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EFFECT OF CROSSING AND SEASONS ON FITNESS TRAITS IN TURKEYS

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ABSTRACT: Crossing between the local Black Baladi (BB) and a commercial White Nicholas (WW) was carried out to estimate heterosis, direct additive and maternal effects for fitness traits, in addition to season effect. The breeding plan permitted the simultaneous production of the two pure varieties (BB and WW) and their reciprocal crosses (BWand WB) throughout two successive years from 2006 to 2007.

Crossing and season had significant effect on most fitness traits studied (fertility, hatchability, late embryonic mortality, total egg loss, mortality rate, survival rate, and fitness index). The interactions between Genotypes and seasons were significant for all fitness traits studied. Eggs of BB hens and those produced from WW hens mated with BB toms had significantly the highest means for most fitness traits. The estimates of heterosis percentages for fitness traits indicated that the BW crosses had superior heterotic effect than the WB cross. The values of maternal additive and direct additive effects showed superiority of BB as sires which suggest that using of this variety as a terminal sire breed in crossbreeding programs including WW dams would be beneficial for improving the fitness traits.

It could be concluded that crossing between BB variety and WW strain of turkey can improve fertility, hatchability and late embryonic mortality percentages, total egg loss, morality rate, survival rate and fitness index.

Key Words: Turkeys, crossing, embryonic mortality, egg loss, survival rate, fitness index.

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INTRODUCTION

Intensive turkey production in Egypt depends not only on imported commercial strains but also, on heavy local strains such as selected local Black Baladi variety and to a great extent on foreign ones. Continuous selection for body weight in these turkey strains is believed to affect their reproductive performance (Nestor et al. 1997). Amin, (2007) reported that selection for body weight at 20 week of age in turkeys led to a decrease in fertility percentage, hatchability and increase in embryonic mortality percentage. Amin, (2014) found that using toms of BB variety of turkey in backcrossing with the White Nicholas (WW) enhanced fertility, hatchability and most of the embryonic mortality traits, also improved mortality percentages, survival rate and fitness index.

Significant differences between strains, lines and crossbreds in hatchability and fertility percentage were reported by Balat (1990), Gad et al. (1991), Hulet et al. (1992), Nestor and Noble (1995), Nestor et al. (1997), Mustafa and Younis (2001). In addition, Amin (2008 and 2014) found that crossing between local Black Baladi and White Nicholas turkey improved significantly fertility and hatchability percentages. Crossing enhanced early embryonic mortality percentage of both the reciprocal crosses.

Seasons effects on fitness traits were reported by Younis and Abd El-Ghany (2003).They found that winter season recorded significantly the highest percentages in fertility and hatchability, while the lowest significantly values were during summer season.

Heterosis, direct additive and maternal effects of fitness traits in turkey were reported in the literature (Zaidan, 1982; Amin, 1999, 2008 and 2014; Emmersen et al. (2002) and Nestor et al., 2004 and 2006).

Fitness Index could be good measure to test the potentiality of different strains of turkeys. Such phenomenon denoted as "Genetic Inertial' by Darlington and Mather (1949) and as "Genetic Homeostasis" by Lerner (1954). They explained that, with respect to fitness, the most likely mechanism lies in the superiority of the heterozygous advantage over the homozygous genotype. They added that the superiority of heterozygous, with regard to fitness was one possible mechanism for "Natural Selection" in favor of phenotypic intermediates. Lerner (1954) postulated that the best-adapted individuals in population were those which exhibited a harmonious combination of all characters leading to maximum fitness. In a population to get higher fitness, the breeder should increase heterozygous genotypes in his flock using he different methods of "heterosis".In crossing between three strains of chickens (Fayoumi, RIR and Golden Montazah), Hossari and Dorgham (2000) found significant heterosis in the fitness traits, laying rate, fertility rate and survival rate. The increase of fitness was more significant in two-way crosses than in three-way.

The main objectives of the present study were to study the effect of crossing between the Black Baladi variety and the commercial White Nicholas line of turkeys on fitness traits, and to estimate heterosis, direct additive and maternal additive effects of these traits.

MATE RIALS AND METHODS

The present study was carried out at the Maryout Research Station, Desert Research Center, Ministry of Agriculture, throughout two successive years from 2006 to 2007. Monthly fluctuations of the min max, average temperatures and RH during the experimental period were estimated (Table 1). Means of temperature and RH of seasons (summer, autumn, winter and spring) were also estimated (Table 2).

