Egyptian Journal of Rabbit Science, 31(2): 199-215 (2021)

GENERAL AND SPECIFIC COMBINING ABILITY OF GROWTH PERFORMANCE ATTRIBUTES IN RABBITS

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ABSTRACT:

This work aimed to estimate general (GCA) and specific (SCA) combining ability and reciprocal crosses (RC) effects on rabbit growth performance attributes from weaning to marketing to recognize the best suitable crossbred for rabbit breeder to use in rabbit meat production under Egyptian circumstances. A total of 123 male (59) and female (64) rabbits represents three breeds and their diallel crosses were used in this study. The pure breeds were New Zealand White (N), Papillon (P) and Flemish Giant (F). The six crossbreeds were NF, NP, FP, FN, PN, PF. The growth performance attributes were body weights at 4 (BW_4), 8 (BW_8) and 12 (BW_{12}) weeks of age, daily weight gain between 4 and 8 weeks (DG_{4-8}), 8 and 12 weeks (DG_{8-12}) and between 4 and 12 weeks (DG_{4-12}) and relative growth rate (RG) at the same interval ages (RG_{4-8}, RG_{8-12} and RG_{4-12}).

The present results showed positive interrelationship among all body weight traits. However, BW_8 was highly correlated with DG at all studied ages (r=0.61 to 0.91). There is highly negative correlation between BW4 and RG at 4-8wks and 4-12 wks of age. The genotype had significant effect on body weight at 8 and 12 weeks of age. N rabbits were recorded to be the heaviest breed at weaning (4 weeks), while PN and FN crosses were recorded to be the heaviest rabbits at market (12 weeks). Genetic groups were found to had highly significant effect on DG and RG, during all intervals age. On the other hand, effect of sex on BW, DG and RG of growing rabbits were not significant at studied intervals. Insignificant effect for GCA, SCA and RC on BW were recorded at different ages, except for the reciprocal cross effect at 12 weeks of age. The NP crossbred seemed to be the best cross combination in improving of BW. GCA, SCA and RC had significant effect ($P < 0.05$ or 0.001) on DG and RG. FN crossbred was found to be the best

genetic group among all crosses for DG and RG.

Conclusively, *the results obtained in present study suggested that Papillon is a promising breed in crossbreeding program regarding growth performance traits. Crossing of New Zealand White as a sire breed with Papillon as a dam breed, NP, would be recommended over other crosses to improve marketing weight in rabbits. However, Crossing of Flemish Giant as a sire breed with New Zealand White as a dam breed, FN, would be recommended over other crosses to improve growth rates in rabbits especially in case of marketing rabbits at constant weight to save time and cost.*

Keywords: Rabbits, Growth traits, General & specific combining ability.

INTRODUCTION

Rabbit is a small livestock species, which makes it a desirable meat producing animal. For its small body size, rabbits need a reduced space and feed. It characterized by short generation, high feed conversion efficiency and faster growth rate with high prolificacy. These characteristics made the rabbit as ideal species for meat production (Bora *et al.,* 2010) compared to other livestock species.

Enhancement in rabbit breeds performance can be achieved through selection or crossbreeding. A lot of benefits can be gained from hybridization and from break of the cumulated inbreeding, which may have occurred during continued selection process and genetic improvement of growth performance attributes (Adenaike, 2013).

A diallel cross is a cornerstone tool applied to evaluate the performance of breeds in their various combinations, especially for those native breeds (Dickerson, 1993).

Combining ability was defined as favorable genes (or features) that are transmitted to their offspring (Rojas and Sprague, 1952). In quantitative genetics, two types of combining ability, general (GCA) and specific (SCA), have been established. GCA may refers to additive effects and additive interactions, while SCA may indicate dominance and epistasis (Rojas and Sprague, 1952). GCA used to denominate the average performance of crossbred line in cross combinations, while SCA used to denominate those cases in which certain combinations do comparatively better or inferior to would be expected based on the average performance of the lines indicated (Kabir *et al.,* 2011). According to Sprague and Tatum (1942), GCA occurred due to the additive effect of genes while SCA occurred because of epistatic or dominance effect of these genes (Kabir *et al.,* 2012). Combining ability are valuable to recognize the nature of genetic variance (El-Bayomi *et al.,* 2012)

and assisting the breeder in choosing suitable parents for improving either lack of information about the effect of crossbreeding in rabbits including Papillon breed was noticed.

Therefore, objective of present work was to examine general and specific combining ability for growth performance attributes of rabbits including Papillon breed, underneath Egyptian conditions.

MATERIALS AND METHODS

Source of data:

A total rabbits of 12 New Zealand White (N),13 Papillon (P) and 12 Flemish Giant (F), as well as their direct crosses *viz* 18 NF, 12 NP and 15 FP with their reciprocal crosses *viz* 13 FN, 14 PN and 14 PF were chosen randomly at weaning (4-weeks of age) and raised to marketing age (at 12 weeks of age) to investigate the effect of general and specific combining ability for some growth performance attributes of rabbits, under Egyptian environmental circumstances. The rabbit records were obtained from private rabbit farm in Qalyubia Governorate, Egypt.

Management of animals:

The experimental rabbits were kept in the same managerial, hygienic, and housing conditions and housed provided with feeders and automatic drinkers. Throughout the experimental period from weaning at 4-weeks to marketing at 12-weeks of age. Feed and clean water were provided *ad libitum*. They were fed a commercial pelleted diets providing 18 % crude protein and 2800 KCal. digestible energy/kg diet until marketing age.

The measured traits

***Growth performance attributes*:**

1. Body weight (BW) at 4, 8 and 12 weeks of age.
2. Daily body weight gain (DG), during the period from 4-8, 8-12 and 4-12 wks.
3. Relative growth rate (RG) during the period from 4-8, 8-12 and 4-12 wks, according to Eman (2011).

Data analysis

Data were analyzed using proc GLM of SAS software (SAS institute, 2011) according to the following statistical model:

$$Y_{IJK} = \mu + G_i + S_j + e_{ijk}$$

Where: Y_{ijk}= the observed value, μ = