)	237.7	35.41	232.8	32.65
horn angularity (alpha-angle) (0.734)	75.96	5.07	74.96	5.65

a, b – different superscript letters show significant difference ($p<0.05$)

The Racka sheep of today have longer horns than those 50-60 years ago (Nagy, 2012). Other descriptions (MARSIGLI, 1726) prove that earlier in history horizontal horns were typical. It is the ambition of some breeders to bring back the horizontally horned Racka individuals, what there isn't against the breed standards for now.

In our next evaluation we searched for linkage among the twist of horncore and horn. Relationship between the twist of horncore and twist of horn is estimated with the following equation, according to which the number of horn twists is in direct proportion to the number of horncore twists, but its development is more intense:
actual twist of horn = 0.6522 + 1.1087*actual twist of horncore; $p = 0.0085$; $r^2 = 0.5164$.

The horn core dependant change in the number of twists is published in Figure 2. Association between the twist of horncore, twist of horn and the length of horncore is determined by the following formulas:
actual twist of the horncore = -1.2063 + 0.0142*actual length of corncore; $p = 0.0024$; $r^2 = 0.4688$, and
actual twist of horn = -0.0321 + 0.012*x; $p = 0.0105$; $r^2 = 0.3268$.

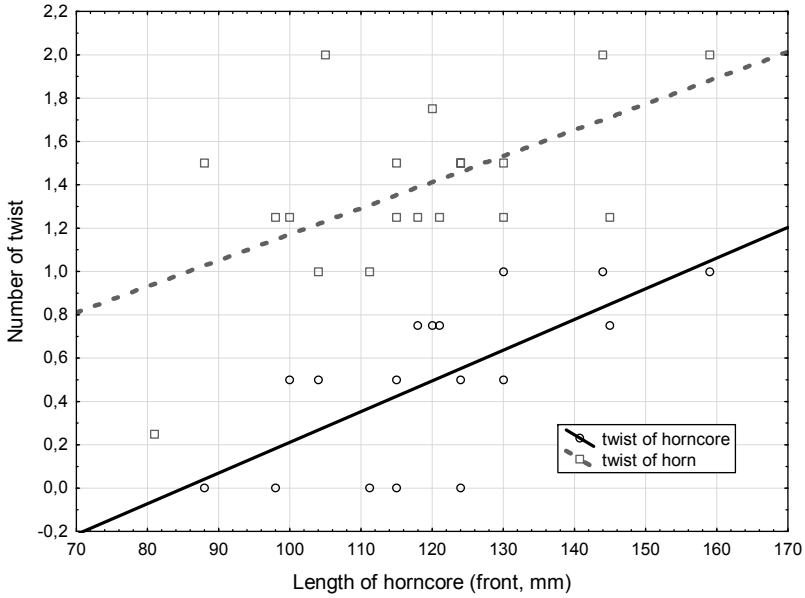

Figure 2. Association between the twist of horncore, twist of horn and the length of horncore

Conclusions and Recommendations

Today both the male and female Hungarian Racka population is horned. We think that this fact is meaningful, and the breeders have to be aware of this in the future. The horn angularity does not show change during the last century. Although in this respect figures from HANKÓ (1947) documented angles of 45-60˚.

Similarly to this, for the course of the first half of the 20th century, no proven alteration in our skull parameters were found. A current evaluation of the skull is highly recommended to reveal any more recent changes and to confirm that the appropriate conservation selection is being made in this breed. Furthermore we propose to integrate skull samples available from an earlier time, before the 20th century in order to make comparisons for a larger period of time. Here, we also want to emphasize a more modern evaluation method of the skull by use of two- or even three dimensional morphometric methods.

Sometimes, very interesting facts (like multiple horns, swept horn angle, feral or polled variants) were documented in the history of the Racka breed group.

In the archaeozoological findings there are often recovered only the horncore, but not the corneous matter of the full horn. It may be possible to presume the shape of the horn and the age of the animal based on the twist of the horn. Through excavations by the Budapest History Museum complete or partial skulls of sheep were discovered. The fragment shown in Figure 3 came from Buda Castle (excavation led by András Végh; finding is yet unpublished) and is dated to the 14-15th century. The identification of the breed could probably be carried out by use of anatomical or genetic comparative investigation.

Figure 3: A well turned horncore fragment
Photo courtesy of Márta Daróczi-Szabó

Regarding the breed history, we would like to call attention to the *in libro* concept of conservation (GÁSPÁRDY, 2011). A longer version of this technical term is *in libro conservatio in causa emoriendi*, namely the conscious preservation of the characteristics entered of an already extinct domestic animal species. The meaning of the *entered* (in a book; *booked*) conservation in a broader sense is the preservation of all the remaining knowledge, keepsake, documents and material inheritance of a still living rare breed. As a reason for the *in libro* conservation the same arguments can be presented as for the *in vivo* and *in vitro* ways of conservation. The keeping in life of an extinct breed does not crop up but the "keeping alive" its one-time presence in the common knowledge is an important role.