The turkey stock consisted of the local Black Baladi (BB) variety which was introduced to the station from El-Minea Government (Amin, 1999), and commercial White Nicholas (WW) strain. The breeding plan permitted the simultaneous production of the two pure strains (BB and WW) and their reciprocal crosses (BW and WB). In artificial insemination, one male was mated to 5 females biweekly. The pure varieties and reciprocal crosses offspring were obtained in one hatch. At hatching, poults were pedigreed, wing banded and reared on litter floor pens until 52 weeks of age. The hens were given stimulatory lighting of 16 h per day with intensity 51 LX when they approximately 39 weeks of age. Poults were fed a starter ration contained 28 % crude protein and 2860 kcal ME/kg until 4 weeks of age, after that, birds received a growing ration contained 22% crude protein and 2950 Kcal ME/kg. At 20 weeks of age, a laying ration containing 15.5 % crude protein and 2920 Kcal ME/kg was given. Feed and water were supplied ad libitum. Pullets were vaccinated according to a vaccination program recommended by the Maryout Research Station in floor brooders. The birds were sexed and housed in pens at 20 weeks of age .Hens of each of the two varieties and their crosses were divided at random into four groups. Each group was composed of seven pens and all pens were containing five pullets.

Settable eggs were sanitized and stored in an egg cooler at approximately 13^{o}C and 70% RH .Eggs were incubated for 24 days at 37.5^{o}C and 60 % RH and then transferred into a hatch operating at 37.2^{o}C and 75 %RH. All eggs that failed to hatch after 28 days incubation were broken, opened and age at embryonic dead was determined. All unhatched eggs were categorized to early embryonic mortality (the number of embryos dead during the first week of incubation), mid embryonic mortality (the number of embryos dead during the second week of incubation), and late embryonic mortality (internal and external pip embryos).Percentage for each category was calculated for fertile setting eggs. Fertility and hatchability were estimated. Total egg loss was estimated by the number of unhatched eggs and infertile eggs. Survival rate was measured as the percentage of live chicks till the time of sexual maturity produced by the same dam. Mortality and survival rates were recorded from the day old hatch till six months of age when pullets had reached the time of sexual maturity. Fitness index has been defined as "the number of offspring produced per dam survived till the age of sexual maturity" (Lerner, 1954).

Statistical analysis:

All percentages of the hatch traits were transferred to arcsine values, while mortality traits were transformed to square root before analysis. Fertility, hatchability and embryonic mortality were analyzed by two ways ANOVA using SAS (1992).

Data of traits were analyzed using the following linear model.

$$Y_{ijk} = \mu + G_i + S_j + (GS)_{ij} + e_{ijk}$$

Where

Y_{ijk} = the observed value of the ijkth poults

μ = the overall mean,

G_i = the effect of the ith genotype,

S_j = the effect of the jth season,

GS_{ij} = the effect of the interaction between genotypes and seasons,

e_{ijk} = Random error.

Heterosis percentages were estimated according to Dickerson's methodology (Dickerson 1992) as Follows:

$$(H\ \%) = [(W \times B + B \times W) - (WW + BB)] / (WW + BB) \times 100$$

Maternal additive effect (i.e. line group of sire differences):

$$G^m_{WW} - G^m_{BB} = [(B\times W) - (W\times B)]$$

Direct additive effect (i.e. line group of sire differences):

$$G^i_{WW} - G^i_{BB} = [(B\times B) + (B\times W)] - [(W\times W) + (W\times B)]$$

Estimating Fitness Index (FI):

According to Lerner (1954 and 1958), FI can be estimated by measuring three main traits in turkeys, fertility percentage (F), rate of egg production (P) and rate of survival (S). Fitness index is the byproduct of these traits and can be estimated as the geometric mean as follows:

Fitness Index = $[(F \times P)^{½} \times S]^{½}$

Where:

F = Fertility,

P = Rate of egg production, and

S = Survival rate.

RESULTS AND DISCUSSION

Monthly fluctuations of min, max, average temperatures and RH during the experiment period are presented in Tables 1 and 2. The difference in between summer and winter season's increased to 13.19°C. Highest differences were between summer and winter seasons, but the lowest differences were found between summer season and the other seasons. They were about 3.5°C and 4.7°C for spring and autumn seasons, respectively. The RH averaged between 49.3% and 60.9% during the experimental period. Similar results were obtained by Zaky (2005), who reported that, the difference in temperature between summer and winter seasons increased to 15 °C. Highest differences between max and min temperatures during May averaged 15 °C, but the lowest differences were found in December. They were about 9°C. The RH averaged between 46% and 62 % during the experimental period.

Table (1): Meteorological data of Maryout Research Station: Minimum (min), maximum (max), means of temperature and relative humidity (RH) by year and month.

