Diallel crossing analysis for livability data involving two standard and two native Egyptian chicken breeds

M M Iraqi, E A Afifi, A M Abdel-Ghany[*] and M Afram[**]

Animal Production Department, Faculty of Agriculture at Moshtohor, Zagazig University, Benha Branch, Egypt
[*] *Animal Production Department, Faculty of Agriculture, Suez Canal University, Ismailia, Egypt*
[**] *Animal Production Research Institute, Ministry of Agriculture, Dokki, Cairo, Egypt*
iraqi@yalla.com

Abstract

Two local breeds, namely Fayoumi (FA) and Dandarawi (DA) and two exotic ones named Rhode Island Red (RIR) and White Leghorn (WL) were used in 4x4 diallel cross mating system. Thirty-two breeding pens were used. Two sires were mated to 16 dams in each breeding pen. Progeny of F_1 of all breed groups (16 groups) were produced in three hatches within two years. Records of 7285 chicks were used to estimate purebreds, heterosis, general (GCA) and specific (SCA) combining abilities, maternal ability (MA) and reciprocal or sex-linked (SL) effects on livability traits. A simple additive genetic model was used to analyze adjusted livability records (expressed as numbers alive counted from hatch up to 12 weeks of age) to determine the crossbreeding effects responsible for the differences among breeding groups.

Results showed that WL chicks had superiority in livability percentage over all purebreds during all the studied periods, followed by RIR. Differences between means of livability of exotic and native breeds were significant ($P<0.05$). Most of crossbreds had higher livability than purebreds. Heterotic effect was highly significant ($P<0.01$) on livability traits during all the studied periods. Crossbreds of FAxDA gave the highest heterotic effect for livability percentage during all the studied periods, except at 12 weeks of age. Crossbreds of RIRxFA, WLxFA and WLxDA, respectively ranked as the first, second and third for economic heterosis of complementary traits (livability and body weight). They were 37.6, 31.2 and 25.0%, respectively. Significant ($P<0.01$) differences among purebreds for the effects of MA, GCA, SCA and SL were obtained on all livability traits. The DA breed gave the highest and positive effect of GCA on all livability traits. The FA had superior estimates for MA in all studied traits. Clearly, the RIRxFA and WLxDA crosses gave the highest and positive estimates of SCA for most traits of livability traits compared to the other crossbreds. The WLxDA cross had superior SL effects for traits at 8 and 12 weeks of age.

From the previous results, it could be concluded that RIR sires (as an exotic breed) and FA dams (as a native breed) would be selected to produce broilers with higher viability in Egypt through crossbreeding programs.

Key words: Economic heterosis, general and specific combining abilities, maternal effect, purebreds, sex-linked effect and livability traits.

Introduction

Crossbreeding is one of the tools for exploiting genetic variation. The main purpose of crossing in chicken is to produce superior crosses (i.e. make use of hybrid vigor), to improve fitness and fertility traits and to combine different characteristics in which the crossed breeds were valuable (Willham and Pollak 1985; Hanafi and Iraqi 200 1). Crossbreeding uses pure- or line-breeding to improve economic traits through the use of complementarity traits or economic heterosis. Complementarity is often very important to success the crossbreeding programs. Often positive complementarity arises because of a multiplier trait, e.g., reproduction and viability traits. Moreover, as with single trait heterosis, however, economic heterosis may be negative (Van Vleck 1993). Heterosis caused by dominance is proportional to heterozygosity and dominance was broadly believed to be the sole cause of heterosis in animals. However, epistasis was shown to be a major mechanism of heterosis in chicken (Sheridan 1981). For the most part, heterosis resulting from epistasis is complicated or hardly attainable to predict because of the number and type of interactions are usually unknown and it could also be affected by dominance. Likewise, diallel crossing schemes makes accessible the assessment of general and specific combining abilities as well as maternal and sex-linked consequences (Griffing 1956a and b).

Livability is a composite character concerns the question of the adaptive value for the organism. Furthermore, it relates to all physiological steps leading from genotype to the resultant phenotype. Livability shows less overall genetic variation weighted against other economic traits (Hill and Nordskog 1958, Khalil et al 1999). Heterosis for livability results from a complex interaction of the specific effects of several diseases and stresses. The productivity and economics of chicken farming depends, among many aspects, upon their livability. However, few studies have been published on the genetic comparison between purebred and crossbred chicken breed groups for livability traits and no reports are available on complementary traits. Therefore, this study was conducted to evaluate genetically livability traits the age intervals of hatch-2, 2-4, 4-6, 6-8 and 8-12 weeks of age using two exotic breeds (Rhode Island Red, RIR and White Leghorn, WL) and two indigenous ones (Fayoumi, FA and Dandarawi, DA) as well as their reciprocal crosses to evaluate the potential of additive and non-additive effects for improving livability traits during the growing period through estimating some inheritance effects (mating group, general and specific combining abilities as well as maternal and sex linkage consequences) besides individual, direct and economic heterotic effects on livability traits.

Materials and methods

Breeding plan and management

This study was carried out at El-Qanater Poultry Research Station, Animal Production Research Institute, Ministry of Agriculture, Egypt. Two local breeds namely Fayoumi (FA) and Dandarawi (DA) and two exotic ones named Rhode

Island Red (RIR) and White Leghorn (WL) were used in 4x4 diallel mating system. Breeds of RIR and WL are the most well spread and adapted to the condition of Egypt, while FA and DA might be regarded as the principal well characterized local breeds of chicken.

All possible purebreds (4 groups) and crossbreds (12 groups) were made among the four breeds. A total number of 16 sires and 128 dams randomly chosen from each breed were used as parents. Thirty-two breeding pens were used. In each breeding pen, two sires were mated to 16 dams to constitute a particular cross which was repeated twice. Each sire was represented in the three hatches. All eggs produced from each breeding pen were individually recorded according to breed group and collected daily for a ten days period. Progeny of F_1 of all breed groups (16 groups) were produced in three hatches within two years. On day of hatch, all chicks were wings banded to keep their breed groups. The chicks were brooded and reared from hatch up to 12 weeks of age at the floor which heated by kerosene. Chicks were fed *ad libitum* using ration contained 22.4 % crude protein, 4.8 % fat and 6.8 % fibers. All chicks were vaccinated, medicated and subjected to the same managerial conditions.

Data and statistical analysis

Livability data of 7285 chicks were individually recorded during the intervals of hatch-2 (L2), 2-4 (L4), 4-6 (L6), 6-8 (L8) and 8-12 (L12) weeks of age. Birds were given the code 1 or 0 to represent their situation if they were alive or dead at a specific age, respectively. Data of livability traits were analyzed using SAS program under Windows (SAS 1996) according to the following linear model:

$$y_{ijklm} = \mu + G_i + H_j + S_k + Y_l + (GH)_{ij} + (GS)_{ik} + (HS)_{jk} + (GHS)_{ijk} + e_{ijklm} \qquad \textit{Model (1)}$$

Where:
y_{ijklm}= the m^{th} observation on the bird hatched in the l^{th} year of the k^{th} sex in the j^{th} hatch of the i^{th} breed group,
μ= the overall mean,
G_i= the fixed effect of the i^{th} breed group,
H_j= the fixed of the j^{th} hatch,
S_k= the fixed effect of the k^{th} sex,
Y_l= the fixed effect of the l^{th} year,
$(GH)_{ij}$= the fixed effect of interaction between i^{th} breed group and j^{th} hatch,
$(GS)_{ik}$= the fixed effect of interaction between i^{th} breed group and k^{th} sex,
$(HS)_{jk}$= the fixed effect of interaction between j^{th} hatch and k^{th} sex, and
$(GHS)_{ijk}$= the fixed effect of interaction among i^{th} breed group, j^{th} hatch and k^{th} sex, and
e_{ijklm}= the random error of the m^{th} bird assumed to be independently randomly distributed (0, σ^2_e).

Genetic analysis

Data adjusted for the fixed effects were analyzed using the following model suggested by Kidwell et al (1960):

$$y_{hijk} = \mu + a_h + p_{ii} + g_i + g_j + m_j + c_{ij} + r_{ij} + e_{hijk} \qquad (Model\ 2)$$

Where:
y_{hijk}= the kth observation on the individual bird produced from the ith breed of sire and the jth breed of dam in the hth type of breeding (purebred or crossbred),
μ= the overall mean,
a_h= an effect common to progeny of the hth type of breeding,
P_{ii}= the effect common to all progeny of a mating between of the ith breed of sire and the ith breed of dam,
$g_i(g_j)$= the effect of general combining ability (GCA) of the ith(jth) breed,
m_j= the effect of maternal ability (MA) for the jth breed of dam,
c_{ij}= the effect of specific combining ability (SCA) of the ijth or jith cross $(i \neq j)$,
r_{ij}= the sex-linked or reciprocal effect (SL) of the ijth cross $(i \neq j)$
and e_{hijk}= random error.

This model was used to test the significance and to estimate the effects of heterosis, purebreds, maternal, GCA, SCA and SL by applying the restrictions suggested by Harvey (1979).

Results and discussion

Means of genetic groups

Least squares means presented in Table 1 show that White Leghorn (WL) chicks had superiority over all pure breeds livability during all the studied periods, followed (in most cases) by Rhode Island Red (RIR) with no signifivant difference between the two standard breeds till the 6th week of age.

Table 1. Least-squares means and standard errors for livability traits from hatch up to 12 weeks during different age intervals for purebred and crossbred chicks.

