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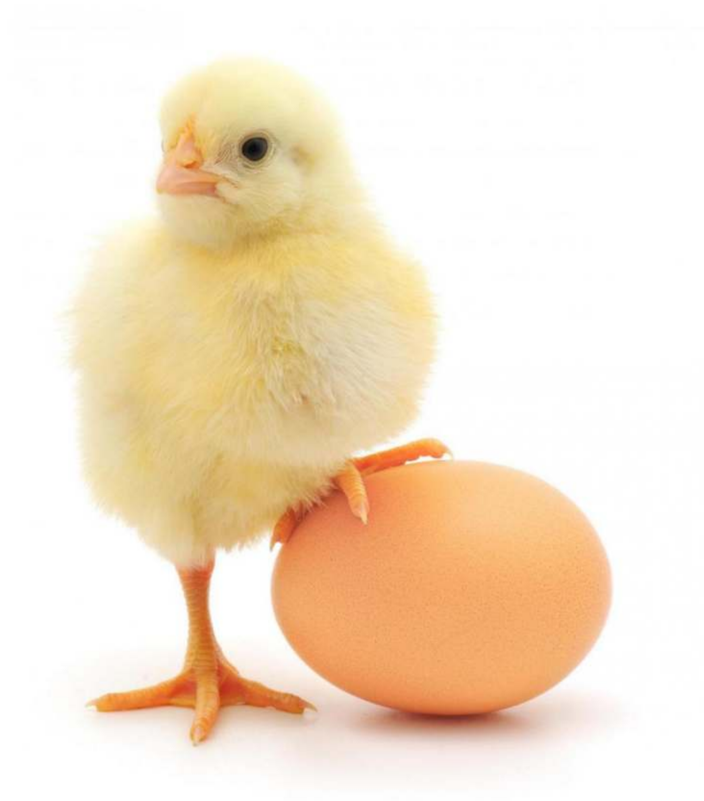

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Research Article
Conservation Aspects of Meat Producing Ability and Heterosis in Crosses of Two Natively Different Local Hungarian Chicken Breeds

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Abstract
Background and Objective: High quality meat producing ability of old chicken breeds must be considered as an important conservation aspect. Consequently, this study aims to investigate body weight, feed conversion ratio, slaughtering yields as well as to identify the existence of heterosis for those traits of the crossings between two natively different local Hungarian chicken breeds, Partridge Coloured Hungarian and White Transylvanian Naked Neck. A high survival rate without significant difference amongst genotypes was recorded at the end of the experiment. **Methodology:** The breeds, kept as *in vivo* gene bank stocks of the Research Center for Farm Animal Gene Conservation were chosen on the basis of their definite difference in genotype and meat producing ability making studies of heterosis (H%) and reciprocal effect (RE) possible in crossings for quantitative traits at different ages, by using separate gender groups of purebreds and their reciprocal crossings. **Results:** A high survival rate without significant difference amongst genotypes was recorded at the end of the experiment. As expected, male chickens have significantly higher body weight and lower feed conversion ratio in comparison with females. Crossbred's body weight and feed conversion ratio are significantly better than those of White Transylvania Naked Neck but rather comparable to Partridge Colored Hungarian pure breds. The highest eviscerated carcass in percentage of live weight, breast and thigh meat weight was detected in the crossbreeds. Positive heterosis of body weight was found in female crossbreeds, while positive heterosis of slaughtering yields and negative heterosis of feed conversion ratio were observed in both males and females. **Conclusion:** It is reasonable to state that using two Hungarian chicken breeds marked in the same category "Indigenous and rare" possess certain potential for genetic improvement by crossing without making a compromise in product quality of the offspring. Crossing therefore can be considered as an additional tool for conservation of highly endangered and low producing breeds.