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Importance of added value products of Vlashko-Vitoroga sheep in the process of in situ conservation

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Abstract

Conservation and saving from extinction all the endangered autochthonous animal genetic resources are high priority worldwide. The Vlashko-Vitoroga sheep is one of the autochthonous, transboundary Zackel types, well adapted to the meadows and pastures of flatlands. As it cannot compete with the high productive breeds, there is a need for alternative opportunities for their sustainable production and conservation. The added value, traditional eco food production in a traditional and sustainable production system is one of the opportunities in the process of in situ conservation of the breed. The chemical analysis of milk of Vlashko-Vitoroga sheep showed favourable composition and it is suitable for production of traditional sheep cheeses and yoghurt. The status of Vlashko-Vitoroga sheep and quality of traditional products based on management of the local resources lead to improved sustainability. The breed is also precious resources of local landscape enrichment at the high nature value Deliblato Sands region.

Keywords: autochthonous, Zackel breed, Vlashko-Vitoroga type, racka, sustainable, milk

Introduction

The modern biotechnological concept of livestock farming system (LFS) has a multidisciplinary approach and is based on a synergy between the livestock production and ecosystem, with special attention on biodiversity and its conservation (RUBINO et al., 2006). Deliblato Sands, or the so called European Sahara, is the largest European continental sandy terrain ecosystem, located in the south-eastern part of the Pannonian Plain, in the north-eastern part of the Republic of Serbia, in the Vojvodina Province. The Deliblato Sand Special Natural Reserve is on the Tentative list of the World Heritage List of the UNESCO from 2002. The area covers a 35000 ha region and it was formed in the Ice Age from the vast layers of silica-carbon sand. Nowadays the local eastern wind, called "Košava", is modelling the

dune relief of the area, which varies between 70 and 200 meters above the sea level (SEDLAK 2019, IVAJNŠIĆ and DEVETAK, 2020). The unique mosaic of ecosystem has a rich biodiversity of flora and fauna in this special area called Deliblaticum. The Deliblato Sand is a protected area which has a high nature value. Among a lot of protected wild animals and rare livestock breeds, it is well known about the presence of the endangered Vlashko-Vitoroga sheep, which enriches the local landscape. The Vlashko-Vitoroga sheep, also called the Racka, "Vlaška žuja" or "Vitoroga žuja", is a transboundary Zackel type, mainly reared in Hungary, Romania and Serbia. As Gáspárdy discusses, The "Racka Sheep" is a collective term, which refers to the breeds with similar shape and horns and co-existence in Southern and Central regions of Europe (GÁSPÁRDY, 2010). In Serbia, the Vlashko-Vitoroga is the only locally adapted, autochthonous Zackel type, which is adapted to the Vojvodina flatlands. According to the FAO DAD IS database it has an endangered maintained risk status in Serbia, with around 850 breeding animals. The breed has an increasing population tendency and for the last five years the population size doubled. In the breed was near to extinction 2005 in Serbia, with only 3 breading rams and less than 50 breeding ewes. At the transboundary breed risk level it has a stabile status, because the population size is bigger, in Hungary around 10.000 breeding animals (FAO DAD IS, 2020). The triple purpose Vlashko-Vitoroga sheep has white, wavy, long coarse wool. They are hardy animals, resistant in the extensive pastured systems with a good health. It belongs to the middle format Zackel types, with the average withers height of 64 cm and body length of 69 cm in ewes. The rams weight around 40 kg, while the ewes are approximately 35 kg. In better management systems and selection, the body format is bigger ant the rams can weight 60 kg. The fleece length can reach 30 cm (MASON, 1988; SAVIĆ et al., 2013; PIHLER et al., 2019). In Serbia, predominant is a type with yellow face, while in Romania and Hungary the black variant is also popular. The type is well known about the robust, V shaped, corkscrewed, long horns which are present in both sexes. It is one of the milking types among the Zackel sheep. Traditionally, in the Banat, the sheep were milking for 6 months. The literature data on average milking performance vary between 80 and 125 kg (SAVIĆ et al., 2013, FAO DAD IS, 2020). The meat quality is good with favourable fatty acid composition (SAVIĆ et al., 2014). In the Banat region it is usually reared in semi-intensive management systems, which includes additional grain feeding, besides the traditional grazing on the local pastures, meadows and agricultural land after the cereal harvesting. As the type was always known about its milking potential and good characteristics of cheese and yoghurt, the aim of this study was to elaborate some of the milk chemical composition parameters and enlighten the possibilities and promotion of added value product of the endangered breed, which can support the in situ conservation process and the survival of the Vlashko-Vitoroga sheep in the traditional, high nature value habitat.

Material and Methods

Two flocks of Vlashko-Vitoroga sheep were included in the study. At the period of milk samplings – mid lactation (April) – the sheep were not feed additionally, only grazed on the meadows of the Deliblato Sands. Both of the flocks were hand milked twice a day, in the morning and in the evening. After the morning milking, representative samples were collected in plastic tubes and were transported in a cooler to the laboratory, where the analysis of chemical composition was done. In total, the chemical composition of 18 bulk sheep milk samples was analysed. The chemical parameters were estimated using the MilkoScan spectrophotometer device (Foss Electric) in accordance with the manufacturer instructions. The content of total solids, solids non-fat, fat, protein and lactose were analysed. The extraction of milk fat, for detecting the fatty acids, was done using the Rose Goltib method,

and the separated fat was frozen at -18ºC. For detection of the selected fatty acids a gas chromatography method was applied, using the Shimadzu chromatograph (17A Shimadzu, Kyoto, Japan). Statistical processing of the data was done using the GraphPrism Softwer.