Year / Month	2006				2007			
	Temperature			RH	Temperature			RH
	min	max	Mean		min	max	Mean	
January	7.5	17.5	12.5	63	7.6	18	12.8	62
February	7.1	17.0	12.05	66.5	8	17.2	12.6	65.9
March	9.1	19.5	14.1	53	8.5	20.1	14.3	55
April	11.7	25.5	18.6	48	11.9	25.9	18.9	49
May	15.2	31.5	23.35	49	16	32	24	49.5
June	19.5	31.5	25.5	50	19.8	32.1	25.95	50.5
July	16.4	34.7	25.55	51	17	34.9	25.95	53
August	21.3	33.9	27.6	55.5	21.9	35	28	56.2
September	18.1	31.5	24.4	57.5	18.9	33	25.95	57.1
October	15.4	26.3	20.85	56	15.6	28	21.8	55.1
November	12.3	23.2	17.75	63.5	12.8	23.9	18.35	61.2
December	9.1	19.5	13.3	60.1	10.1	20.1	15.1	62.3

Table (2): Means of temperature and Relative humidity (RH) by season.

Seasons	Summer	autumn	Winter	Spring
Temperature	26.24	21.51	13.05	22.71
RH	55.05	58.40	60.90	49.33

1- Fertility, %:

Genotypes had significant effect on fertility by season (Table 3). Egg set by pullets of pure BB variety and BW cross had the highest fertility for all seasons compared to the other two genotypes. Similar results were reported in the literature (Nestor and Noble, 1995; Nestor et al., 1997; Mostafa and Younis, 2001; and Amin, 2007 and 2008). Moreover, fertility percentage appears to be decreased in the heaviest lines of turkey than the lightest lines (Amin, 2007). Similar results was obtained by (Amin, 2014) Eggs set by pullets of pure BB variety (in the 1st, 2nd and 3thgenerations) and backcross (7/8 B x 1/8 W) had the highest F% which were nearly similar (89.39%, 90.1%, 90.9 % and 88.5%), respectively compared to the other genotypes. While, those laid by WW pullets, (3/4 W x 1/4 B) and (7/8 W x 1/8 B) backcrosses had the lowest values in the same trait, through the three generations.

Regarding seasons effects on fertility, winter and spring seasons had the highest fertility followed by autumn season, while summer was the lowest fertility percentage (Table 3). These results were agreement with Younis and Abd El-Ghany (2003). The variation in fertility between seasons may be due to some environmental factors such as ambient temperature and relative humidity.

The estimates of heterosis, maternal additive effect and direct additive effect for fertility were positive (0.57%, 2.06 and 11.54, respectively). The values of maternal additive effect showed that the offspring of the BW mating had better performance than those of the WB mating for fertility. These results were in agreement with that reported by Godwin et al. (2005).They found that egg fertility of hybrid EUROFP turkey breeder was 90 %. In addition, Mostafa (2011) found that direct additive and direct maternal genetic effects for fertility were – 7.79 and 4.02, respectively. He also reported that pullets sired or mothered by egg line were superior in fertility. In chickens; Khalil et al. (2004) found that direct additive effect of White Leghorn as sired hens had higher values of direct additive effects than Baladi Saudi - sired hens.

2- Hatchability, % of total eggs (HTE) & fertile eggs (HFE):

Significant differences among genotypes by seasons for hatchability of fertile eggs (HTE) were observed (Table 4). Eggs set by pullets of the pure local variety (BB) had the highest THE (74.1 %). While, the pure commercial strain (WW) was the lowest in THE (55.2%). In addition, eggs of pullets of the local (BB) or commercial (WW) turkeys which were mated to the local variety (BB) were significantly superior in THE than the other genotypes (Table 4). Similar results were obtained by Mostafa and Yoins (2001) and Amin (2007 and 2014) who reported significant differences among different genotypes, lines and strains in HTE. In contrary, Gad et al. (1991), Nestor and Noble (1995) and Nestor et al. (1997) found no significant difference between two random bred populations of turkeys. Regarding seasons, winter had the highest THE, followed by autumn and spring, while summer was the lowest in THE (Table 4).

Concerning hatchability of fertile eggs (HFE), the same trend was observed (Table 5). The eggs of pure BB variety had the highest overall mean of HFE (82.3%), while the lowest value was for the pure WW eggs (68.9%). The reciprocal crosses (BW and WB) improved HFE by about 25.40% and 9.19%, respectively compared to the pure WW eggs. No significant differences between seasons for the overall means of HFE were observed (Table 5). Contrary to these results, seasons had significant effects on HFE (Mohapatra et al., 1986; Mostafa and Younis, 2001).