Effect^{+}	**No of chicks**	**L2^{++}**	**L4^{++}**	**L6^{++}**	**L8^{++}**	**L12^{++}**
		Mean±SE	**Mean±SE^{bcde}**	**Mean±SE^{bc}**	**Mean±SE^{c}**	**Mean±SE**
Genotype group:						
Purebred:						
RIR	550	94.4 ±0.02^{cde}	93.5±0.02^{bcde}	92.8±0.02^{bc}	90.6±0.02^{c}	79.0±0.03^{de}
WL	207	96.7 ±0.03^{cde}	96.5±0.04^{bc}	95.7±0.04^{b}	95.1±0.05^{ab}	88.2±0.05^{ab}
FA	736	86.3 ±0.02^{gh}	81.5±0.02^{h}	72.7±0.02^{e}	69.4±0.03^{g}	56.2±0.03^{h}
DA	550	91.9 ±0.02^{ef}	89.5±0.02^{fg}	86.1±0.03^{d}	85.1±0.03^{e}	80.0±0.03^{e}
Crossbred:						
RIR-WL	489	87.8 ±0.03^{h}	86.4±0.03^{g}	84.1±0.03^{d}	77.6±0.04^{f}	66.7±0.04^{g}
WL-RIR	486	94.4 ±0.02^{cde}	94.1±0.02^{bcde}	92.1±0.02^{bc}	89.6±0.03^{bc}	73.5±0.03^{de}
RIR-FA	651	89.7	89.6±0.02^{ef}	88.9±0.02^{c}	86.6±0.02^{cd}	81.1±0.02^{cd}

		±0.01^{fg}				
FA-RIR	497	95.9 ±0.02^{abc}	95.1±0.02^{bcd}	92.0±0.02^{bc}	90.7±0.02^{bc}	85.6±0.03^{bc}
RIR-DA	441	95.7 ±0.02^{cde}	95.3±0.03^{bcd}	92.4±0.03^{bc}	90.6±0.03^{bc}	77.8±0.04^{cde}
DA-RIR	389	95.4 ±0.03^{abc}	94.5±0.04^{bcd}	93.0±0.04^{bc}	89.5±0.05^{bc}	79.9±0.05^{cde}
WL-FA	394	93.1 ±0.02^{efd}	92.1±0.02^{def}	90.5±0.03^{c}	87.1±0.03^{de}	82.0±0.03^{de}
FA-WL	261	96.2 ±0.02^{cde}	95.2±0.03^{bc}	93.4±0.03^{b}	88.6±0.03^{bc}	81.1±0.04^{bc}
WL-DA	248	99.0 ±0.02^{ab}	98.4±0.02^{ab}	97.0±0.03^{b}	90.0±0.03^{c}	81.7±0.04^{cde}
DA-WL	225	100.0 ±0.02^{a}	100.0±0.02^{a}	99.4±0.03^{a}	97.4±0.03^{ab}	92.3±0.03^{a}
FA-DA	491	95.9 ±0.02^{cde}	95.7±0.02^{bcd}	95.1±0.02^{b}	91.1±0.02^{bc}	84.7±0.03^{cd}
DA-FA	670	94.6 ±0.02^{cde}	93.4±0.02^{cde}	88.7±0.02^{d}	83.8±0.03^{ef}	75.2±0.03^{f}

$^{+}$*RIR= Rohde Island Red; WL= White Leghorn; FA= Fayoumi; DA= Dandarawy.*
$^{++}$*L_2, L_4, L_6, L_8 and L_{12}= livability during the growth intervals hatch – 2, 2-4, 4-6, 6-8 and 8-12 weeks of age.*
Means with the different letters in each column are significantly different (P<0.05).

However, when considering the native breeds, it was obvious that Dandarawi chicks (DA) significantly surpassed Fayoumi (FA) ones in their livability during all periods under consideration. In this respect, livability differences among purebred shown in Table 2, were highly significant (P<0.01). On the other hand, Khalil et al (1999) found non-significant differences between White Leghorn and Baladi Saudi chickens. Also, Custodio (2000) revealed that the differences among breeding types were not statistically significant.

Table 2. F-ratios and significance of least-square analysis of variance of factors affecting livability traits from hatch up to 12 weeks of age in chickens.

Source of Variation	L2^{+}		L4^{+}		L6^{+}		L8^{+}		L12^{+}	
	df	**F-value**	**df**	**F-value**	**df**	**F-value**	**df**	**F-value**	**df**	**F-value**
Heterosis	1	9.92**	1	18.96**	1	26.70**	1	9.06**	1	10.23**
Purbred	3	13.24**	3	21.91**	3	42.64**	3	40.31**	3	45.92**
GCA	3	6.72**	3	5.98**	3	5.57**	3	3.18**	3	2.02
Maternal	3	7.47**	3	6.04**	3	4.85**	3	5.05**	3	3.28*
SCA	2	5.02**	2	5.09**	2	5.93**	2	8.39**	2	19.74**
Sex-linked	3	2.33	3	2.48	3	2.65*	3	6.09**	3	4.68**
Error d.f.	7269		7269		7269		7269		7269	
Error M.S.		0.0758		0.0974		0.1306		0.1636		0.2168

GCA= General combining ability; SCA= Specific combining ability; MA= Maternal ability.
$^{+}$ *traits as defined in Table 1.*
**= P<0.05; ***= P<0.01.*

When compared between purebred and crossbred chicks, results show that crossbreds gave higher livability percentage at all the studied periods. Results in Table 3 showed that crosses increased the general mean by 1.25, 1.96, 2.69, 1.75 and 2.14 % for L2, L4, L6, L8 and L12, respectively. These results could constitute an encouraging factor for poultry producers in Egypt to cross their native breeds with the exotic ones. Conversely, Khalil et al (1999) found that livability traits in purebreds were higher than crossbreds of White Leghorn with Saudi Arabia chickens.

Table 3. Least-squares constants (Con.) and standard error (S.E.) for livability traits from hatch up to 12 weeks of age in chickens.

Item*	**L2+**	**L4+**	**L6+**	**L8+**	**L12+**
	Con.±S.E.	**Con.%±S.E.**	**Con ±S.E.**	**Con.%±S.E.**	**Con.±S.E.**
μ	93.6±0.00	92.2±0.00	89.5±0.00	86.8±0.00	78.0±0.01
Type of mating:					
Pure	-1.25±0.01	-1.96±0.01	-2.69±0.01	-1.75±0.01	-2.14±0.01
Cross	1.25±0.00	1.96±0.00	2.69±0.00	1.75±0.01	2.14±0.01
Purebreds:					
RIR	2.08±0.01	3.24±0.01	5.97±0.02	5.54±0.02	3.11±0.02
WL	4.43±0.02	6.28±0.02	8.90±0.03	10.1±0.03	12.4±0.03
FA	-6.05±0.01	-8.78±0.01	-14.1±0.01	-15.6±0.01	-19.6±0.02
DA	-0.45±0.01	-0.74±0.01	-0.76±0.02	0.03±0.02	4.11±0.02
GCA:					
RIR	-0.91±0.01	-0.95±0.01	-1.23±0.01	0.18±0.01	-2.37±0.01
WL	0.08±0.01	-0.02±0.01	0.45±0.01	-0.63±0.01	-0.51±0.01
FA	-2.20±0.01	-2.31±0.01	-2.71±0.01	-2.45±0.01	0.57±0.01
DA	3.03±0.01	3.28±0.01	3.49±0.01	2.90±0.01	2.31±0.01
MA:					
RIR	-3.13±0.01	-3.11±0.01	-2.94±0.01	-3.75±0.01	-3.34±0.01
WL	0.62±0.01	0.72±0.01	0.69±0.01	0.76±0.01	-0.71±0.01
FA	2.64±0.01	2.74±0.01	3.08±0.01	3.21±0.01	3.26±0.01
DA	-0.13±0.01	-0.36±0.01	-0.83±0.01	-0.22±0.01	0.79±0.01
SCA:					
RIR-WL	-1.61±0.01	-1.77±0.01	-2.20±0.01	-3.02±0.01	-5.11±0.01
RIR-FA	1.33±0.01	1.67±0.01	2.11±0.01	2.62±0.01	5.05±0.01
RIR-DA	0.28±0.01	0.10±0.01	0.09±0.01	0.40±0.01	0.07±0.02
WL-FA	0.28±0.01	0.10±0.01	0.09±0.01	0.40±0.02	0.07±0.02
WL-DA	1.33±0.01	1.67±0.01	2.11±0.02	2.62±0.02	5.05±0.02
FA-DA	-1.61±0.01	-1.77±0.01	-2.20±0.01	-3.02±0.01	-5.11±0.01
Reciprocal:					
RIR-WL	1.45±0.01	1.95±0.01	2.21±0.02	3.73±0.02	2.11±0.02
WL-RIR	-1.45±0.01	-1.95±0.01	-2.21±0.02	-3.73±0.02	-2.11±0.02
RIR-FA	0.19±0.01	-0.17±0.01	-1.49±0.02	-1.44±0.02	-1.07±0.02
FA-RIR	-0.19±0.01	0.17±0.01	1.49±0.01	1.44±0.02	1.07±0.02
RIR-DA	-1.64±0.01	-1.78±0.02	-0.72±0.02	-2.29±0.02	-1.04±0.02
DA-RIR	1.64±0.01	1.78±0.01	0.72±0.02	2.29±0.02	1.04±0.02
WL-FA	0.54±0.02	0.55±0.02	0.24±0.02	-0.48±0.03	-2.43±0.03
FA-WL	-0.54±0.01	-0.55±0.02	-0.24±0.02	0.48±0.02	2.43±0.02
WL-DA	0.91±0.02	1.40±0.02	1.97±0.02	4.21±0.03	4.54±0.03
DA-WL	-0.91±0.02	-1.40±0.02	-1.97±0.02	-4.21±0.03	-4.54±0.03
FA-DA	0.73±0.01	0.37±0.01	-1.25±0.01	-1.92±0.02	-3.50±0.02
DA-FA	-0.73±0.01	-0.37±0.01	1.25±0.02	1.92±0.02	3.50±0.02

+ *traits as defined in Table 1.*

**First letters denoted to breed of sire and second denoted to breed of dam.*

As regarding, the cross of DAxWL gave higher livability percentages during all the studied periods compared with other crosses or purebreds of mating groups (Table 1). Its reciprocal cross has higher mortality rates, though it is somewhat superior compared with other crosses, and the differences between these two reciprocals crosses reveal significance from the 6 week of age onwards (Table 1). In this respect, Custodio (2000) reported that chicken thorough breds differed in mortality rate because of maternal and additive effects, while environmental and genetic maternal effects were mainly responsible for differences between reciprocal crosses.

