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Growth Performance and Genetic Parameters of Chickens Using Full Diallel Cross Between Local and Super-Harco Breeds

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Abstract

The full diallel cross is used by both male and female reciprocally as parents in crossing design to judge the optimum offspring's performance and producing the superiority. A total number of 336 individuals belonging to Local Kurdish and Super-Harco breeds are used in this trial for as parental breeds. They are reared in Kani-Graw private field around Erbil city, Kurdistan region, Iraq. The experiment aimed to assess its growth genetic parameters and performance using diallel crossing. Body weight (BW), body length (BL), shank length (SL), keel length (KL) and body circumference (BC) were measured. General combining ability (GCA), specific combining ability (SCA), heterosis (H %), reciprocal effect (RE), maternal effect (ME) of body weight (BW) and some body measurements were studied. The findings showed highly significant ($p<0.01$) differences between the studied purebreds and their crosses for BW and most body measurement traits. GCA for BW at 10 weeks old appeared significant ($p<0.05$) difference between both studied purebreds (LL & HH) as (988.5 vs. 130.67 gm.), respectively. The highest SCA was recorded for BW of LH cross at 10 weeks old (627.5 gm.) and the lowest SCA was recorded for its KL at 1 day old (0.015 cm). ME appeared the superiority for HH dams; and H % recoded positive significant superiority for LH cross vs. negative percentages for the reciprocal one (HL). As conclusion diallel cross discovered the best sire and dam in mating system.

Keywords: chickens, diallel crossing, growth traits, genetic parameters.

1. Introduction

Indigenous breeds exhibit potential productivity when the crossings are performed on the correct bases. Obtaining high performance individuals belonging to these breeds is of great importance, because the local gene pool still supplies the local markets with chickens' products.

Full diallel design of crossing uses the same parents as males and females that makes the crossing somewhat complicated [13], but it resulted in progeny's heterosis.

Heterosis is mainly affected by the dominant genes but achieve the superiority via the epistasis mechanism [24]. The genetic diversity of local stocks of chickens may be exploited to improve the productive performance of their economic traits such as body weight, and the combining ability makes such improvement.

General combining ability (GCA) uses the additive gene effect of the parents, while the specific combining ability (SCA) utilizes the interaction between genes (dominance and epistasis) in the offspring. Therefore, the progeny of diallel cross exploit all genetic capacity to produce hybrid vigour [25, 10].The diallel crossing between Egyptian and exotic breeds of chickens for body weight trait showed the superiority of heterosis in some crosses and the GCA was pointed as the largest variation source [19].

Some investigators had utilized the diallel crossing for genetic improvement of some productive characters i.e. traits associated with morphometric characters such as body weight, weight gain, body measurements at different ages [7, 15, 16]). However, [18] reported that the direct genetic effect resulted in more variation when different breeds utilized in crossing; they added that for 3x3 cross with diallel design of different breeds (Brown Line, White Leghorn and New Hampshire), the heaviest body weight was achieved in the BR x NH cross, while the New Hampshire purebred has the highest body weight among all studied purebreds during different ages. Iraqi et al. (2002) mentioned that White Leghorn (WL) chickens had superiority in liveability rate over all studied purebreds for all intervals, while the crossbreds had better liveability than purebreds; they added that the heterotic was highly significant ($P<0.01$) for productive traits and the maximum heterosis of BW was 25 % for WL x Dandarawi (DA) with the highest estimation of SCA; and the highest effect of GCA for Dandarawi breed at most intervals[12].

Maternal effect (ME) significantly affects body weight at different ages [19, 9]. Reciprocal cross effect was mentioned as significant source of variation [12] for body weight and liveability traits at certain ages. However, shank length, keel length and body circumference are the most important body measures in local breeds of chickens[11, 3]. Significant correlation coefficients between body weight and some body measurements were reported [1, 23, 21]. The aim of this investigation is to assess the diallel cross design as genetic improvement tool for growth traits of local breeds of chickens, and to achieve the target (selecting the sire/dam).

2. Material and Method

2.1. Experimental design and management. The trial was designed as full diallel cross (2X2) to produce 4 combinations (genotypes), where the two purebreds were: Local or Local Kurdish - LL and Super Harco – HH, the cross was LH (Local cock with Harco hens), and the reciprocal cross was HL- (Harco cock with Local hens).