Key words: Conservation, local chicken, crossing, heterosis, reciprocal effect

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

In spite of their moderate productivity, local chicken breeds are generally accepted as potential resources that can contribute to sustainable agriculture either by poverty alleviation or genetic conservation or both[1-5]. Local chickens are preferred for their exceptional meat and egg quality, which partly comes from their "seeking habit" at free range[6]. Practical use of highly endangered local chickens is an efficient method for their protection reviewed recently by Sokolowicz *et al.*[7]. Therefore, the meat producing ability of old chicken breeds becomes an important conservation aspect. In Hungary, 7 native chicken breeds are registered and kept by Hungarian academic institutions as *in situ* gene banks. All the breeds are protected and maintained under strict conservation programmes[8]. Among the breeds, Partridge Coloured Hungarian (PH) chicken is characterized by relatively good meat and egg production, while White Transylvanian Naked Neck chicken (WT), despite its long history of conservation, is still highly endangered due to its lowest production capacity among the breeds[9,10]. Conservation in a broad sense also means fostering the utilization of the breeds, most types of usage however would depend on their production capacity. As gene bank or conservation stocks cannot be the subject of any kind of direct selection for certain production traits, many scientists have attempted to cross native local breeds with exotic commercial ones to improve production of the offspring[11-16]. These types of crossings, however, may have negative effect on both general resistance, adaptability of the offspring and quality of their products as compared to local purebreds. Those aspects are to be considered particularly in special breeding and conservation programmes aiming to utilize the uniqueness of local breeds, in which production should insist on the use of 100% old breeds only[5,17,18].

Presuming that the crossing of two local breeds can solve the problem, this study aims to investigate the productivity in terms of Body Weight (BW), Feed Conversion Ratio (FCR) and slaughtering yields of PH and WT purebreds and crossbreds produced by the reciprocal crosses between those local breeds as well as to find a crossing scheme that suits the special traditional Hungarian chicken production. The breeds were chosen on the basis of their definite difference in genotype and meat producing ability[8,9,19,20], making studies of heterosis (H%) and Reciprocal Effect (RE) possible in crossings[21-23].

MATERIALS AND METHODS

Chicks of four investigated genotypes (PH and WT pure breeds and the offspring of reciprocal crosses WT♂×PH♀ and PH♂×WT♀) were hatched at the poultry gene bank farm of the Research Centre for Farm Animal Gene Conservation (HáGK), Hungary. Wing bands were used for individual recording. Initially, the experimental groups of birds were kept separately in closed cages on deep litter. From 4 weeks of age, birds were released in a running area during the day and closed at night. Birds had free access to feed and water. The arrangement of the experiment and the labeling of experimental groups are described in Table 1. Mortality, individual Body Weight (BW) of birds and feed intake of each pen were recorded during the experiment and calculated for 12, 14 and 16 weeks of age. Feed conversion ratio (FCR, kilogram feed per kilogram body weight gain) is calculated according to the number of live birds recorded in each pen, using the following equation:

$$\text{FCR} = \frac{\text{Feed consumption (kg)}}{\text{Body weight gain (kg)}}$$

To study slaughtering yield, individual live weight, eviscerated carcass, breast and thigh weight of 4 randomly chosen birds of each pen were measured at the age of 12, 14 and 16 weeks. The percentage of eviscerated carcass was estimated as follows:

$$\text{Eviscerated carcass (\%)} = \frac{\text{Eviscerated carcass weight}}{\text{Average live weight}} \times 100$$

Heterosis was calculated using means, with the formula adapted from Williams *et al.*[22]:

$$\text{H (\%)} = \frac{\text{F1} - 0.5 \times (\text{P1+P2})}{0.5 \times (\text{P1+P2})} \times 100$$

where, H is heterosis in percentage of parental performance, F1 is the performance of crossbreds, P1 and P2 is the performance of the progeny from each of the two parental populations. RE for each parameter were calculated as the difference between reciprocal F1 performances with the formula adapted from Sola-Ojo *et al.*[23]:

$$\text{RE} = \text{PW-WP}$$

Table 1: Arrangement of the experiment and the labeling of investigated genotypes produced by Partridge Colored Hungarian (PH), White Transylvania Naked Neck (WT) gene bank stocks and their reciprocal crosses

Crosses (male×female)	Gender	No. of pens	No. of birds pen^{-1}	Labels
PH×PH	Male	3	20	mPH
	Female	3	20	fPH
WT×WT	Male	3	20	mWT
	Female	3	20	fWT
PH×WT	Male	3	20	mPW
	Female	3	20	fPW
WT×PH	Male	3	20	mWP
	Female	3	20	fWP

where, PW is the mean performance of the F1 from a PH rooster and WT hen cross, WP is the mean performance of the offspring from a WT rooster and PH hen cross data were subjected to two way analysis of variance (ANOVA) by using SPSS software[24]. Significant differences among the averages were examined by using *post hoc* Tukey HSD.