Table 4. Estimates of heterosis percentages for livability traits from hatch up to 12 weeks of age in chickens.

Breed group[*]	**L2**[+]	**L4**[+]	**L6**[+]	**L8**[+]	**L12**[+]
Single-cross[+]					
RIR-WL	-8.1	-9.1	-10.8	-16.4	-20.2
WL-RIR	-1.2	-1.0	-2.3	-3.5	-12.0
RIR-FA	-0.7	2.5	7.4	8.2	20.0
FA-RIR	6.1	8.7	11.1	13.3	26.6
RIR-DA	2.8	4.1	3.3	3.1	-2.0
DA-RIR	5.7	8.0	12.4	11.9	18.2
WL-FA	1.7	3.5	7.4	5.9	13.5
FA-WL	5.1	7.0	10.8	7.7	12.2
WL-DA	4.9	5.8	6.7	-0.1	-2.8
DA-WL	6.1	7.7	9.3	8.1	9.8
FA-DA	7.7	12.0	19.8	18.0	24.3
DA-FA	6.3	9.2	11.7	8.5	10.4
Combined cross[++]					
RIR-WL	-4.7	-5.0	-6.5	-10.0	-16.1
RIR-FA	2.7	5.6	9.3	10.8	23.3
RIR-DA	4.2	6.0	7.8	7.5	8.1
WL-FA	3.4	5.2	9.1	6.8	12.9
WL-DA	5.5	6.7	8.0	4.0	3.5
FA-DA	7.0	10.6	15.8	13.2	17.4

[+] *traits as defined in Table 1.*
[*]*First letters denoted to breed of sire and second denoted to breed of dam*
[+]*Heterosis percent= (single cross – midparent)/midparent.*
[++]*Heterosis percent= (reciprocal crosses – midparent)/midparent*

Non-genetic effects

No significant differences among hatches in livability traits during different age intervals were obtained (Table 5, except that of L8 (P<0.05) and that of L12 (P<0.001). Sex effects were highly significant (P<0.001) on L% during all age intervals under consideration meanwhile the effects of the year of hatch was found to exert its significant (P<0.001) effects on the early stages of livability from hatch up to 6 weeks of age (P<0.001). Two-way interactions were hardly significant except at 2 and 12 week of age.In this respect, Custodio (2000) found that there were no significant differences among hatches.

Table 5. F-ratios of least-squares analysis of variance of factors affecting livability traits in chickens.

Source of variation	**Livability triats**									
	L2^{+}		**L4^{+}**		**L6^{+}**		**L8^{+}**		**L12^{+}**	
	df	**F-ratio**	**df**	**F-ratio**	**df**	**F-ratio**	**df**	**F-ratio**	**df**	**F-ratio**
Breed group (BG)	15	3.59***	15	4.37***	15	6.26***	15	5.39***	15	7.39***
Sex	1	64.92***	1	76.71***	1	108.49***	1	154.53***	1	286.93***
Hatch (H)	2	1.03	2	1.11	2	1.51	2	1.65*	2	2.3***
Year (Y)	1	13.84***	1	9.93***	1	13.20***	1	1.23	1	2.52
BG*Sex	15	1.82**	15	1.34	15	1.21	15	1.19	15	3.97***
BG*H	30	5.20**	30	1.51	30	0.93	30	0.85	30	5.29**
Sex*H	2	0.90	2	1.09	2	1.32	2	1.21	2	2.6***
BG*Sex*H	30	36.80***	30	69.35***	30	74.68***	30	3.13	30	0.01
Remainder d.f.	7188		7188		7188	7188	7188	7188	7188	
Remainder M.S.		0.0704		0.0896		0.1177		0.1477		0.1813

$^{+}$ *traits as defined in Table 1.*
**= P<0.05; ***= P<0.01; ***= P<0.001*

Heterotic effect

Results in Table 2 show that heterotic effect was positive and highly significant (p<0.001) for livability traits during all the studied periods. These results are agreement with findings of Warren (1942), Kosba et al (1981) and Sabri and Hataba (1994) and Khalil et al (1999).

Based on single-cross, heterotic effects in Table 4 were mostly positive and ranged from -20.2 to 26.6% for livability traits during different age intervals up to 12 weeks. In this respect, Kosba et al (1981) and Sabri and Hataba (1994) showed that livability of crossbred birds during different age intervals of the study were generally associated with positive heterotic effects. Moreover, heterotic effect in Table 4 indicate that superiority of FAxRIR cross (averaged 13.16% across all the studied intervals) over its reciprocal cross RIRxFA (averaged 7.48% across all the studied intervals. Also, FAxDA and DAxRIR crosses surpassed their reciprocal ones in livability. This indicated that FA sires and DA dams as well as DA sires and RIR dams gave the highest heterosis percent for livability traits. This could be an encouraging factor for using these breeds in a crossbreeding program in Egypt to improve the livability traits in our local breeds. Conversely, the RIR sires and WL dams gave the highest negative heterotic effect from hatch up to 12 weeks of age (the highest mortality rate was attained). Therefore, it must be avoided in any program of crossing.