Heterosis% for HTE and HFE were positive (0.07% and 0.7%, respectively). Maternal additive and direct additive effects were positive for HTE (9.0 and 27.9) and HFE (8.7 and 22.1), respectively. These values of maternal additive effect showed that the offspring of the BW mating had better performance than those of the WB mating for HTE and HFE. In chickens, crossing between lines improved fertility and hatchability percentages compared to the pure lines (Khalil et al., 2004; Amin, 2008; Mostafa, 2011; Taha et al., 2013).

3- Embryonic mortality, % {Early (EEM), Mid (MEM), Late (LEM)}:

Based on the overall means of embryonic mortality, early (EEM) and mid (MEM) embryonic mortality % were not statistically significant between the genotypes (Tables 6, 7), while significant differences were observed between genotypes concerning late mortality % (LEM) (Table 8).

Although eggs of BB variety had the lowest EEM (1.8%) in summer season of production, they had the highest percentages in the other three seasons. However, crossing between BB varieties with WW strain enhanced EEM of both the reciprocal crosses (Table 6).

The MEM of BB variety differed significantly compared to the other three genotypes in summer and autumn seasons of production, which had the highest values (6.20% and 5.50%, respectively), while WW strain had the lowest corresponding means (1.44% and 3.52%, respectively). In winter season, WW strains had the highest mean of MEM % (6.72%), while WB cross had the highest MEM % in spring. Using two lines of turkeys and their reciprocal crosses, Christensen et al. (2007) found that crossing random bred control with one line selected for egg production and other line selected for increased body weight resulted in better embryos survival and lower death losses at piping, than those for the pure lines.

The pure BB variety had significantly the lowest LEM in compare to the other genotypes for all seasons of egg production, where means of LEM of the subsequent four seasons were 10.62%, 7.8%, 3.4% and 5.3%, respectively, while those of the WW strain were approximately double these estimates in summer and autumn seasons and approximately three times that found for BB variety in winter and spring seasons of production. The BW cross had the second rank of the LEM followed by the WB cross. These results were agreement with those reported by Gowe et al. (1993), Cahaner and Gutman (1993),Abdel- Rahman, (2000), Christensen et al. (2007) and Amin (2007, 2008 and 2014).

Heterosis% and maternal additive effect were negative for EEM (-16.7 % and -0.35) and MEM (-11.8% and -0.42), respectively. Direct additive effects were positive for EEM (0.22) and MEM (0.68). For LEM, heterosis % was positive (11.92%), while maternal additive and direct additive effects were negative (-6.37 and -17.91), respectively (Table 8).

4- Total egg loss, % (TEL):

Total egg loss % (TEL) was significantly the lowest mean for BB variety, and approximately half of that of the WW strain (Table 9). Means of TEL for BB were (33.2%, 27.3%, 19.4% and

23.4%) for the subsequent seasons, respectively.

The WW strain had the highest means of the TEL, which they were 50.7%, 46.0%, 40.0% and 45.0% for the subsequent seasons studied, respectively. The overall means of TEL for BB, BW, WB and WW genotypes were 25.8%, 30.8%, 39.8% and 45.4%, respectively. Crossing improved TEL by 32.17% and 14.53% for the two reciprocal crosses compared to the WW parent. Heterosis estimate of TEL was negative (-0.84%).The values of maternal additive and direct additive effects of TEL were negative (-9.0 and -28.6, respectively). The value of maternal additive effect showed that the offspring of the BW mating had better performance than that of the WB mating for TEL. This means that using White Nicholas (WW) poults as a dam-breed with (BB) toms as a sire-breed give an advantage for this trait. These results lead to confirm that dams of WW strain were better concerning their mothering ability versus strains. Estimate of direct additive effect indicated that using BB toms was better than WW toms for TEL. The superiority of BB as sires suggests that use of this strain as a terminal sire breed in crossbreeding programs including WW dams would be beneficial for improving this trait.

5- Mortality Rate at 0-28 wks of age, % (MR):

Genotypes had statistically significant effect on mortality rate at 0-28 wks of age (MR) (Table 10). The progeny of BB strain had the lowest significant mean of the morality rate (9.9%), while the WW strain had the highest significant mean (22.5 %) at 0-28 weeks of age. The means of MR for the crosses (BW and WB) were statistically equal (13.3 vs. 15 %) and were intermediate between both pure genotypes (Table 10). These results were in agreement with those reported by Nestor and Noble (1995), Mostafa and Nofal (2000), Nestor (1997), Nestor et. al. (1972) and Amin (2008 and 2014). Heterosis estimate of morality rate was negative (-12.6 %). The values of maternal additive effect (-1.7) and direct additive effect (-14.3) showed that using WW hens as a dam with BB toms as a sire gives an advantage for this morality rate. These results lead to confirm that dams of WW variety are better concerning their mothering ability versus strains. The superiority of BB as sires suggests that the use of this variety as a terminal sire breed in crossbreeding programs including WW dams would be beneficial for improving morality rate.

