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BIOLOGICAL CHARACTERISTICS OF TUROPOLJE PIG BREED AS FACTORS IN RENEWING AND PRESERVATION OF POPULATION

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Summary

Since 1996, Turopolje pig breed, an autochthonous Croatian breed and one of the older European pig breed is in the state of renewal and conservation. The aim of this study was to determine the size of breeding and effective (Ne) population and some of the biological traits which should be of importance in the program of in-situ preservation. According to the FAO standards, this breed is in the status of critical/endangerment although the obtained results showed the increase of breeding (12 vs. 130 sows and 3 vs. 15 boars) and effective population (9.6 vs. 53.8) from 1996 to 2008, respectively. The average litter size (number of born piglets in total and live were 7.7 and 6.3, respectively) and piglets weights at 1st (1.25 kg) and 42nd (4.4 kg) day of age were within the standards for this breed. The average survival of piglets from 1st to 42nd day of age was 73.5%. The composition of carcass and carcass parts estimated as a ratio of muscle:fat tissues was 1.1:1.0 and 0.8-1.5:1.0, respectively. In addition, fatty acid composition of M. longissimus dorsi (MLD) and back fat as well as MLD histochemical and histomorphological characteristics (diameter and proportion of red slow-twitch oxidative (SO), white fast-twitch glycolytic (FG) and intermediate fast-twitch oxidative glycolytic (FOG) fibre types) were specific. The characteristics of carcass and tissues traits are consequences of specific historical conditions, breeding, selection and production in specific environment. The biological traits of Turopolje pig breed are not limiting factors in the increasing of breeding population and changing of the present endangerment status.

Key words: Turopolje pig, effective population, litter size, carcass composition, tissues traits.

Introduction

The knowledge of certain biological traits such as liter size and survival of piglets in some period of life, the composition of carcass (muscle, fat and bone tissue distribution) as well as meat quality traits are of importance in pig breeding and meat production.

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Knowing these traits at Turopolje pig breed could be one of the main factors in renewing and in-situ preservation of Turopolje pig breed and in crossbreeding program

Since 1996, Turopolje pig breed – an autochthonous Croatian breed and one of the older European breed is in the status of the renewing and conservation *in-situ* (Robić et al., 1996). A number of scientific and professional papers (Ritzoffy 1931, 1933; Ogrizek, 1941; Đikic et al., 2002) were published about origin, historical and economic importance and reasons which brought this breed into the FAO list of endangered and disappearing breeds (World Watch List for Domestic Animal Diversity, Loftus and Scherf, 1993). This list was formed after signing the Convention on Biological Diversity (CBD) in Rio de Yaneiro in June 1992. Republic of Croatia signed CBD in 1997 and 1999 passed the strategy of Biologycal diversity of flora and fauna which include Turopolje pig breed (Radović, 1999). It is important to emphasize that Turopolje pig breed was created as a breed for the outdoors production system in ecosystem of forests (*Quercs robur*, *Fraxinus excelsior*, *Fagus sylvatica*) and marsh meadows (*Deschampsietum caespitosae*) and traditional Croatian low input in the outdoor production system. In the past the researches were focused on the determination of numerous biological traits of Turopolje pig at phenotypic and genetic level (Đikic et al., 2002, 2006; Harcet et al., 2006; Margeta et al., 2006). Some of the researchers (Jurić et al., 1997; Uremović et al., 2003; Senčić et al., 2007) were studied low input management in outdoor production system. In Croatia, there is no economically based program for using this breed or their crossbreds in production of dry cured meat products as it is a usually practice with native breed in Italy, Spain or Hungary (Oliver et al., 1997). In the last two years a few outbreaks of *Brucella suis* in Turopolje pig breed population were detected which strongly influenced on size of breeding population.

The objective of this paper was to estimate some biological traits of Turopolje pig breed important for setting-up the breeding and economic program in the preservation of this breed.