When considering the two reciprocal crosses, results in Table 4 showed that FAxDA cross gave the highest heterotic effect, followed by RIRxFA cross for livability traits during all the studied age intervals, except at 12 weeks of age. It was increased gradually from hatch weeks up to 12 weeks of age (at marketing age). These findings suggest the presence of dominance and/or epistasis effects (Fairfull 1990) in livability associated with crossing between scrutinized local and standard breeds of chickens and/or between native ones. Khalil et al (1999) found that heterosis percentage for livability ranged from -0.5 to 4.2 % when crossing occurred between White Leghorn and Saudi chickens under hot climate conditions. Fairfull (1990) reported that heterosis percentage for livability ranged from -6.1 to 9.1 % when crossed among 24 Leghorn strains.

Results in Table 3 showed also that crosses were higher in livability traits than purebreds during all the studied periods. Directional dominance of genes may be responsible for such superiority. Theses results are in agreement with findings of Warren (1942), King and Bruckner (1952), Glazener et al (1952), Nordskog and Ghostley (1954), Morris and Skaller (1958). On the contrary, Dunnington et al (1966) and Custodio (2000) reported that mortality rates were higher in hybrids than in purebreds.

Economic heterosis (EH)

Heterosis for complementary traits of body weight and livability are given in Table 6.

Table 6. Estimates of economic heterosis percentages for complementary traits of livability and body weight from hatch up to 12 weeks of age in chickens.

Breed group*	2-Weeks		4-Weeks		6-Weeks		8-Weeks		12-Weeks	
	BW2**	BWL2	BW4**	BWL4	BW6**	BWL6	BW8**	BWL8	BW12**	BWL12
Single-cross⁺:										
RIR-WL	-8.35	-15.8	-3.09	-11.8	4.21	-7.0	3.14	-13.8	6.11	-15.2
WL-RIR	0.43	-0.8	0.37	-0.5	2.37	0.1	3.50	-0.1	5.03	-7.5
RIR-FA	-0.51	-1.5	3.62	5.5	7.10	13.9	8.23	16.1	9.00	29.8
FA-RIR	10.07	16.5	10.53	19.4	12.65	24.0	12.56	26.4	15.57	45.3
RIR-DA	4.10	6.9	8.96	13.3	16.88	20.3	11.85	15.0	13.16	10.8
DA-RIR	9.85	15.6	8.51	16.5	5.70	17.6	14.55	27.0	14.71	34.6
WL-FA	13.86	15.5	20.89	24.5	26.35	34.8	23.89	30.2	21.49	37.6
FA-WL	7.53	12.7	14.41	21.8	23.84	36.4	15.04	23.0	11.41	24.8
WL-DA	6.72	12.0	10.85	17.1	22.12	29.9	29.12	28.5	19.22	15.5
DA-WL	6.39	12.8	18.20	27.2	27.48	38.9	23.35	32.9	22.74	34.4

FA-DA	6.44	14.4	8.03	20.8	7.57	28.9	6.36	25.6	6.232	33.1
DA-FA	-3.19	2.6	3.89	13.4	7.48	20.1	5.29	14.4	3.524	15.2
Combined cross++**:**										
RIR-WL	-3.96	-8.3	-1.36	-6.2	3.29	-3.4	3.32	-6.9	5.57	-11.4
RIR-FA	4.78	7.5	7.08	12.4	9.88	18.9	10.39	21.3	12.29	37.6
RIR-DA	6.97	11.3	8.73	14.9	11.29	18.9	13.20	21.0	13.93	22.7
WL-FA	10.70	14.1	17.65	23.1	25.10	35.6	19.47	26.6	16.45	31.2
WL-DA	6.55	12.4	14.53	22.2	24.80	34.4	26.23	30.7	20.98	25.0
FA-DA	1.62	8.5	5.96	17.1	7.52	24.5	5.82	20.0	4.88	24.1

Complementary of livability and body weight traits computed as mean of body weight at certain age multiplied by mean of livability trait during the corresponding stage of age.

* *First letters denoted to breed of sire and second denoted to breed of dam.*

** *Heterosis estimates for body weights as cited by Afifi et al (2002), resulted from the same set of data analysis.*

\+ *Heterosis percent for single cross= [(single cross – midparent)/midparent] x 100.*

\++ *Heterosis percent for combined cross = [(reciprocal crosses – midparent)/midparent] x 100.*

Results, bases on single crosses, showed that FAxRIR cross ranked the first because the EH was 45.3%, followed by WLxFA cross (37.6%) and DAxRIR cross (34.6%) at 12 weeks. These percentages are high and indicate that benefits of the crossbreeding program for all related traits (Van Vleck 1993). On other hand, WLxFA and DAxRIR crosses were not be recommended based on direct heterosis for only livability trait, but now they recommended when complementarity traits are considered. So that the economic heterosis for complementary traits should be considered in crossbreeding programs to evaluate the whole program. Based on combined crosses, the RIRxFA, WLxFA and WLxDA crosses, respectively, ranked first, second and third for EH of the two traits (livability and body weight). They were 37.6, 31.2 and 25.0%, respectively. In spite of that WLxFA and WLxDA crosses were not recommended before based on heterosis for only body weight (Afifi et al 200 2), but it is preferred now based on EH for both traits. Therefore, it is recommended that poultry breeders to evaluate their crossbreeding programs based on economic heterosis for livability and growth traits. There are no publications available for economic heterosis in chickens.