6- Fitness Index (FI):

Fitness Index (FI) can be estimated by measuring three main traits in turkeys, fertility %, egg production rate and survival rate.

Egg production rate:

Pullets of BB genotype had significantly highest egg production rate (25%) during the whole period (Table 11), compared to the other genotypes. Rate egg production of both genotypes (WW and BW) was statistically equal (16 %), while using WW as a sire, egg production rate decreased significantly to 13 % for the genotype (WB).

Heterosis (%) of RL was negative (-29.27 %) while, the values of maternal additive effect and direct additive effect of egg production rate showed that using WW a hen as a dam with BB toms as a sire gives an advantage for this trait.

Survival Rate, % (SR):

Genotypes had significant effect on survival rate (SR). The pure BB variety had significantly the highest value of SR (90.1%). While WW strain had the lowest SR (77.5%) (Table11). No significant difference in SR was observed between BW and BW crosses, which had intermediate means of SR between the pure genotypes (86.7% and 85.0%), respectively. In chickens, similar results were reported by Hossari et al. (2003b). He reported that SR was higher for Fayoumi than for Rhode Island Red (89.70 vs. 83.90 %) from one day old to age at sexual maturity. Heterosis estimate of SR was positive (2.44 %). The values of maternal additive and direct additive effects were positive (1.7 and 14.3, respectively). Generally, using White Nicholas (WW) turkeys as a dam breed with Black Baladi (BB) toms as a sire breed gives an advantage for survival rate.

Pullets of BB variety had the highest estimate of fitness index (FI) (65.26) compared to the other genotypes, while, WW poults had the lowest FI (52.51) (Table 11). These results were agreement with reported by Amin, (2014) who found that BB variety in the 1st, 2nd and 3thgenerations and backcross of 7/8 B x 1/8W had the highest values of fitness index (65.3, 67.7, 66.7 and 62.3, respectively), and SR% (90.1%, 92.9%, 91.5% and 90.1%, respectively) compared to the other genotypes, while, the progeny of WW poults had the lowest values for fitness index and SR% in the three studied generations.

Moreover, FI of both crosses (BW and WB) were 56.67 and 53.02, respectively. In chickens, the pure local breed in Egypt (Fayoumi breed) was superior for fitness over others (Rizk and EI-Ibiary, 1960; Nordskog and Philips, 1960). In addition, Hossari et al. (2003b) estimated FI for three developed strains (Bn, Gm and Sm). They found insignificant difference between the estimates of FI for the strains adapted for several years in Egypt. Their estimates of FI were 72.88, 73.67, and 73.9.1, respectively.

Heterosis of FI was negative (-6.68%) while, the values of maternal additive effect and direct additive effect were positive (3.60 and 16.4), respectively (Table 11).

In chickens, Hossari and Dorgham (2000) crossed three local strains of chickens.

Table (3): Means± SE of fertility %, heterosis %, maternal additive effect and direct additive effect for the local Black Baladi (BB), White Nicholas (WW) turkey and their reciprocal crosses by season

seasons / Genotype	Summer %		Autumn %		Winter %		Spring %		Overall %	
	Actual	**Corrected**	**Actual**	**Corrected**	**Actual**	**Corrected**	**Actual**	**Corrected**	**Actual**	**Corrected**
BB	85.3[b]	67.2±0.3	89.5[a]	80.0 ±0.7	92.3[a]	73.6±0.4	90.4[a]	71.6 ±0.6	89.4[A]	70.6 ±0.5
BW	82.0[b]	64.9±0.6	85.4[b]	67.2±0.9	90.0[a]	71.6 ±0.6	87.0[a]	68.9 ±0.5	86.2[B A]	68.0 ±0.5
WB	80.3[c]	63.4 ±0.3	83.5[bc]	65.6 ±0.7	87.3[ab]	68.9 ±0.4	85.3[b]	67.2 ±0.4	84.1[B]	66.4±0.5
WW	75.8[e]	62.7±1.7	77.5[ce]	61.3±0.7	84.7[b]	67.2 ±0.8	81.6[c]	64.9±0.7	79.9[C]	63.4 ±0.1
Overall	80.9[Z]	64.2 ±0.7	83.9[Y]	66.4 ±0.7	88.6[X]	70.5 ±0.7	86.1[X]	68.0±0.5		
Heterosis (%)									0.570	
Maternal additive effect									2.060	
Direct additive effect									11.54	

a–e: Different letters between means of genotype season interactions are significant (P<0.05).
A–C: Different letters between overall means of genotypes are significant (p<0.05).
X-Z: Different letters between overall means of seasons are significant (p<0.05).