Material and methods

The size of breeding population (number of sows and boars) was analyzed in period between 1996 and 2008 using a data of Annual reports - Pig breeding of Croatian Livestock Center (CLC, 1997 to 2009). The effective size of

population (Ne) was calculated according to formula by Falconer and Mc Key (1996):

$$Ne = 4\ x\ \frac{Nm\ x\ Nf}{Nm + Nf}.$$

Nm = number of male (boars) individuals; Nf = number of female (sows) individuals

Investigation was carried out on three categories of animals; sows in farrowing, piglets and hogs. The whole production cycle (breeding, rearing and fattening) took place in outdoor system of flood forest biocenosis (*Quercus robur*) and marsh meadows (*Deschampsietum caespitosae*) in Turopolje area near the Zagreb. Traditional Croatian technology of low feed input (0.5 kg of corn seed/animals/day) in ecosystem was implemented at sows and hogs. Natural resources (acorn, soil and pasture) were utilized. During two weeks, in farrowing and suckling period sows and piglets were in wooden field building type "stanci" and sows were fed 2 kg of mixture/day/head (mixture composition: 40% corn, 30% barley and 30% super concentrate with 40% of CP). The piglets were additionally offered with grower mixture after 21st day of age.

The litter size (total and live born number, gender and mortality of piglets) per sow was analyzed at 15 sows which were farrowed in the spring. In addition, in the group of piglets (n=34) the birth weight and its influence on weights and survival from 1st to 42nd day of age were analyzed. All piglets were born within two weeks and weights were determined individually at 1st (within 24 h after birth), 7th, 14th, 21st, 28th, 35th and 42nd day of age.

In the abattoir the carcass composition was analyzed at hogs (n=10, age 679±20 days, weight 100.3 ±4.9 kg, warm carcass weight 80.1±4.6kg). The S-EUROP classification was determined on warm carcasses by two point method according to Croatian Regulation (NN 85/05). The ratio and distribution of muscle, fat and bone tissues in the carcass and each parts of the carcass were determined by total dissection. The Weniger method (1963) was used for cutting the left halves in parts: leg, shoulder, loin, neck and belly rib part (BRP), less valuable parts (LVP), double chin and lard.

Samples of *Musculus longissimiu dorsi* (MLD) and belonging back fat (BF) were taken from the left halves between the 13th and 14th rib and analyzed for crude fat content by Soxlet method. Fatty acid composition of MLD and BF was analyzed by gas chromatography (ISO 5508/1990). The proportion of

saturated (SFA), monounsaturated (MUFA) and polyunsaturated (PUFA) fatty acid are shown in this paper.

Muscle fiber characteristics were determined in the sample of the MLD taken on dorsal side in the 13/14th rib level 5 min after slaughtering and frozen in liquid nitrogen until analysis. For muscle fiber typing (Salomon, 1981 and Pearse, 1972), 10 µm thick transverse serial sections were cut in cryostat (Frigocut 2800, Reichert–Jung, Heidelberg, Germany) and stained for actomyosin ATP-ase after pre-incubation in alkaline (pH 9.4), and acid (pH 4.33 and 4.6) media in order to identify three main fiber types (slow twitch oxidative, SO; fast twitch glycolityc, FG and fast twitch oxidative-glycolityc, FOG). In addition, serial sections were used to demonstrate SDH and NADH reductase activity. The fiber diameter (µm) was calculated from fiber cross section area assuming fibers were circular in shape.

Descriptive statistics were used to describe biological traits of Turopolje pig breed (PROC UNIVARIATE, SAS v. 8.1, 1999). The effect of birth weight (1st day) on live weight at 7th, 14th, 21st, 28th, 35th and 42nd day of age were tested using the analysis of variance (PROC GLM; SAS v. 8.1, 1999).

Results and discussion

In the period from 1996 to 2008 the size of breeding population (table 1) was increased more than ten times in the number of sows and five times in the number of boars registered in herdbook of Turoplje pig breed (CLC, 1997-2009).