General combining ability (GCA)

General combining ability was a significant source of variability (Table 2) among purebred groups (P< 0.01) on livability percentages during all the studied periods, except during 8-12 weeks (L12).

This significance indicates the importance of the additive components and refers to the way of selection applicable to improve livability in juvenile stages. Estimated constants for GCA of different breeds revealed in general positive contribution and superiority for DA breed. However, figures of FA as a native breed were mostly negative revealing that using this breed as sires with purebred groups will reduce the livability (Table 3), i.e. increase mortality, and vice versa as regard to DA ones. These results suggest that DA are the best breed of choice for use in crossbreeding programs, followed by WL and RIR breeds, exerted to produce profitable chicks during the growing period up 12 week of age.

Maternal ability (MA)

Maternal ability effect revealed that it was a significant source of variation among purebred groups ($P<0.05$ or $P<0.01$) on L% during all age stages from hatch up to 12 week of age (Table 2). MA constants estimates for different breeds (Table 3) showed generally positive contribution and superiority for FA breed. However, figures of DA as the second tested native breed were frequently negative revealing that using this breed as dams with purebred groups will reduce the livability assessing from their MA. These results suggest that dams of FA breed may choice to be used in crossbreeding programs, including WL and RIR breeds, exerted to produce viable growing chicks up 12 week of age judging from MA. This may be due to FA dams support their chicks, through the eggs, with nutrient nourishment that sustain their livability afterward. Custodio (2000) concluded that maternal effects contributed to a higher viability of the progeny from the White Leghorn dams compared to Rubronegra (Black Australorp x New Hampshire) dams whose viability was comparatively lower. He also classified maternal effect into environmental and genetic maternal effects. The higher viability of WL over RIR can be explained by a combination of additive and maternal effects. The maternal genetic effects appear confounded with maternal environmental effects in reciprocals and breeds of dams.

Specific combining ability (SCA)

Specific combining ability was a significant source of variability among the cross-bred groups for livability traits during all age intervals (Table 2). This indicate that importance of non-additive genetic component on livability traits during the tested periods. SCA constants estimates for different breeds in Table 3 showed generally that crossing between the two standard breeds (e.g. RIR and WL) or between the two native breeds, i.e. FA and DA was not associated with SCA on livability traits during the experimental period of the study (poor SCA). However, Both sorts of crossing gave negative SCA figures as a deviation from the crosses overall least squares mean. This is in turn confirm that crossing between the two standard or between the two native purebreds was not recommended when the goal is to promote livability traits during the growing period from hatch up to 12 weeks of age. Moreover, crossing (RIRxFA) or (WLxDA) were premium regarding their SCA compared versus those between (RIRxDA) or (WLxFA) revealing much more heterozygosity in the former as compared to that in the later. In this respect it is expected that using reciprocal recurrent selection would produce much more SCA between these two crosses.

Reciprocal effect or sex-linkage (SL)

Sex-linkage effect (Table 2) was a significant source of variability ($P<0.05$ or $P<0.01$) for livability traits among the crossbred groups during the later stages (from 6 up to 12 weeks of age). Constants of SL effects for different breed crosses in Table 3 showed generally that cross (i.e. RIRxWL) attained the livability traits superiority at 4 and 6 weeks, meanwhile (WLxDA) recognized it at 8 and 12 weeks of age. Cook et al (1972) described that differences among male progeny of reciprocal crosses to be attributable to maternal effects and not to sex-linkage, because the homogametic males in reciprocal crosses have comparable sex chromosomes. Hence, for Cook et al (1972), reciprocals test the possibility that sex-linkage is operative when significant differences are found among female progeny because each female receives its sex chromosome from its sire. Sabri et al (2000) reported that the magnitude of sex linkage effects is expected to be influenced by the breeds implicated in the crossbreeding scheme, which confirmed the importance of the choice breed of sire and the breed of dam in the planning of broiler crossing programs.