Table (4): Means± SE of hatchability of total eggs %, heterosis%, maternal additive effect and direct additive effect for the local Black Baladi (BB), White Nicholas (WW) turkey and their reciprocal crosses by season

seasons / Genotype	Summer %		Autumn %		Winter %		Spring %		Overall %	
	Actual	**Corrected**	**Actual**	**Corrected**	**Actual**	**Corrected**	**Actual**	**Corrected**	**Actual**	**Corrected**
BB	$66.7^{b\,c}$	55.6±0.8	$72.5^{a\ b}$	58.1±0. 1	80.6^{a}	64.1±0.9	76.6^{a}	60.7±0.9	74.1^{A}	59.3±0.9
BW	60.3^{a}	50.8±1.3	69.4^{b}	56.2±1.5	75.3^{a}	60.0±1.3	71.9^{b}	58.1±1.3	69.2^{B}	56.2±1.5
WB	55.0^{e}	47.9±0.7	60.0^{d}	50.8±0.8	65.5^{c}	54.2±0.8	60.2^{d}	50.8±0.9	60.2^{C}	50.8±0.7
WW	50.2^{d}	45.0±0.1	54.5^{d}	47.3±0.1	60.7^{c}	51.4±1.1	55.2^{d}	47.9±0.1	55.2^{D}	47.9±0.8
Overall	58.0 Z	49.6±0.9	64.0 Y	53.1±1.0	70.5 X	57.4±1.1	66.0 Y	54.3±0.8		
Heterosis (%)									0.07	
Maternal additive effect									9.00	
Direct additive effect									27.9	

a–e: Different letters between means of genotype season interactions are significant ($P<0.05$).
A–D: Different letters between overall means of genotypes are significant ($p<0.05$).
X-Z: Different letters between overall means of seasons are significant ($p<0.05$).

Table (5): Means± SE of hatchability of fertile eggs %, heterosis %, maternal additive effect and direct additive effect for the local Black Baladi (BB), White Nicholas (WW) turkey and their reciprocal crosses by season

seasons / Genotype	Summer %		Autumn %		Winter %		Spring %		Overall %	
	Actual	**Corrected**	**Actual**	**Corrected**	**Actual**	**Corrected**	**Actual**	**Corrected**	**Actual**	**Corrected**
BB	78.2^{b}	62.0±1.2	81.0^{ab}	64.2±1.4	87.3^{a}	68.9±1.2	82.8^{a}	64.9±1.5	82.3^{A}	64.9±1.4
BW	73.5^{b}	58.7±1.1	81.2^{ab}	64.4±1.0	83.5^{a}	65.6±1.7	82.5^{ab}	64.5±1.1	80.2^{A}	63.4±1.5
WB	68.5^{c}	±0.8 55.6	71.9^{b}	58.1±1.0	75.0^{b}	60.0±0.9	70.5^{b}	57.4±1.0	71.5^{B}	±0.9 58.1
WW	66.2^{c}	54.3±1.3	70.3^{b}	56.8±1.5	71.6^{b}	58.1±1.3	67.6^{c}	55.6±1.5	68.9^{B}	55.6±1.2
Overall	75.4	60.0±1.0	76.1	60.7±1.4	75.4	60.4±1.0	75.9	60.7±1.2		
Heterosis (%)									0.70	
Maternal additive effect									8.70	
Direct additive effect									22.1	

a–c: Different letters between means of genotype season interactions are significant (P<0.05).

A–B: Different letters between overall means of genotypes are significant (p<0.05).

Table (6): Means± SE of early embryonic mortality%, heterosis%, maternal additive effect and direct additive effect for the local Black Baladi (BB), White Nicholas (WW) turkey and their reciprocal crosses by season

seasons / Genotype	Summer %		Autumn %		Winter %		Spring %		Overall %	
	Actual	**Corrected**	**Actual**	**Corrected**	**Actual**	**Corrected**	**Actual**	**Corrected**	**Actual**	**Corrected**
BB	1.80 [c]	1.34±0.32	3.80 [a]	1.94±0.11	3.87 [a]	1.96±1.44	4.59 [a]	2.14±0.78	3.51	1.87±0.54
BW	2.85 [b]	±0.09 1.68	2.15 [b]	1.46±0.42	2.96 [b]	1.72±0.27	2.11 [c]	1.45±0.05	2.51	1.58±0.21
WB	2.90 [b]	±0.47 1.7	3.49 [a]	1.86±0.89	2.83 [b]	1.68±0.14	2.23 [c]	1.49±0.27	2.86	1.69±0.49
WW	3.56 [a]	1.88±0.43	2.90 [b]	1.70±0.18	2.11 [c]	1.45±0.05	3.20 [ab]	1.70±0.25	2.94	1.71±0.25
Overall	2.77	1.66±0.32	3.08	±0.50 1.75	2.99	1.72±0.18	3.03	1.74±0.41		
Heterosis (%)									-16.7	
Maternal additive effect									-0.35	
Direct additive effect									0.22	

a–c: Different letters between means of genotype season interactions are significant (P<0.05).