Results and Discussion

Analysing the principles of the European high nature value farming system, reviewed by BALDOCK (1999) and ANDERSON et al. (2003), also the LFS principles defined by FAO and RUBINO et al. (2006) it can be concluded that it is applicable for the Deliblato Sand region, which is also declared as a zone of high nature value, composed of unique bio ecosystems with rich biodiversity of flora and fauna.

The results of the chemical composition of milk samples of the Vlashko-Vitoroga sheep are presented in the Table 1. As it is presented the raw milk of the tested flocks has high total dry matter content, almost 18%. The present study showed that the milk components are favourable, with almost 7% of milk fat and over 5% of proteins.

Table 1. Chemical composition of the raw bulk milk samples of the Vlashko-Vitoroga sheep

Sheep milk composition (%)	X±SD	IV	CV
Fat	6.73±1.31	4.55-8.76	18.71
Protein	5.44±0.37	5.11-6.25	7.10
Lactose	4.42±0.16	4.21-4.68	4.56
Total solids	17.98±1.46	15.39-20.48	14.98
Solids non fat	10.88±0.32	10.59-11.62	7.30

All the mentioned characteristics ensure a good raw material for preparing traditional sheep milk product.

The content of some fatty acids of milk of the Vlashko-Vitoroga sheep is presented in the Table 2. In the last decades there are efforts made to produce a healty food. It is well documented that favourable fatty acid composition of the food has a benefit for human health (RAMIREZ-REMATA et al., 2014). The quality of the animal products is multifactorial influenced, where feedstuff, such as the botanical composition of the natural meadows and grasslands, has great impact (BECSKEI et al., 2017). As the results showed, the samples had high content of capronic and caprylic acid, which are the main factors of the specific flavour of the milk and traditional milk products, reaching 3.3g and 5.3g/100g of milk fat.

Table 2. Content of some fatty acids of the raw bulk milk samples of the Vlashko-Vitoroga sheep

Fatty acids	M±SD
C 4:0	1.86±0.18
C 6:0	3.31±0.25
C 8:0	5.37±0.33
C 14:0	9.04±0.43
C 16:0	21.71±2.23
C 18:0	10.91±2.13
C 18:1	31.13±2.54
C 18:2	4.47±0.27
C 18:3	1.51±0.22

According to GRDOVIĆ et al. (2012), the botanical composition of the region, where the Vlashko-Vitoroga is reared, is very rich and diverse. One of the most important factors affecting sheep production and the quality of meat and milk is the composition of the feed. The detailed botanical analysis and chemical composition of the tested forage and mixed hay samples showed that the presence of grass species of high nutritional value were dominated on the grasslands of the Deliblato Sands region (GRDOVIĆ et al., 2012). Chemical analyses of samples from the pastures pointed out that the levels of crude proteins, cellulose, fats, macro and micro elements are sufficient to satisfy the requirements of low input sheep farming system and therefore can be considered a solid base for reintroduction of autochthonous sheep breeds in the peripheral parts of the Deliblato Sands area, and can ensure a good quality of animal products (GRDOVIĆ et al., 2012).
Just like cheese, yoghurt made of sheep milk is a traditional milk product of Vojvodina. In the past centuries, every rural household having sheep was making its own yoghurt and chees. As the milk of the Vlashko-Vitoroga has favourable composition, it is a good opportunity to promote the production of cheese and yoghurt, as a local traditional eco-product from sustainable pasturing at the Deliblato region. In comparison with some other Zackel types in the region, such as Bardoka, Zetska, Pivska, Sjenica and Lipe, it can be concluded that the Vlashko-Vitoroga sheep has a better potential from milk production. From the listed Zackel types, only the Lipe sheep was found to have higher milk yield (ADŽIĆ et al., 2003, BECSKEI et al, 2018). The Vlashko-Vitoroga has a good average milk yield which reaches 125 kg per lactation (FAO DAD IS, 2020). Even though some of the milk components detected in this study were not as high as the literature reports for some other Zackel types, the raw milk of the Vlashko-Vitoroga sheep is suitable for traditional cheese and yoghurt production. Also, it should be take into account that the milk samplings were done using the morning milk samples in the mid lactation, in April, when the milk solid material content does not reaches the highest values yet (FAO, 1985). The favourable fatty acid composition could make an additional promotion and positively influence the added value branding of the products and the sustainability of the Vlashko-Vitoroga sheep.

Conclusion and Recommendations

The status of Vlashko-Vitoroga sheep and quality of its traditional products based on management of the local resources lead to improved sustainability. The rural tourism is expanding throughout in Europe, as well as in Serbia. The further steps in branding the regional eco food (cheese and yoghurt) with labelled added value could be an opportunity and valuable support of the *in situ* conservation process and promotion of the Vlashko-Vitoroga sheep. It has attractive exterior with long wavy fleece of wool, yellow head with massive spiral horns in both sexes, which makes it an important, traditional pastoral landscape enrichment of the UNESCO evidenced, high nature value, Special Natural Reserve Deliblato Sands, which enriches the region for centuries.