A total number of 336 birds were used in the present study, where 96 birds (80 females and 16 males) utilized as parent stock that were distributed as families (each family had one cock for 5 hens), while 240 birds (124 females and 116 males) were utilized as progeny flock, distributed equally on the four mentioned combinations (60 chicks for each). The birds were aged from one day up to 10 weeks. All birds were reared on the floor.

This experiment was conducted at Kani-Graw private field –around Erbil city-Kurdistan Region, Iraq.

The local breed was collected from different villages around Erbil city according to its plumage colour, while the commercial breed (Super Harco) was imported from Hungary. The Super Harco commercial breed is widely used in dual purposes. The chicks are in a good health, having been vaccinated against the most common diseases, according to the veterinarian instructions. The feeding system and lighting programme were applied according to ISA –Brown guidance.

2.2. Studied traits and parameters. The body weight (BW) in grams, and some body traits (cm) were studied. The body measurements included the following:

- Body length (BL): measured as the distance between the back neck and the tail.
- Shank length (SL): measured as the distance between the feet and the thigh.

- Keel length (KL): measured as keel bone length.
- Body circumference (BC): measured as circle body from the keel up to the dorsal region.

Also, the following genetic parameters were estimated for BW and body traits according to Falconer (1988), and Williams et al. (2000) [6, 27].

General Combining Ability **(GCA):** Calculated for both breeds as means of specific breed for giving trait [6]:

$$GCA_i = \Sigma y_i / n$$

Where:

GCA_i= the GCA for breed i;

yi = traitmeasured for the progeny belonging to a specific breed *I;*

n= the number of all crosses.

Specific Combining Ability (SCA): Calculated for the crosses as the difference between mean of cross and its reciprocal cross, and mean of GCA for both breeds, for a given trait [6]:

$$SCA_{AB} = [(AB + BA) /2 - (GCA_A + GCA_B)/2]$$

Where:

AB= the cross;

BA= the reciprocal cross

Heterosis (H %): Heterosis or hybrid vigor was calculated on the basis of percentage of mid-parents for the studied trait [27]:

$$H \% = \{F_1-[(P_1 + P_2)/2] / [(P_1 + P_2) / 2] \times 100\}$$

Where

F_1 = mean of the first generation, and

P_1 and P_2 are the parents in the diallel cross design.

Reciprocal Effect (RE): Reciprocal effect was calculated as half of the difference between the cross and its reciprocal cross for the given trait [6]:

$$RE = (y_{ji} - y_{ij}) / 2$$

Where:

y_{ji} = reciprocal cross;

y_{ij} = the cross.

Maternal Effect (ME): Maternal effect was calculated as the mean deviation of progeny for a specific dam, from mean estimated for a specific sire [27]:

$$ME = (\bar{y}_{.i} - \bar{y}_{i})$$

Where:

$\bar{y}_{.i}$ = particular dam mean;

$\bar{y}_{i}$ = particular sire mean.

2.3. Statistical analysis. The experiment was designed as diallel cross within completely randomized block design (CRBD), and the collected data were analyzed using SAS [22] software via GLM procedure, according to the following model:

$$Y_{ij} = \mu + C_i + R_j + e_{ij}$$

Where:

Y_{ij}: observations of the studied trait of the birds;

μ = overall mean;

C_i: the cross effect;

R_i: fixed effect of replication (family);

e_{ij}:random error.

The differences of the means were calculated using Duncan multiple range test [5].

3. Results and Discussions

3.1. Growth performance. The growth performance of both studied purebreds, their cross and reciprocal cross at different ages are presented in Table 1. One may observe that the live body weight of the cross (LH) at one day old has surpassed significantly ($p<0.01$) its reciprocal cross and local purebred (LL), while it didn't differ significantly ($p>0.05$) of the purebred (HH) that represents its dam. Also, the same hybrid significantly recorded the heaviest BW (436.5 and 1083 g) at 5 and 10 weeks old, respectively. These results suggest that the use of the purebred Harco as dam and the local breed as sire led to the obtaining of the desired BW. Body length of hybrid LH appeared significant ($p<0.01$) superior compared to LL and HL at 5 weeks old, while it didn't differ significantly at 1 day and 10 weeks old.

The same trend is reported for KL, while the opposite was true for SL from the age point of view. In purebred HH was recorded significantly ($p<0.01$) the lengthiest shank at 10 weeks old, and this result shows that the growth stage (before maturity) is important for bone conformation.

LH cross recorded significantly ($p<0.01$) the highest measures of BC at 1 day and 5 weeks old, this mean that BC may be reformed at early ages.