RESULTS AND DISCUSSION

A survival rate without significant difference amongst genotypes of 87.50% for mWP and fWP, 92.50% for mPH, fPH, mWT and fWT, 95.00% for mPW and fPW was recorded at the end of the experiment. According to ANOVA test, the impact of gender and genotype on average BW, FCR, eviscerated carcass, breast and thigh weight was apparent in all analyses (at 12, 14 and 16 weeks of age, $p<0.01$). Significant interaction effect of genotype and gender was seen on FCR at 12, 14 and 16 weeks of age ($p<0.01$). Body weight, FCR and slaughtering yields at 12, 14 and 16 weeks of age of all genotypes are summarised in Table 2-4, respectively. The results revealed that male chickens have significantly higher BW and lower FCR, in comparison with females. The average BW and FCR of mPH, mPW and mWP were superior to the other groups. At the end of the rearing period, the highest BW and lowest FCR was obtained in mPH while the lowest BW and highest FCR belonged to fWT. Crossbred's results were significantly better than those of WT but rather comparable to PH purebreds. A mere difference in terms of BW and FCR could be seen between mPW and mWP, fPW and fWP. The highest weight of eviscerated carcass, breast and thigh meat was achieved in mPH, mWP and fPW while the lowest was observed in fWT. However, fWT owned the highest eviscerated carcass in percentage calculated on the basis of live weight. Data provided in Table 5 represent H% and RE of crossbreds in terms of BW, FCR and slaughtering yields. Positive H% of BW and slaughtering yields and negative H% of FCR were observed in all female crossbreds except for fWP's thigh meat weight. In case of male crossbreds, noticeable positive H% of slaughtering yields and negative H% of FCR could be found in mWP and mPW, respectively. Nonetheless, it was hard to cumulatively conclude the RE on other traits due to the heterogeneity of the outcome.

Overall, the use of local chicken breeds as parents for crossings may provide an advantage with regards to BW and FCR traits as it has been found for meat and egg production for chicken[11,12,15,17] for duck[25] and for local guinea fowl[26] as the higher degree of heterozygosity of the crossed offspring compared to their parents is mostly the reason for heterosis in certain traits[21,22]. In other words, two Hungarian chicken breeds marked in the same category "Indigenous and rare" possess realistic option for genetic improvement by crossings based generally on their genetic diversity as revealed by Bodzsar *et al.*[19].

The results obtained from this study support the dissemination practice and prospects including HU-BA production system of old Hungarian chicken breeds kept under genetic conservation programme[18], in which the utilisation of traditional breeds is a major concern and decisions on crossing partners should be made on the basis of both their production and reproduction traits to find the proper genotype for use. Furthermore, crossings may draw certain local breeds with low performance into special production programmes, especially if phenotypic markers advantageous in some way for marketing of final products appear (e.g., mostly uniform white plumage with some brownish shade or heterozygote naked neck appearance), which was the case in this experiment. Practical considerations based on the egg production profiles of purebreds[9] as well as on RE results obtained in this study, PH with higher egg production is proposed as female and WT as male parent for production in cross.

Regarding that old Hungarian chicken breeds belong to the dual purpose category[8], which determines the traditional practical use of genders (males are mostly kept for meat, while

Table 2: Average body weight and feed conversion ratio (FCR) of both male (m) and female (f)