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Effect of spring stimulating feeding on the population shift of honeybee *(Apis mellifera L.)* colonies depending on the age of queen bees in Hungary

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Abstract

The effect of spring stimulating feeding on population shift and development of honey bee, *Apis mellifera* L. (Hymentoptera: Apidae), colonies were examined in a 2-year study (2016-2017). An apiary trial was conducted in Nyírmada, Szabolcs-Szatmár-Bereg County, Hungary. The monitoring covered the number of brood-frames of honeybee colonies with different age queen bees in both years. The spring development study included 59 colonies in the first test year and 58 colonies in the second test year. The data were recorded seven times in both years. Data on number of brood frames were subjected to one-way analysis of variance and the Tukey-test was used to compare means as post-hoc test. During the evaluation of our results we experienced that in the time of population shift all three queen-years were different in both years. This trend was also typical on 19th May 2017, when the honey collection from black locust influenced the brood areas. The significant difference during honey collection from black locust can be helpful in determining the proper time of queen change. The premature population shift was experienced on 17th April in 2017, which may have been caused by spring incentive feeding. The population shift was detected on 1st May in 2016, when the spring feeding was only a half a kilogram of pie. The effects of incentive feeding were reflected in the spring development of colonies.

Keywords: *Apis mellifera* L., number of brood frames, demographic development, age of queen bee, population shift

Introduction

At the end of winter, when the daytime temperature rises, the queens started laying eggs in the honey bee colonies. Egg laying typically begins at the end of February (ÖRÖSI, 1957; ROBERTS and STANGER, 1969), but at this time only scattered, sporadic eggs can be found. Day-to-day ovulation is only between 20 to 50 eggs (DEÁK, 2018). The accurate assessment of performance of queen bees cannot be determined by these conditions - therefore the first data were collected during the second spring survey. Several methods are known for determining the colony development of honeybee colonies (ROBERTS and STANGER, 1969; JOHANSSON and JOHANSSON, 1973). According to ZSIDEI (1990) the

number of frames with brood areas was counted at the second half of March, when the external temperature had reached 15-18°C. As a result of too early intervention, the brood was cold. The larvae had become dark and the wall and the cover of honeycombs were dented or punctured (ÖRÖSI, 1957). In judging colony growth of colonies, we have to consider the age of queen bees. In Hungarian beekeeping practice, the queens are changed after two years of age. The performance of a queen changes over time. While the one year-old queens provide 70% of their genetically-possible capacity, in the second year this value can reach 100 % and if they remain alive, this high value show decreasing tendency year after year of some 10-15% (DEÁK, 2018).

Presently, the rate of acceptance of queen bees has declined, due mainly to the appearance of the Italian honey bee (*Apis mellifera ligustica*) in Hungary. The Italian honey bee worldwide was a popular variety of honey bee (*Apis mellifera* L.), due to their excellent adaptability to different climate conditions and their ability to accumulate large amounts of honey. For all these reasons, *Apis mellifera ligustica* is often exported worldwide. In the regions where honeybees already had an established local subspecies, the appearance of the Italian bee led to a reduction in genetic clarity (DE LA RÚA et al., 1998; GARNERY et al., 1998 ab). The protection of the local, state-approved subspecies and the maintenance of their original genetic structure are of great concern in many countries (GARNERY et al., 1998 ab).

For these reasons, the performance of queens of different ages was examined. If the performance of three year-old queen bees approached the younger queen bee's capacity at the time of population shift or honey harvest, the replacement of queens is not deemed necessary in a given year.

Materials and methods

The beekeeping site was not the identical in the two examined years. In 2016, a black locust forest secured the site, while in 2017 the measurements were carried out in a closed garden, in Szabolcs-Szatmár-Bereg County, Nyírmada, Hungary.

During the first spring control the number of brood frames data recording started in the middle of March. The study of the spring colony development of the colonies was carried out by monitoring the number of brood frames (NEUMANN and MORITZ, 2000) (Number of brood frames/Middle-Boczonádi brood chamber). Of the 10 frames (frame size: 42x29 cm) of the brood chamber, the number of frames with contiguous brood area was recorded for each hive. The spring-growth study covered the examination of number of brood frames in 21 colonies with three-year-old, 22 with two-year-old and 16 with one-year-old queens in the spring of 2016, and 18 colonies with three-year-old, 20 with two-year-old, 20 with one-year-old queens in the spring of 2017. The data were recorded seven times between 18th March and 1st May in 2016 and 16th March and 19th May in 2017. HARBO (1988) also examined the colony growth in a similar time range (15th March – 13th May).