Table 1. – THE SIZE OF BREEDING AND NE POPULATION

Breeding size	YEAR												
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Boar	3	8	6	6	5	5	4	6	9	14	13	29	15
Sow	12	17	13	36	40	45	70	99	116	129	137	164	130
Ne	9.6	21.8	16.4	20.6	17.8	18.0	15.1	22.6	33.4	50.5	47.5	98.6	53.8

Ne – effective size of population

The increase in number of boars and sows resulted in the increase size of effective population. According to the FAO criteria for determining breeds at risk (Loftus and Scherf, 1993), by the results this breed was in critical status from 1996 to 2003 and in the status of endangerment from 2003 to 2008. But in 2008 the numbers of sows and boars was decreased about 21% in

relation to 2007, primarily due to outbreak of *Brucella suis* in Turopolje pig breed population. This finding highlights problems in control of infectious diseases in Turopolje pig production systems. It is important to emphasize that by the particular years the increasing of breeding population was very different and low besides the state subside. Some of reasons for slow increasing of breeding population could be low farrowing index, appearance of disease (Brucellosis), no interest of family farm and lack of land forests areas for breeding and keeping animals. However, it must to be saying that Turopolje pig breed was originally created and selected in outdoor production system of biocenosis flood forest and marsh meadows according to Croatian technology of low feed input in ecosystem and extensive management. In addition, Turopolje pig breed as well Croatian low input technologies in outdoor system are the part of Croatian and World wide biological diversity and cultural heritage and therefore need to be preserved.

The results in table 2 show that from 115 farrowed piglets 82 % were born alive. The numbers of total born piglets were within the standard of this breed by Ritzoffy (1931). The average number of male and female in a litter meant the ratio of 44.4% of males to 55.6% of females. The litter size as a trait at present population indicates the possibility of revival and preservation of this breed in the future.

Table 2. – LITTER SIZE AT TUROPOLJE PIG BREED (N=15)

Item	Total born	Live born			Losses
		Total	Male	Female	
n	115	94	43	51	21
$\overline{X}$	7.7	6.3	2.8	3.4	1.4
sd	1.36	1.65	1.33	1.42	1.29
Range	5-10	2-8	0-5	1-5	0-4

n = number of piglets of 15 sows

Weights and number of survived piglets from 1st to 42nd day of age are shown in table 3. The results (table 3) of average piglets' weights were within standard limits stated for this breed by Ogrizek (1941) and Belić et al. (1961). Piglets' weight distribution on 1st day of age shows that there were 29.4 % piglets with less, 55.9 % within and 14.7% above averages piglets' birth weights of Turopolje breed and selected pigs (1.4 kg, Uremović and Uremović, 1997). Changes in piglet's weight from 1 to 42 day of age analysed within the distribution classes indicates the influence of birth weight as a factor in later growth and development of piglets. The average birth weight in Turopolje pig breed (1.25 kg) was lower for 11% in comparison to modern

selected pigs (Uremović and Uremović, 1997) and less for 50% in the period from 7 to 42 days of age.

Table 3. – THE EFFECTS OF BIRTH WEIGHT ON WEIGHTS AND SURVIVAL OF PIGLETS FROM 1ST TO 42ND DAY OF AGE.

Day of age	Weights of piglets (kg) at 1st day of age									
	< 1.0 (n=2)		1.0 – 1.2 (n=8)		1-2 – 1.4 (n=19)		> 1.4 (n=5)		Average (total n=34)	
	$\overline{X}$ ± sd	%	$\overline{X}$ ± sd	%	$\overline{X}$ ± sd	%	$\overline{X}$ ± sd	%	$\overline{X}$ ± sd	%
1st	0.9±0.09	5.9	1.1±0.08	23.5	1.3±0.03	55.9	1.5±0.04	14.7	1.25±0.14	100
7th	1.18±0.0	2.9	1.8±0.25	23.5	2.2±0.19	52.9	2.6±0.31	14.7	2.12±0.39	94.0
14th			2.2±0.13	23.5	27.0±0.41	52.9	3.3±0.23	14.7	2.68±0.45	91.1
21st			2.6±0.19[a]	23.5	3.1±0.47	52.9	3.7±0.15[b]	14.7	3.08±0.51	91.1
28th			3.0±0.42[a]	23.5	3.6±0.62	47.1	4.2±0.41[b]	14.7	3.59±0.67	85.3
35th			3.2±0.65[a]	17.6	4.0±0.80[b]	41.2	4.5±0.69[b]	14.7	3.92±0.79	73.5
42nd			3.6±0.88[a]	17.6	4.4±0.71[b]	41.2	5.0±0.52[b]	14.7	4.35±0.96	73.5

[a,b] Within the same rows means with different superscript differ at P<0.05.