Conclusion

- Results of economic heterosis estimates indicated that crossing between RIR sires and FA dams as well as between WL sires and FA dams gave the highest heterotic effect for complementary traits (livability percentages and body weights).
- Ranks of crosses were changed when considered the complementary traits than direct heterosis for each trait separately.
- It is recommended that poultry breeders should evaluate their crossbreeding programs based on economic heterosis for complementary traits.
- Based on highly significant effects of purebreds, GCA, SCA, MA and SL on livability traits, therefore, these effects should be considered before planning any crossbreeding program.
- Generally, crossing among native and exotic breeds of chicken, usually, is associated with high heterotic effects on livability traits.
- Based on the Egyptian studies for local breeds, it is indicated that local breeds had high non-additive genetic effects of livability traits.
- Therefore, we need more crossbreeding programs in Egypt using native breeds (or newly improved strains) and exotic ones to promote the expansion of superior breeds and to develop superior strains from selected combinations.

References

Afifi E A, Iraqi M M,El-Labban A M and Afram M 2002 Evaluation of heterosis and combining abilities for body weight traits in chickens. Annals of Agricultural Science Moshtohor, Volume 40(2): 857-870.

Cook WT, SiegelP B and Hinkelmann K 1972 Genetic analyses of male mating behavior in chickens. II. Crosses among selected and control lines. Behavior Genetics, New York, 2 (4): 289-300.

Custodio R W S 2000 Analysis of a diallel cross involving two sources of germplasm in chickens. Ciências agrotecnicas, Lavras, 24(3): 730-737. http://www.editora.ufla.br/revista/24_3/art22.pdf

Dunnington E A, Siegel P B and Anthony N B 1966 Reproductive fitness in selected lines of chickens and their crosses. The Journal of Heredity, New York, 81: 1061-1070.

Fairfull R W 1990 Heterosis. Pp913-933 in: Poultry Breeding and Genetics. R. D. Crawford, ed. Elsevier, Amsterdam, The Netherlands.

Glazener E W, Comstock R E and Blow W L 1952 Crossbreeding for egg production. Poultry Science, Champaign, 31: 1078 -1083.

Griffing B 1956a A generalized treatment of the use of diallel crosses in quantitative inheritance, Heredity 10 (1956) 31-50.

Griffing B 1956b Concept of general and specific combining ability in relation to diallel crossing systems, Australian Journal of Biological Science 9 (1956) 463-493.

Hanafi M S and IraqiMM 2001 Evaluation of purebreds, heterosis, combining abilities, maternal and sex- linked effects for some productive and reproductive traits in chickens. Second International Conference On Animal Production and Health in Semi-Arid Areas, 4-6 September, Organized by Faculty of Environmental Agricultural Sciences, Suez Canal Univ. El Arish-North Sinai, Egypt, 2001: 545-555.

Harvey W R 1979 Least-squares analysis of data with unequal subclass numbers. Agriculture Research Services, US Department of Agriculture, USA.

Hill J F and Nordskog A W 1958 Heterosis in poultry. 3. Predicting combining ability of performance in the crossbred fowl. Poultry Science, Champaign, 37: 1159 - 1169.

Khalil M H, Hermes I H and Al-Homidan A H 1999 Estimation of heterotic components for growth and livability traits in a crossbreeding experiment of Saudi chickens with White Leghorn. Egyptian Poultry Science Volume 19(III) September: 491-507.

Kidwell J F, Weeth H J, Harvey W R, Haverland L H, Shelby C E and Clark R T 1960 Heterosis in crosses of inbred lines of rats. Genetics 45:225-231.

King S C and Bruckner J H 1952 A comparative analysis of purebred and crossbred poultry. Poultry Science, Champaign, 31: 1030 - 1036.

Kosba M A, Mahmoud I H, Khalil A Z and Abd-Allah G M 1981 A comparative study of four breeds of chickens and their F1 crosses. Body weight and chick viability. Agricultural Research Review, 59(6): 93-103.

Morris J A and Skaller F 1958 Single crossing between White Leghorn and Australorp. Australian Journal of Agricultural Research, Melbourne, 9: 842- 851.

Nordskog A W and Ghostley F J 1954 Heterosis in poultry. 1. Strain crossing and crossbreeding compared with closed flock breeding. Poultry Science, Champaign, 33: 704-715.

Sabri H M and Hataba N A 1994 Genetic studies on some economical traits of some local chicken breeds and their crosses. 1. Growth and viability. Egyptian Journal of Applied Science 9(5): 949-963.

Sabri H M, Khattab M S and Abdel-Ghany A M 2000 Genetic analysis for body weight traits of a diallel crossing involving Rhode Island Red, White Leghorn, Fayoumi and Dandarawi Chickens. Annals of Agricultural Science Moshtohor, 38: 1869-1883.

SAS 1996 SAS' Procedure Guide. "Version 6.12 Ed." SAS Institute Inc., Cary, NC, USA.

SheridanA K 1981 Crossbreeding and heterosis. Animal Breeding Abstracts 49 (3): 131-144.

Van Vleck L D 1993 Selection index and introduction to Mixed model Methods. CRC Press, London, PP 310-311.

Warren D C 1942 The crossbreeding of poultry. Agricultural Experimental Station, Manhattan, Warren, Bulletin 52.

Willham R L and Pollak E 1985 Theory of heterosis. Journal of Dairy Science 68: 2411-2417.

Received 4 May 2005; Accepted 11 June 2005; Published 1 July 2005

Go to top