Foraging by bees is susceptible to environmental variation (NUNEZ, 1982; SEELYES and TOWNE, 1992), but there is a lack of pollen and nectar, the spring colony growth of honeybee colonies diminishes. In 2016, one portion antibiotic-free pie was allocated in the hives (3rd March), because the spring wild-flowering bee pastures were ensured by undergrowth of the black locust forest. The copious spring stimulation of the honeybee colonies was justified in 2017 by the poor ecological conditions of the new beekeeping site, where the pollen and water, which were required for nourishing a brood, was limited. During spring stimulation of honeybee colonies, two antibiotics-free pies were placed in the hives. The pie was prepared using 10 kg of powdered sugar and 2.7 kg of syrup containing 15% inactivated barm. The use of the syrup became necessary because we did not have access to honey from our own beekeeping and we did not wish to risk using other honey from

extraneous beekeeping due to the risk of American foulbrood (*Paenibacillus larvae*). According to FRIES and NORDSTÖRM (2001), the infection level was detected from honey samples without disease symptoms. For the first time (1st March 2017), the 12.7 kg sugar the pie was divided into 20 divisions into 20 colonies and during the second allocation divided into 10 hives divided into 10 parts (21st March 2017).

The protection against *Nosema apis* and *Nosema ceranae* was carried out with Nosevit (oak bark extract), which were applied at 1 ml/honeybee colony dose by a liquate procedure on the seams. During the application in the pie, uniform dispersion cannot be ensured, so even all members of the honeybee colonies come in contact with it. Furthermore, there is a risk that the pie was not carried by the bees. During the spring feeding the bee colonies were stimulated four times using 1:1 proportion sugar syrup in 2017.

In case of a lack of adequate drinking water, a temperate water drinker was placed front of the hives, the water of which was enriched by zeolite-preparation. Moss was planted in the drinking tray, which was justified by the fact that bees prefer natural source of water.

The concentration and volume of sugar syrups are decisive in each period: for spring stimulation it is suggested to be 1: 1, while in autumn or winter it is recommended to apply 5-10 litres per week (SOMERVILLE, 2000). In the absence of adequate drinking water, temperate water (drinker) was placed. The drip faucet is equipped with a drinking tip. Standing drinking water can be a source of illness (*Nosema sp*.).

Statistical analysis of the data was carried out using a one-way analysis of variance (ANOVA) with Tukey's post hoc test using the IBM SPSS (version 22) statistical package. Seven measurements were implemented and presented the data as mean ± standard deviation (SD).

Results and Discussion

During the evaulation of our results we found that on 18th March the number of brood frames did not show any significant difference between the groups. At this time, in the colonies with the youngest queen bees the number of brood frames was an average of 2.1±0.2 (n=16), while in the colonies with three-year-old queen bees, this value was 1.6±0.2 (n=21).

There was significant difference between each of the three groups (colonies of one, -two and three yera old queens) from 25th March to 17th April and on 1st May in 2016. The time of population shift was detected on 1st May. The last monitoring would have been middle of May, but on 8th May, the livestock perished.

Table 1. Number of brood frames during the colony-development study in spring of 2016 year

Year of Queen Bee	18th March	25th March	1st April	8th April	17th April	25th April	1st May
2013 n= 21	1.6^{a}±0.2	1.9^{a}±0.2	2.4^{a}±0.2	3.6^{a}±0.1	4.5^{a}±0.1	5.5^{a}±0.2	6.9^{a}±0.2
2014 n= 22	1.9^{a}±0.1	2.6^{b}±0.1	3.5^{b}±0.1	4.3^{b}±0.1	5.5^{b}±0.2	6.9^{b}±0.2	7.7^{b}±0.1
2015 n= 16	2.1^{a}±0.2	3.1^{c}±0.2	4.2^{c}±0.2	5.1^{c}±0.3	6.4^{c}±0.2	7.4^{b}±0.2	8.6^{c}±0.2

$^{a-c}$: group means with similar letters are not significantly different at 0.05 level (According to Tukey-test)

During the interpretation of our results, we experienced that in the colonies with the queen from the year 2014, the number of brood frames showed a significant difference between colonies with one and two-year-old queens. In the colonies with the oldest queen bees were

detected an average of 1.9 ±0.7 (n=18) brood frames, while in the colonies with one and two-year-old queen bees were found an average of 2.7±0.6 (n=20) brood frames (Table 1)
During the 17th April monitoring, the condition described by ZSIDEI (1990) was experienced, that is the time of population shift and on 19th May was the first black locust honey harvest, when the last data were recorded.
According to ZIMMER (2018), the time of population shift in the honey bee colonies can be dated to the third decade of April, when brood area is extensive but the population is still small. The most striking signs of population shift are that we find old, died bees in front of the hives, despite of a powerful ovulation of queen bees and number of brood frames are high, the population is low in the honey bee colonies.
There was no significant difference between the queens of the year 2015 and 2016 on 29th March and on 10th April. In these bee colonies, on 1st May, there was a large-scale brood area in 6-7 frames, while in the three-years-old queen's colonies, this condition was detected on May 19th (Table 2). In the study of 17th April and 19th May each of the data of the three queen-year-groups were differed. In 17th April a population shift was experienced in the honey bee colonies. The honey harvest took place on 19th May, when in the colonies with younger queen bees 8-9 frames with brood were experienced.