The results of the total number of survived piglets by periods, especially up to 21st day (91.2 %), and even up to 42nd day of age (73.5 %), indicate a good vitality of Turopolje breed piglets. But, analysis of the results within the investigated periods, especially at 14th and 21st day of age, also indicate the possible influence of other biological and technological factors (e.g. lactation stage of the sows, changes in passive and active immunity, the technological management conditions). Stated factors are supported by numerous authors according to Uremović M. and Uremović Z. (1997). The analysis after 21st and 28th day within the weight distribution evidently shows that some of above stated factors have influence on the survival rate. Therefore, these factors should be considered with the purpose of increasing the breeding population. In the suckling period weight and survival of piglets, especially after 21st day of age indicate the need for the research of sow keeping and piglet nurturing according to the traditional Croatian low input technology in the outdoor system with the aim of renewing and conservation of Turopolje pig breed.

The characteristics of carcass and tissues

Carcass weights and some technologies characteristics are shown in table 4. According to the results, established values of slaughtering and cold carcass weights in relation with age indicate very low daily gain at pigs produced in the outdoor system with technology of low feed input. The estimated values of

carcass lean meat percentage and carcass classes are in accordance with the values of back fat thickness and dept of MLD (table 4). Analysis of carcass composition showed that muscle:fat ratio in carcass with the lard was in favor of muscle tissue, and the ratio was 1.1:1. Regarding muscle:fat tissue relation in the carcass, according to other references (Vukina, 1961, Belić et al. 1961) Turopolje pig is a late-mature fat production type of pig, together with Mangalitsa and Bagun. On the contrary, at the base on his own research, Horvat (1939) concluded that fattened pigs with the average cold carcass weight of 81.6 kg of were too fatty for fresh meat production but too little fatty for fat production (which was important at that time). Also, the legs and shoulders conformations were very narrow and thin. The conclusions and results of Horvat induced us to investigate the tissue composition. However, if the established results for muscle:fat tissue ratio were compared with data on Mangalitsa and Black Slavonian breed (Kralik and Petričević, 2001) then the present population of Turopolje pig can be defined as a late mature combined meatiness – fatty type of pig for production in low feed input technology in the ecosystem of biocenosis of marsh meadows and flood forests.

Percentage of IMF in MLD at Turopolje pig breed (3.03%) was lower than at the Black Slavonian pig, 5.96% (Uremović et al., 2001) and higher than at selected pigs, 2.53% (Pass et al., 2004). Oliver et al. (1997) established 3.96% of IMF in *m. thoracis* of Iberian breed and 0.66% in Swedish Landrace breed under the intensive production conditions. These findings are interesting because older references cited by Đikić and Jurić (2002) pointed out that both Turopolje and Iberian breed descend from *Sus mediteraneus* pig. Besides that, the literature in the past (Horvat, 1939) and meat consumers today say that Turopolje pig has very juicy and tasteful meat what could be a result of higher IMF percentage of meat. The percentage of fat in the back fat of Turopolje pig breed was higher than in Mangalitza and Black Slavonian pigs and selected commercial pigs (Kralik and Petričević, 2001). In Turopolje pig breed the proportion of SFA and PUFA in the IMF of MLD and SFA in fat of backfat were lower while MUFA was higher than in selected pigs (Karolyi, 2007). But fatty acids in backfat analyzed as a ratio of UFA and SFA showed more favorable ratio than established the Oliver et al. (1997) on Iberian and Swedish landrace pigs, as well as by Karolyi (2007) at commercial selected pigs. However, data referred by the literature indicated that nutrition and management could change the ratio of fatty acid in the meat and fat in animals which should be of interest in human nutrition.