Table (7): Means± SE of mid embryonic mortality%, heterosis %, maternal additive effect and direct additive effect for the local Black Baladi (BB), White Nicholas (WW) turkey and their reciprocal by season

seasons / Genotype	Summer %		Autumn %		Winter %		Spring %		Overall %	
	Actual	**Corrected**	**Actual**	**Corrected**	**Actual**	**Corrected**	**Actual**	**Corrected**	**Actual**	**Corrected**
BB	6.20 ^{a}	2.48±0.28	5.50 ^{a}	2.34±0.14	3.87 ^{b}	1.96±1.45	3.94 b	1.98±0.98	4.87	2.20±0.67
BW	3.61 ^{b}	.90±0.55	3.79 $^{b c}$	1.94±0.56	3.40 ^{b}	1.84±0.44	3.62 ^{b}	1.90±0.08	3.60	1.89±0.41
WB	2.25 ^{c}	1.50±0.14	4.26 $^{a b}$	20.6±0.42	4.45 $^{a b}$	2.10±0.38	5.12 ^{a}	2.26±0.25	4.02	2.00±0.35
WW	1.44 ^{c}	1.20±0.04	3.52 ^{b}	1.87±0.07	6.72 ^{a}	2.59±0.50	3.43 ^{b}	1.85±0.11	3.77	1.94±0.16
Overall	6.40	2.52±0.28	4.26	2.06±0.21	4.61	2.14±0.2	4.02	2.00±0.22		
Heterosis (%)									-11.8	
Maternal additive effect									-0.42	
Direct additive effect									0.68	

a–c: Different letters between means of genotype season interactions are significant (P<0.05).

Table (8): Means± SE for late embryonic mortality%, heterosis %, maternal additive effect and direct additive effect for the local Black Baladi (BB), White Nicholas (WW) turkey and their reciprocal crosses by season

seasons / Genotype	Summer %		Autumn %		Winter %		Spring %		Overall %	
	Actual	**Corrected**	**Actual**	**Corrected**	**Actual**	**Corrected**	**Actual**	**Corrected**	**Actual**	**Corrected**
BB	10.6^{c}	3.25±0.63	7.80^{ce}	2.79±0.68	3.4^{e}	1.84±0.23	5.30^{e}	2.30±0.57	6.77^{C}	2.6±0.25
BW	15.3^{b}	3.90±0.89	10.2^{c}	3.19±0.61	8.5^{c}	2.91±0.09	9.50^{c}	3.08±0.78	10.85^{B}	3.29±0.54
WB	20.9^{a}	4.57±1.52	15.7^{b}	3.96±0.98	14.6^{b}	3.82±0.98	17.8^{ab}	4.21±1.01	17.22^{A}	4.14±1.21
WW	20.3^{a}	4.50±1.59	17.0^{ab}	4.12±1.08	15.9^{b}	3.98±1.01	20.0^{a}	4.47±1.55	18.31^{A}	4.27±1.25
Overall	15.2^{X}	3.9±1.22	12.7^{XY}	3.56±0.80	10.6^{Y}	3.25±0.60	13.2^{X}	3.63±0.10		
Heterosis (%)									11.92	
Maternal additive effect									-6.37	
Direct additive effect									-17.91	

a–e: Different letters between means of genotype season interactions are significant (P<0.05).
A–C: Different letters between overall means of genotypes are significant (p<0.05).
X-Y: Different letters between overall means of seasons are significant (p<0.05).

Table (9): Means± SE for total egg loss % (unhatched eggs), heterosis %, maternal additive effect and direct additive effect for the local Black Baladi (BB), White Nicholas (WW) turkey and their reciprocal crosses by season.