	Weeks of age					
	12		14		16	
Traits	Mean	SD	Mean	SD	Mean	SD
Body weight (g)						
mPH	1336[a]	31.7	1688[a]	31.24	2051[a]	56.7
fPH	992[c]	36.3	1238[c]	50.34	1457[c]	55.9
mWT	1181[b]	14.7	1455[b]	13.50	1712[b]	53.0
fWT	869[d]	32.3	1031[d]	41.15	1156[d]	54.9
mPW	1269[ab]	37.9	1568[ab]	80.30	1854[b]	55.6
fPW	1029[c]	15.9	1246[c]	29.72	1410[c]	37.0
mWP	1244[ab]	26.3	1557[ab]	64.56	1845[b]	36.2
fWP	989[c]	13.7	1180[c]	35.79	1358[c]	51.5
ANOVA test, p-value		<0.01		<0.01		<0.01
FCR (kg feed kg^{-1} b.wt.$^{-1}$ gain)						
mPH	2.11[d]	0.10	2.37[d]	0.11	2.59[d]	0.06
fPH	2.84[a]	0.10	3.19[b]	0.15	3.60[b]	0.16
mWT	2.21[cd]	0.03	2.69[c]	0.01	3.05[c]	0.10
fWT	2.91[a]	0.10	3.71[a]	0.13	4.48[a]	0.19
mPW	2.01[d]	0.17	2.47[cd]	0.18	2.79[cd]	0.19
fPW	2.46[bc]	0.04	3.06[b]	0.08	3.64[b]	0.10
mWP	2.09[d]	0.06	2.53[cd]	0.05	2.86[cd]	0.08
fWP	2.50[b]	0.03	3.12[b]	0.08	3.72[b]	0.18
ANOVA test, p-value		<0.01		<0.01		<0.01

[a-d]Different letters in the same column denote significant differences (p<0.05) among treatments, detected by *post hoc* Tukey HSD test, PH: Progeny of Partridge Coloured Hungarian chickens, WT: Progeny of White Transylvanian Naked Neck chickens, PW: Progeny of the cross between Partridge Coloured Hungarian cockerels and White Transylvanian Naked Neck hens, WP: Progeny of the cross between White Transylvanian Naked Neck cockerels and Partridge Coloured Hungarian hens chickens at 12, 14, 16 weeks of age

Table 3: Eviscerated carcass in gram and percentage of both male (m) and female (f)

	Weeks of age					
	12		14		16	
Parameters	Mean	SD	Mean	SD	Mean	SD
Eviscerated carcass (g)						
mPH	1080[a]	108.3	1288[a]	79.3	1335[a]	107.0
fPH	815[cd]	106.7	957[b]	72.7	1008[cd]	106.2
mWT	858[c]	57.7	982[b]	61.8	1214[abc]	108.3
fWT	653[d]	60.6	795[d]	32.7	876[d]	62.6
mPW	1030[ab]	108.3	1273[a]	77.9	1203[abc]	117.0
fPW	798[cd]	69.4	881[cd]	69.0	1263[ab]	108.1
mWP	907[bc]	61.0	1149[a]	71.2	1310[a]	80.7
fWP	762[cd]	54.7	919[cd]	75.7	1051[bc]	110.5
ANOVA test, p-value		<0.01		<0.01		<0.01
Eviscerated carcass (%)						
mPH	79.4	1.7	78.6[c]	0.4	79.7[cd]	0.8
fPH	78.4	1.3	79.7[bc]	1.3	78.9[d]	1.1
mWT	80.4	2.3	81.8[a]	1.0	81.6[b]	1.0
fWT	80.1	1.2	80.8[ab]	1.1	83.5[a]	1.4
mPW	83.1	6.0	80.2[bc]	0.8	80.4[bcd]	1.2
fPW	81.7	4.5	80.1[bc]	0.9	81.5[b]	1.0
mWP	78.1	4.1	79.7[bc]	0.9	80.4[bcd]	1.3
fWP	80.8	1.1	80.8[ab]	1.4	80.9[bc]	1.4
ANOVA test, p-value		0.06		<0.01		<0.01

[a-d]Different letters in the same column denote significant differences (p<0.05) among treatments, detected by *post hoc* Tukey HSD test, PH: Progeny of Partridge Coloured Hungarian chickens, WT: Progeny of White Transylvanian Naked Neck chickens, PW: Progeny of the cross between Partridge Coloured Hungarian cockerels and White Transylvanian Naked Neck hens, WP: Progeny of the cross between White Transylvanian Naked Neck cockerels and Partridge Coloured Hungarian hens chickens at 12, 14, 16 weeks of age

Table 4: Breast and thigh meat yield of both male (m) and female (f)