Table 2. Number of brood frames during the colony- development study in spring of 2017 year

Year of Queen Bee	16th March	29th March	10th April	17th April	1st May	11th May	19th May
2014 n= 18	1.9^{a}±0.7	2.0^{a}±0.8	2.5^{a}±0.7	3.6^{a}±0.5	4.5^{a}±0.6	5.4^{a}±0.6	6.5^{a}±0.6
2015 n= 20	2.7^{b}±0.5	3.5^{b}±0.5	4.2^{b}±0.5	5.4^{b}±0.8	6.9^{b}±0.7	7.7^{b}±0,6	8.4^{b}±0.7
2016 n= 20	2.7^{b}±0.6	3.9^{b}±0.9	4.6^{b}±0.8	6.2^{c}±0.7	7.2^{b}±1.0	8.2^{b}±0.9	9.0^{c}±0.8

$^{a-c}$: group means with similar letters are not significantly different at 0.05 level (According to Tukey-test)

During the 17th April inspection, we detected that in the colonies of three-year-old queens the degree of brood significantly fell behind compared to the colonies of the one and two-year-old queens nevertheless, even between the one and two-year-old queen's colonies one brood frame difference was typical. According to ZSIDEI (1990) during this period 2/3 part of frames of brood chamber should be occupied by brood.
On the 19th of May, the three groups showed a significant difference during the first black locust honey harvest. The number of frames with brood in the colonies of one-year-old queen were 9.0±0.8 (n=20), while in the colonies with three-year-old queen, this number was 6.5±0.6 (n=18).

Conclusion

The strength of honeybee colonies was influenced by several factors. Due to the cold weather at the beginning of May, there was a moderate increase in the volume of brood.
The equable population shift (within our beekeeping), which was detected on 17th April in 2017 (suddenly decreasing population, increasing the number of frames with brood, the death of old bees at the front of the hives) was precious, which was induced by the spring stimulating feeding of colonies. The optimal quantity and quality of pollen and water was not insured by the beekeeping site due to the poor ecological conditions, so it became necessary

to place antibiotic-free pies and sugar syrup in the hives and to put the temperate water drinker at the front of the hive area, the water of which was enriched by zeolite preparation. Zeolite plays an important role in reducing the harmful effects of *Nosema* infection (TLAK GAJGER et al., 2015).

FREE and SPENCER-BOOTH (1961) reported in their work that the feeding of honeybee colonies in disadvantageous weather can show an effect on the extent of brood area, but in preferential weather the feeding effect not relevant. The colonies produced more honey due to the effect of incentive feeding.

The effects of spring stimulating feeding have been published in the 1930s. The supply of sugar syrup is considered differently by beekeepers (CRANE, 1950). According to DIGGES (1936), spring feeding has a stimulating effect on bee colonies and on the work of nurse bees (brood rearing and care), while HAMILTON (1945) suggested that, stimulate spring feeding was not required with well-developed honeybee colonies and poor colonies also did not require it under favourable weather conditions. BUTLER (1946) argues that spring feeding has no stimulating effect and can delay spring growth of honeybee colonies.

However, it becomes clear that feeding with sugar pie, sugar syrup contributes to the spring growth of honeybee colonies, because even in the colonies with three-year-old queen bees were found an average of 6.5 frames with brood on the May 19th monitoring in 2017.

Published research on the population shift of honeybee colonies is rare (POTTS et al., 2010). As to the practical aspects of our results, we determined that the number of brood frames at the time of the population shift shows different rates for each queen bee group in both years. This difference was moderated by the stimulating feeding in the middle of May, because in the colonies with three-year-old queens, two-thirds of the frames of the brood chamber were occupied by brood.

As a result of spring incentive feeding, the population shift of honey bee colonies may occur at an earlier time (17th April in 2017; 1st May in 2016), however, the effect of queen bee's age on honey bee colony strength during the period of demographic development is not mitigated. Among the honey bee colonies of different ages of queen bees examined at the same time, the number of frames containing covered brood was significantly higher in the colonies with younger queen bee at the time of the population shift. As a result of increased incentice feeding (application of sugar pies and sugar syrups), the number of frames containing covered brood was significantly higher in the colonies of one- and two-year-old queen bee.

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Results of the reconstruction experiments of Black Mangalica

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Keywords: Black Mangalica, reconstruction program

Introduction

Previously, Mangalica pigs were separated as different colour varieties, but nowadays we distinguish them as different breeds based on the results of RADNÓCZI et al. (2006). The Blonde Mangalica was established in Hungary based on the crossing of local breeds and Sumadia pig. TORMAI (cit. E. DORNER, 1925) and SCHANDL (1948) considered only the blonde colour variety to be the original breed. The Black Mangalica was created by crossing the local fatty pigs and with the black pig of the 'Szerémség' in the second half of the 19th century, according to SCHANDL et al. (1953). Subsequently, the Swallow-bellied Mangalica emerged from the crossing of Blonde and Black Mangalica pigs (SCHANDL, 1948). Red Mangalica was selected from the offspring of 'Szalontai' and Blonde Mangalica crossbred animals which were created during the breed rescue method of 'Szalontai' pig at the beginning of the 20th century (SZABÓ, 2013).

According to various publications and references, Black Mangalica, considered as the most resistant, disappeared from public farming in the 20ies of the last century and was therefore declared extinct by professionals.