Table 4. – CHARACTERISTICS OF CARCASS AND MUSCLE AND FAT TISSUES

Carcass characteristics ($\overline{X}$ ± sd)							
Carcass weight	Back fat	MLD	Lean meat	SEUROP class	Total tissues in carcass		
kg	mm	mm	%		muscle	Fat	Bone
79.4±4.4	32.0±0.81	50.2±1.32	45.25±0.22	R	40.6±1.39	38.0±1.3	9.4±0.85
Intramuscular fat content and fatty acid profile of MLD and back fat (%; $\overline{X}$ ± sd)							
MLD				Back fat			
IMF	SFA	MUFA	PUFA	IF	SFA	MUFA	PUFA
3.03±0.4	39.6±3.74	54.8±2.95	5.6±2.87	93.0±3.76	37.0±3.37	50.8±1.97	12.2±2.41
Muscle fiber characteristics of MLD ($\overline{X}$ ± sd)							
SO		FG		FOG			
µm	%	µm	%	µm		%	
38.9±12.1	10.5±1.09	57.7±14.83	52.8±14.86	53.5±14.57		36.7±18.27	

In Turopolje pig breed the fiber diameter and proportion of SO, FG and FOG (table 4) showed and beside some higher variability's values in a normal range when compared to the general records for the swine as species by Lawrie (1998). However, the size of fiber types SO is more less in the Turopolje pig than in crossbred selected pigs LWHyF (average value of crossbred pigs of eight vary known breeding companies from Great Britain, Maltin et al., 1997). The estimated results in the consideration with results of many authors cited by Pas et al (2004) indicated that Turopolje pig breed could be genetically different compared to other breeds, if keep in mind the factors as well as its origin (Ritzoffy, 1931, 1933) and no intensive selection for lean muscle growth which in pigs may have caused a large genetic change in fibre type composition. The carcass composition and tissues distribution in the carcass and parts of carcass are shown in table 5.

Table 5. – CARCASS COMPOSITION AND TISSUES DISTRIBUTION IN THE CARCASS AND PARTS (%; $\overline{X}$ ±SD)

Parts	Parts in carcass**	Tissue					
		Muscle		Fat		Bone	
		carcass	parts	carcass	parts	carcass	parts
Leg	25.7±0.53	12.7±0.77	49.6±2.9	10.6±0.95	39.9±2.61	2.4±0.26	10.5±1.45
Shoulder	15.5±0.20	8.20±0.52	54.1±4.39	5.7±0.58	35.3±4.97	1.6±0.48	10.6±0.84
Loin	14.8±0.63	6.6±0.57	44.5±2.8	5.8±0.47	39.7±2.06	2.4±0.60	15.8±1.88
Neck	8.8±0.48	5.2±0.44	58.6±3.81	2.3±0.33	26.5±3.37	1.3±0.13	14.9±1.2
BRP*	19.2±0.54	7.9±0.37	40.8±3.04	9.6±0.79	50.7±3.15	1.7±0.15	8.5±0.98

**Less valuable part = 9.2%; Double chin = 2.8%; Lard = 4.0%; * BRP – Belly rib part;

In fattened pigs of Turopolje breed, regarding the share of parts in carcass, leg is in the first place, followed BRP, shoulder, loin and neck. Although, the data on carcass length showed that Turopolje pig has relatively short carcass (the average lengths *os pubis – atlas* and *os pubis* – first rib were 87.0 and 68.4 cm, respectively) compared to modern pig genotypes (98.5 cm and 88.3 cm, Đikic et al., 2002).

The percent of muscle tissue from leg, loin, neck and BRP in the carcass is low, while percentage of fat tissue is relatively high, when compared to the ration in selected pigs. However, percentage of muscle tissue in the parts was higher than fat in all parts of carcass, except for BRP. In the parts of carcass the ratio of muscle:fat tissues was from 0.80-1.53:1.0 depending of carcass part. Results (table 5) obtained in fattened Turopolje pigs of present population do not suggest that breeding and selection process in modern pig production had any influence on this population in the sense of increasing muscle:fat tissue ratio in carcass, or in increase in the ratio between back (leg + loin) and front (shoulder + neck) part of carcass.

The ratio between muscle and fat tissue in the parts indicate that the meat of this breed could be used for some kind of pork product processing (dry ham, dry loin or various sausages). Obtained values, in addition to the previous results (Grunenfelder, 1994; Robić et al., 1996; Đikić et al., 1999, 2002) confirm that Turopolje pig due to its specific origin (Ritzoffy, 1931, 1933) as well as biological characteristics is a valuable cultural and biological resource. Assuming that statements of Sellier (1998), Hammond (1998) and Grunenfelder (1994) are accepted, this breed could also have an economical value.