	Weeks of age					
	12		14		16	
Parameters	Mean	SD	Mean	SD	Mean	SD
Breast meat weight (g)						
mPH	193[a]	27.4	250[a]	31.1	260[a]	23.3
fPH	152[bc]	20.7	187[c]	30.4	201[bc]	26.0
mWT	144[c]	14.0	190[bc]	14.5	253[a]	31.2
fWT	131[c]	17.3	171[c]	19.9	191[c]	10.6
mPW	177[ab]	34.4	249[a]	16.0	239[ab]	48.7
fPW	150[bc]	11.5	184[c]	18.2	265[a]	39.0
mWP	161[bc]	17.9	221[ab]	23.6	269[a]	13.9
fWP	149[bc]	10.8	195[bc]	14.6	235[abc]	32.5
ANOVA test, p-value		<0.01		<0.01		<0.01
Thigh meat weight (g)						
mPH	292[a]	46.8	350[a]	44.5	376[a]	55.7
fPH	213[cd]	32.9	251[cd]	43.1	268[cd]	41.8
mWT	231[bc]	28.0	277[bc]	24.0	356[ab]	35.3
fWT	175[d]	23.9	209[d]	22.8	240[d]	19.7
mPW	278[ab]	54.5	348[a]	29.6	337[abc]	84.1
fPW	216[cd]	24.3	226[d]	18.4	343[abc]	67.4
mWP	243[abc]	18.8	315[ab]	27.2	377[a]	30.5
fWP	198[cd]	17.00	239[cd]	18.9	281[bcd]	33.8
ANOVA test, p-value		<0.01		<0.01		<0.01

[a-d]Different letters in the same column denote significant differences ($p<0.05$) among treatments, detected by *post hoc* Tukey HSD test, PH: Progeny of Partridge Coloured Hungarian chickens, WT: Progeny of White Transylvanian Naked Neck chickens, PW: Progeny of the cross between Partridge Coloured Hungarian cockerels and White Transylvanian Naked Neck hens, WP: Progeny of the cross between White Transylvanian Naked Neck cockerels and Partridge Coloured Hungarian hens chickens at 12, 14, 16 weeks of age

Table 5: Heterosis (%) and reciprocal effect calculated for body weight, feed conversion ratio (FCR) and eviscerated carcass, breast and thigh weight of both male (m) and female (f)

		Heterosis (%)				Reciprocal effect	
Age (weeks)	Traits	mPW	mWP	fPW	fWP	(mPW-mWP)	(fPW-fWP)
12	Body weight	0.79	-1.17	10.54	6.24	24.74	39.95
	FCR	-6.71	-3.32	-14.46	-13.18	-0.07	-0.04
	Eviscerated carcass weight	6.29	-6.42	8.73	3.78	123.16	36.31
	Breast meat weight	5.33	-4.58	6.13	5.28	16.70	1.20
	Thigh meat weight	6.32	-7.15	11.23	2.05	35.18	17.80
14	Body weight	-0.22	-0.96	9.80	3.98	11.65	66.04
	FCR	-2.26	-0.04	-11.42	-9.53	-0.06	-0.07
	Eviscerated carcass weight	12.21	1.26	0.53	4.84	124.34	-37.74
	Breast meat weight	13.14	0.28	3.20	9.34	28.30	-10.98
	Thigh meat weight	11.08	0.45	-1.79	4.15	33.34	-13.66
16	Body weight	-1.48	-1.91	7.93	3.95	8.03	52.04
	FCR	-1.05	1.24	-9.93	-7.91	-0.06	-0.08
	Eviscerated carcass weight	-5.59	2.77	34.11	11.54	-106.53	212.58
	Breast meat weight	-6.56	5.10	35.62	19.89	-29.86	30.79
	Thigh meat weight	-7.88	2.99	35.14	10.80	-39.76	61.79

PH: Progeny of Partridge Coloured Hungarian chickens, WT: Progeny of White Transylvanian Naked Neck chickens, PW: Progeny of the cross between Partridge Coloured Hungarian cockerels and White Transylvanian Naked Neck hens, WP: Progeny of the cross between White Transylvanian Naked Neck cockerels and Partridge Coloured Hungarian hens chickens at 12, 14, 16 weeks of age

females for egg production), concern on how and to what extent the reciprocal crossing affects the expression of reproductive traits can be still the subject of a further study, nevertheless heterosis is usually greater for reproduction traits than for BW[21].

CONCLUSION

Considering that, no selection is applied in gene bank stocks, crossings of the same category of chickens can be a reasonable tool to improve low productivity and ensure utilization of a highly threatened breed without making a compromise in product quality of old breeds.

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