"In the last year of the 20th century, I saw a black coloured Mangalica meadow leaning on a pasture between the Danube and Tisza rivers near the village of Szank, which was almost flawless by its phenotype. In retrospect, this individual appears to have been the result of a mutation because of the high birth rate of black coloured offspring when mated with swallow sows." (SZABÓ, 2016). The results of the crossover experiment were presented on a poster at OMÉK show in 2005. At that time we had 40 female and 2 male black coloured Mangalica pups, which was not yet a recognized breed. In 2007, the portfolio was sold for economic reasons.

Another attempt was begun in 2013 at the Du Maco limited, to develop the Black Mangalica pig with the basis of 20 female and 6 male black coloured Mangalica piglets bought from 3 local stock farms.

The research programme

Tasks and requirements to be solved during the reconstruction of Black Mangalica Pigs:

- The raising of the 6 male and 20 female black piglets/gilts purchased in 2013, and then separation and breeding of them based on their origin.
- In breeding based on selection, crossing with other breeds is excluded, however, all varieties of purebred breeding were used.

- Black-born individuals in the population should be raised in the "experiment" for breeding purposes.
- Piglet with unwanted colour and having other negative traits should be strictly selected from the breeding stock.
- Perform a large number of tests and planned pairings to find the best combinations.
- Sows with the best conformation and performance should raise litters from as many boars as possible (test mating). Based on their results, the mothers of breeding strains are selected from among them.
- Establishing sow families for the best performing sows, and boar lines for selected males. The breeding results after 6-8 boars have to be strictly monitored during the first 3 years of the experiment.
- Select male piglet for breeding pigs from the upcoming offspring generation and testing the rotation of these lines in the 3-5 years of the experiment.
- Announcing and approving the use of a denomination on the basis of the number, conformation, breed character, homogeneity and production of black specimens.

Expected time periods, number of breeding animals and professional activities for the reconstruction and breeding of the Black Mangalica can be seen in Table 1. It can be clearly seen from the data that the research program was recorded in 2013.

Table 1. Framework of the breeding work

Year	Research timetable	Breeding animals		Young sows	Activity
		boar	sow		
2013-2014	Years 0-1.	5-6	5-10	-	Finding and raising proper-looking individuals
2015	Years 2.	7-9	15-25	20	Development of strains: 1 male + 3-4 sows, mating and breeding
2016	Years 3.	10-12	30-40	50	Involvement of male and female offspring in the breeding program, building of families and lines
2017	Years 4.	13-15	80-100	100	Testing of inbreeding (to detect recessive undesired genes)
2018	Years 5.	16-24	100-150	200	Testing of rotation of boars on the lines
	Total:	25-36	150-200	300-350	

Throughout the breeding process, efforts should be made to select individuals of inappropriate colour, appearance and value, while increasing and consolidation of the gene pool of favourable individuals with the expected phenotype is the most important task.

The most important selection criterion is the black colour and its correct inheritance to the upcoming generations, as long as "foreign" coloured piglets are born.

The "core" tasks, activities and expectations described in the research program were fully satisfied in 2019.

When the number of breeding sows reaches 150-200 individuals and the number of boars is 20-25 and the population is uniform and sufficiently homogeneous in terms of performance and appearance, it is necessary to initiate or recommend the placement of individuals belonging to the given line in separate colonies. Each line includes 30-40 sows and 4-5 boars, which, due to the current animal health situation, should be housed in 3 or more farms (Figure 1 and 2).

Figure 1. Founder boar of line 6

Figure 2. Breeding sows from line 6

Table 2. Main data of the reconstruction experiment of Black Mangalica (2014-2019)

Trait / Line		Number of farrowing	Piglets born alive	Average litter size	Culling at the 21st days	Ratio of black and 'mismark' animals				Animals raised for breeding			
						black		„mismark"		boar		sow	
No.	Name	piece	piglet	piglet	%	animal	%	animal	%	animal	%	animal	%
1	Bugac	31	233	7.52	12.00	207	88.85	26	11.15	4	10.9	44	13.1
2	Bakony	16	99	6.18	10.12	86	86.86	13	13.14	5	13.5	38	11.3
3	Bánk	27	171	6.33	11.70	159	92.98	12	7.02	3	8.1	38	11.3
4	Diószeg	35	247	7.06	14.17	230	93.12	17	6.88	5	13.5	55	16.4
5	Martin	34	246	7.24	17.14	229	93.09	17	6.91	6	16.2	45	13.4
6	Haláp	33	215	6.52	13.33	197	91.62	18	8.37	6	16.2	56	16.6
7	Hathalom	10	70	7.00	11.42	56	80.00	14	20.00	2	5.4	16	4.8
8	Homokhát	32	219	6.84	15.74	213	97.26	6	2.70	6	16.2	44	13.1
Total:		218	1500	6.88	14.40	1377	91.80	123	8.20	37	100.0	336	100.0

Table 3. Reproduction of the Black Mangalica sows

Trait	Unit	Order of farrowing									Sum Mean
		1.	2.	3.	4.	5.	6.	7.	8.	9.	
Litter size at born	piece	90	54	32	19	12	8	2	1	1	217
Average farrowing	piece	6.47	6.85	7.47	6.94	7.58	6.75	6.50	11.00	8.00	6.82
Litter size at 21st days	piece	5.71	5.82	6.34	5.84	6.50	5.75	6.50	8.00	8.00	5.92
Mortality up to 21st day	piece	0.76	1.03	1.13	1.10	1.08	1.00	-	3.00	-	0.90
	%	11.74	18.10	15.06	15.90	14.28	14.81	-	27.30	-	14.40

The comparison of experimental results and its reliability are significantly enhanced by keeping the parent and offspring populations in the same housing, feeding and care environment for the first 4-5 years of genotype and environment interaction and animal health conditions.