The results of the present study disagree with the findings reported by Saadey et al. (2008), who stated that, concerning BW at one day old, the purebred surpassed the crosses and reciprocal crosses of Egyptian local breeds and exotic ones, but at later age stages the crosses significantly surpassed purebreds and their reciprocal crosses [19].

Table 1. Body weight and measurements of purebreds, cross and reciprocal cross

Age	Trait	Purebred		Cross/reciprocal		SEM	Significance (P)
		LL	HH	LH	HL		
1 day old	BW	33.8[bc]	36.5[ab]	38.75[a]	32.85[c]	1.16	**
	BL	5.1	5.2	5.65	5.25	0.17	NS
	SL	1.9[ab]	1.8[b]	2.1[ab]	2.29[a]	0.08	**
	KL	2.5	2.7	2.8	2.48	0.14	NS
	BC	8.9[b]	8.7[b]	9.36[a]	8.81[b]	0.32	**
5 weeks old	BW	357[b]	390.8[b]	436.5[a]	349.2[b]	21	**
	BL	11.2[c]	13.98[a]	14.11[a]	12.33[b]	0.4	**
	SL	4.9	5.01	5.35	4.86	0.2	NS
	KL	5.8[b]	6.12[b]	6.8[a]	5.75[b]	0.32	**
	BC	20.56[b]	21.76[b]	22.97[a]	20.83[b]	0.51	**
10 weeks old	BW	937.5[b]	1064 [ab]	1083[a]	945[ab]	52	*
	BL	18.36	18.5	18.8	18.9	0.55	NS
	SL	6.05[a]	6.1[a]	5.5[b]	5.3[b]	0.2	**
	KL	10.7	11.14	11.35	11.47	0.36	NS
	BC	29.31	30.6	29.45	29.31	0.62	NS

NS= Non-significant; *=significant at p<0.05; **= significant at (p<0.01); means having common letters within each row do not differ significantly.

3.2. General combining ability (GCA). The general combining abilities are shown in Table 2. The values of the purebred HH appear to be in general higher compared to those reported in LL for majority studied traits and ages. This higher combining ability is reported in crosses when HH is used as dam not as sire, in the mating system (Table 2).

However, the general combining ability reflects the additive effect of genes across the generations, which suggests that at next generations the values of the studied characters may be higher. However, the findings indicated by Adebambo (2011), and Razuki and AL-Shaheen (2005) [17, 4], concerning GCA, confirmed the variations among different local and exotic purebreds [19].

Table 2. General combining ability for the purebreds at different ages

Character	Purebred	1 day	5 weeks	10 weeks
BW	LL	35.13	380.9	988.5[b]
	HH	36.03	392.17	1030.67[a]
BL	LL	5.33	12.55	18.69
	HH	5.37	13.47	18.73
SL	LL	2.09	5.04	5.62
	HH	2.06	5.07	5.63
KL	LL	2.59	6.12	11.17
	HH	2.66	6.22	11.32
	LL	9.02	21.45	29.36
BC	HH	8.96	21.85	29.79

Means having different letters within each trait/age differ significantly at p<0.05.

3.3. Specific combining ability (SCA). In Table 3 are presented the results of specific combining ability for the crosses that result from diallel crossing between local and exotic purebreds at different ages. It could be noticed that at 1 day and 5 weeks old, the SCAs were relatively small, but at 10 weeks old, are reported the highest values for the studied traits (i.e. SCA for BW reached 627.5 g), which certainly comes from the interaction between different genes of both purebreds.

The SCA indicating the ability of interaction to be appeared, which may has negative values too. However, most results mentioned by [19,8] concerning SCA for growth performance were negative, meaning that there were negative interactions between their genes [18].

Table 3. Specific combining ability for the cross and its reciprocal (LH & HL) at different ages

Trait	1 day	5 weeks	10 weeks
BW	0.1	6.32	627.5
BL	0.22	0.21	5.84
SL	0.12	0.05	0.35
KL	0.015	0.11	5.24
BC	0.095	0.25	7.73

3.4. Reciprocal effect. The reciprocal effects are presented in Table 4. As it shown, most values of most traits are small and negative, that means that local purebred has a negative role when it is used as dam in mating system. Thus, this investigation suggests the use of the local breeds as sires in crossings and breeding strategies in Kurdistan region. The present results agree with those reported by [8] who mentioned insignificant reciprocal effect on growth performance and disagreed with those mentioned by [26; 18] who found significant reciprocal effect in poultry crossings [10].