seasons / Genotype	Summer %		Autumn %		Winter %		Spring %		Overall %	
	Actual	**Corrected**	**Actual**	**Corrected**	**Actual**	**Corrected**	**Actual**	**Corrected**	**Actual**	**Corrected**
BB	33.2 ^{c}	35.1±1.52	27.3 ^{d}	31.3±1.12	19.4 ^{e}	26.2±1.09	23.4 ^{de}	28.7±0.99	25.8 ^{D}	30.7±1.19
BW	39.7 ^{b}	39.2±1.71	30.7 ^{c}	33.8±1.02	24.7 ^{d}	30.0±1.04	28.2 ^{cd}	31.2±0.89	30.8 ^{C}	33.8±1.21
WB	45.0 ^{a}	42.1±1.95	40. 0 ^{b}	39.2±2.45	34.5 ^{bc}	36.3±1.45	39.8 ^{b}	39.2±1.89	39.8 ^{B}	39.1±1.96
WW	50.7 ^{a}	45.6±2.31	46.0 ^{a}	42.7±3.55	40.0 ^{b}	39.2±2.57	45.0 ^{a}	42.1±1.98	45.4 ^{A}	42.2±2.94
Overall	24.6 ^{Z}	30.0±1.05	35.98 ^{X}	36.9±2.20	29.7 ^{Y}	33.2±1.50	34.0 ^{X}	35.7±1.10		
Heterosis (%)									-0.84	
Maternal additive effect									-9.00	
Direct additive effect									-28.6	

a–e: Different letters between means of genotype season interactions are significant (P<0.05).

A–D: Different letters between overall means of genotypes are significant (p<0.05).

X-Z: Different letters between overall means of seasons are significant (p<0.05).

Table (10): Means± SE of mortality rate %from 0-28 wks of age, heterosis%, maternal additive effect and direct additive effect for the local Black Baladi (BB), White Nicholas (WW) turkey and their reciprocal crosses.

Genotype	mortality rate	
	Actual	**Corrected**
BB	9.90 [C]	3.14±1. 1
BW	13.3 [B]	3.64±1. 2
WB	15.0 [B]	3.87±1. 4
WW	22.5 [A]	4.74±2.21
Heterosis (%)	-12.6	
Maternal additive effect	-1.7	
Direct additive effect	-14.3	

A–C: Different letters between genotypes are significant (P<0.05).

Table (11): Means ± SE for survivor%, egg production %, fitness index, heterosis %, maternal additive effect and direct additive effect for the local Black Baladi (BB), White Nicholas (WW) turkey and their reciprocal crosses.

Genotype	Survival %		Egg production %		Fitness index
	Actual	**Corrected**	**Actual**	**Corrected**	
BB	90.1 [a]	71.6±5.44	25 [a]	5.0±4.1	65.26
BW	86.7 [b]	68.9±4.75	16 [b]	4.0±1.1	56.67
WB	85.0 [b]	67.2±4.11	13 [c]	3.6±1.1	53.02
WW	77.5 [c]	61.5±3.95	16 [b]	4.0±2.0	52.51
Heterosis (%)	2.44		-29.27		-6.86
Maternal additive effect	1.70		3.000		3.65
Direct additive effect	14.3		12.00		16.4

a–c: Different letters between genotypes for each trait are significant (P<0.05).

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الملخص العربى

تأثير الخلط والموسم على صفات الموائمة فى الرومى

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تم الخلط بين صنفين من الرومي (البلدي الأسود BB والنيوكلاس الأبيض WW). تم قياس قوة الهجين, التأثير الأبوى والتأثير الأموى لصفات الموائمة بألاضافة الى تأثير الموسم. خطة التربية أعتمدت على قياس الإنتاج للصنفين النقيين (BB وWW) والخليط (BW) والخليط العكسي (WB) خلال عامين متتاليين ٢٠٠٦-٢٠٠٧ . الخلط والموسم كان له تأثير معنوي على معظم صفات الموائمة التي تم دراستها (الخصوبة، الفقس، النفوق الجنيني المتأخر، الفاقد الكلى من البيض، نسبة النفوق، معدل الحياتية ودليل الخصوبة). التفاعل بين التركيب الوراثي والموسم كان له تأثير معنوي على كل صفات الموائمة. بيض الدجاجات BB و البيض الناتج من تزاوج دجاجات الرومي WW مع ذكور الرومي الأسود BB كان الأعلى متوسط في معظم صفات الموائمة .قياسات نسب قوة الهجين لصفات الصلاحية تدل على الخليط BW له تأثير تفوقي في قوة الهجين عن الخليط WB. قيم التأثيرات الأموية والأبوية أظهرت تفوق الرومي BB بأعتباره ذكر لذلك يمكن أستخدامة في برنامج خلط يشمل النيوكلس الأبيض كأم يكون مفيد في تحسين صفات الصلاحية .يمكن نستخلص أن خلط صنف الرومي الأسود BB مع الرومي WW يؤدى الى تحسين صفات الخصوبة، الفقس، النفوق الجنيني المتأخر، الفاقد الكلى من البيض، نسبة النفوق، معدل الحياتية ودليل الخصوبة.