The most important breeding and selection results

The breeding results of the last 5 years of breeding are shown in Table 2, sorted according to the boar-lines developed in the experimental work.

The breeding lines are denoted by the number of the 8 founder boars. Six of them originated from purchases while two of them were own-bred. Selection and combination procedures were recorded in the breeding plan, followed by family and lineage breeding. Individuals of outstanding genetic value have also been tested for close inbreeding. At the beginning of the experiments, 221 farrowing were registered as the result of 25-30 test and about 250 planned matings from which three and later again two were subsequently destroyed.

Reproduction and growing performance results

There were 10-35 farrowing per line, of which 70-247 piglets were born. Overall, there were 218 farrowing, 1,500 live piglets were born, which means an average of 6.88 litter size. The farrowing was completed by 90 sows, the average farrowing was only 2.45 and the ratio of first farrowing was 40.7%. Estimating lifetime performance, the average litter size would increase to 7.1-7.2 per sow if the number of farrowing per sow reached the mean of 5. This black population exceeds the litter size of the other 3 Mangalica breeds by 1 (approximately 15%). From this it can be concluded that there was no degradation in the reproduction rate because of inbreeding during the experiment. As the population size and number of farrowing increase, the average litter size will probably fall to between 6.5 and 7.0. Experimental conditions could only marginally improve reproductive performance, which was manifested in improved "attention".

During the experiment, there were 125 farrowing and 899 born piglets and the average litter size was 7.19 after the eight founder boars. There were 15 farrowing and 100 born piglets within lines. The average litter size was between 6 and 7.63 after the founder boars. The highest difference between two lines was 1.63 (21.4%), which can be reduced by the rotation of the boar-lines. The minimal litter size was valid for only one boar-line, whereas it was 7.29 for the other 115 farrowing.

The rest of the offspring is after 23 descendants of the eight founder boars. The 601 piglets were born in 93 farrowing with an average litter size of 6.46. This value is favourable because almost all was first farrowing of young sow. Piglet mortality by the age of 21 was 14.4%. The highest difference in mortality was found between line 2 and 5 and was almost 40%, to the disadvantage of sows having more one more piglet (line 5).

As it was shown in Table 3, the number of Black Mangalica sows litter size at born and at 21 days-of-age was higher compared to the first farrowing up to the 6^{th} farrowing. However, piglet mortality was the most favourable for first farrowing sows (11.74%) up to 21 days-of-age, probably due to lower litter size and increasing birth weight.

Selection for the black colour

The most important aspect during the evaluation of the conformation of the individuals of the future black breed was the colour. Overall, 91.8% (1,377 piglets) of the born piglets were

'flawless' black individuals and 123 (8.2 %) were "mismark", i.e. blonde, red, swallow-bellied and bun-coloured individuals.

There were 85 piglets (9.9%) among the 899 offspring of the founder eight boars having different colour than black, so called “mismark”. Among the 601 piglets born as offspring of 23 boars who have been reared or tried so far, 38 (6.32 %) had colour problems. As a result of attentive target pairing and selection, the proportion of mismark individuals has so far decreased by more than 36 % in the experiment.

There were mismark piglets within all the eight lines. The smallest and most favourable was 2.7% and the largest was 20% for the line 8 and line 7, respectively. In the case of several sow, only black piglets were found within the litter. The "most valuable" sow was the ‘4’ having 77 piglets from 9 farrowing after boars from 7 different lines, and all offspring were black. Several of his male offspring were raised for breeding animals.

Breeding supply ratio

The number of female offspring selected for breeding is 50 % of the female population raised. In the case of boars, twice the need (63 animals) was raised because there was mismark piglet also after the best-looking boar. Therefore, if there is a mismark piglet in several litters within a line after the best-looking boar, it should also be selected from breeding. Sow and boar can only be reared for breeding from litters without any mismark piglets. The selection should be carried out consistently until a mismark piglet occurs within the herd.

In the near past, 140 breeding sows and gilts and 12 breeding boars have been sold to our eight Mangalica breeder members. There are currently 200 female and 30 male ready for breeding Black Mangalica pigs available, which population provides a reliable basis for the breed in a favourable veterinary environment and size (10 sow and 1 possibly 2 boars) for further selection, performance recording and maintaining the variety.

Recognition of the breed

In 2019, the Hungarian National Association of Mangalica Breeders, as the recognized breeding organization of Mangalica breeds in Hungary, announced its application for Black Mangalica breed recognition to the NÉBIH and the Ministry of Agriculture. The High Authority recognised the breed in 2019, while in early 2020 the designation of the breed as native was accepted.

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