Table 4. Reciprocal effect (HL) at different ages

Trait	1 day	5 weeks	10 weeks
BW	-2.95	-43.65	-69
BL	-0.2	-0.89	0.05
SL	0.095	-0.245	-0.1
KL	-0.16	-0.525	0.06
BC	-0.275	-1.07	-0.07

3.5. Maternal effect (ME). The effect of dam (the maternal effect) for the studied traits are shown in Table 5. One may observe that the effect of exotic dam (Harco) is significantly higher ($p<0.05$) compared with the local one in most traits and at most ages (e.g., chickens BW at 10 weeks of age, increased by about 1200 grams when H hens were used as dams in mating, compared to about 800 g reported in local ones, L; this increasing in BW reported in L dams represents only 2/3 of BW increasing in individuals that have H dams).

Therefore, and as mentioned previously, the introducing of the exotic dams (H) in the mating system of local purebreds will result in valuable progeny. At 5 weeks old, the BW of the progeny of L dam represents just 56% of BW of the progeny of H dams, while BL of the progeny of L dam represents about 60 % of the progeny of H dam, at the mentioned age. The same, KL of the progeny of H dam surpassed KL of the progeny of L dam by about 66 %.

Concerning BC, our study shows that in progeny of H dam it surpassed significantly ($p<0.05$) the values reported in the progeny of L by about 77 %. However, the findings of [19,18] insured the present results; while the findings reported by [2] disagreed with the results of the present investigation, because they indicated no significant maternal effect or growth traits in poultry [14].

Table 5. Maternal effect of purebred dams at different ages

Trait	Dam	1 day	5 weeks	10 weeks
BW	L	27.9	269.7^{b}	799.5^{b}
	H	42.4	478.1^{a}	1202^{a}
BL	L	4.7	9.42^{b}	18.46
	H	5.6	15.76^{a}	18.4
SL	L	2.09	4.41	5.85
	H	1.61	5.5	6.3
KL	L	2.18	4.75^{b}	10.82
	H	3.02	7.17^{a}	11.02
	L	8.35	18.42^{b}	29.17
BC	H	9.25	23.9^{a}	30.74

Means having different letters within each trait/age differ significantly at $p<0.05$.

3.6. Heterosis %. The percentages of heterosis that occurs in the offspring are presented in Table 6. It could be notice from the mentioned table that LH cross had surpassed significantly ($p<0.05$) the HL crossings at 1 day of age in majority of studied traits (except SL). It means that the effect of H dam is obviously active for growth performance because shorter shank doesn't affect the productive performance. Also, at 5 weeks of age, all studied traits (including SL character) had positive hybrid vigour in LH cross, while its reciprocal cross resulted in negative counterpart values, this mean that heterosis share of the LH cross surpassed their parents, while the reciprocal cross had lower values compared with their parents. Thus, this study suggests introducing LL breed as sires in the mating system, while HH breed as dams. Anyway, these results confirm that the cross tend to improve the growth traits, and vice versa is true for reciprocal cross. The diallel cross design is very important to know which sire/dam is responsible of the genetic improvement, especially in local stocks. These results are similar to those indicated by Saadey et al. (2008), and [20, 28] who mentioned negative significant heterosis of several growth traits in some genotypes. Another experiment had insignificant heterosis for BW trait [9].

Table 6. Heterosis % of the cross and its reciprocal cross at different ages

Trait	Cross / Reciprocal	1 day	5 weeks	10 weeks
BW	LH	10.24 a	16.74 a	8.22 a
	HL	-6.54 b	-6.61 b	-5.57 b
BL	LH	9.71 a	12.07 a	2.01
	HL	1.94 b	-2.07 b	2.55
SL	LH	13.51 b	7.97 a	-9.47
	HL	23.78 a	-1.92 b	-12.76
KL	LH	7.69 a	14.09 a	3.94
	HL	-4.62 b	-3.52 b	5.04
	LH	6.36 a	8.55 a	-1.69
BC	HL	0.11 b	-1.56 b	-2.15

Means having different letters within each trait/age differ significantly at $p<0.05$.

4. Conclusion

It could be concluded from the present investigation that the diallel cross design appeared obviously that the best growth performance will be achieved when using Harco hens as dams and local Kurdish cocks as sires in mating system. This study illustrates the importance of diallel cross design in mating system of local breed for optimum performance.

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