The obtained results (table 4 and 5) indicate that Turopolje pig was not influenced by trends in pig selection directed by changes in demands for muscle and fat tissue on pig meat market which resulted in very high share of muscle tissue in carcass, (Đikić and Jurić, 2003). Reeds et al. (1993) reported that in the commercial fattened Landrace and Large White breeds at the age of 210 days and body weight of 90 kg, in the year 1940 muscle:fat tissue ratio was 0.87:1, while in 1980 it was 1:1. Today, this ratio is 2.5:1 at selected pigs. If these figures are compared to fattened Turopolje pigs, the status of selection according to carcass quality in the remaining population is visible.

In present population of Turopolje pig breed the some traits of carcass and tissue composition are specific and could be a consequence of specific historical conditions of breeding and selection and production in the specific environment of the outdoor system. The carcass and tissue composition give opportunity to

setting up a program which would support reestablishment of the population on the economic base.

Conclusions

On the basis of the size of breeding and effective population, the Turopolje pig breed passed from critical to endangerment status in period from 1996 to 2008. Litter size and weights of piglets on 1st day of age of today's Turopolje breed are within the standards for this breed, and should not be limiting factors in renewing and preservation of this breed. In the suckling period weight and survival of piglets, especially after 21st day of age, indicate the need for the research of sow and piglets keeping and feeding according to the traditional Croatian low input technology in the outdoor system. In present population of Turopolje pig breed the some traits of carcass and tissue composition are specific and could be a consequence of specific historical conditions of breeding, selection and production in the specific environment of the outdoor system. The carcass and tissue composition give opportunity to setting up a breeding program which would support the reestablishment of the population on the economic base.

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BIOLOŠKE ZNAČAJKE TUROPOLJSKE PASMINE SVINJA KAO ČIMBENICI OBNOVE I OČUVANJA POPULACIJE

Sažetak

Turopoljska pasmina svinja – autohtona hrvatska pasmina i jedna od starijih pasmina svinja u Europi je u statusu obnove i zaštite od 1996 godine. Cilj rada je utvrditi veličinu uzgojne i efektivne (Ne) populacije kao i neka biološka svojstva koja su od važnosti za provođenje in situ programa očuvanja pasmine. Prema FAO standardima o veličini populacija životinja koje su u nestajanju, ova pasmina je u statusu kritične ugroženosti iako broj za 1996 i 2008 pokazuju povećanje populacije kako uzgojne (krmača 12 i 138; nerasta 3 i 15), tako i Ne (9.6 i 53,8). Prosječne vrijednosti za svojstva, veličina legla (ukupno 7,7 i živo 6,3 oprasene prasadi) i mase prasadi 1. i 42. dan starosti (1,25 kg i 4,4 kg) su u granicama standarda za ovu pasminu. Preživljavanje prasadi od 1. do 42. dan života je 73,5%. U radu je analiziran sastav trupa i pojedinih dijelova, a omjeri mišićnog i masnog tkiva u trupu i dijelovima bili su 1,1:1 i 0,8-1,5:1,0. Sastav masnih kiselina utvrđen u mišiću Longissimus dorsi (MLD) i leđnoj slanini (pozicija 13./14. rebro) kao i histokemijska i histomorfološka svojstva mišićnih vlakana MLD, crvena (red slow-twitch oxidative, SO), bijela (white fast-twitch glycolytic, FG) i srednja (intermediate fast-twitch oxidative glycolytic, (FOG) su specifični kod ove pasmine u odnosu na neke druge. Značajke trupa i tkiva posljedica su specifičnih povijesnih uvjeta uzgoja, selekcije i tehnologija proizvodnje otvorenog sustava u specifičnom okolišu. Biološke značajke Turopoljske svinje/pasmine nisu ograničavajući čimbenici povećanju uzgojne populacije i mijenjanja sadašnjeg statusa ugroženosti od nestajanja.

Ključne riječi: turopoljska svinja, efektivna populacija, veličina legla, sastav trupa, kakvoća tkiva.

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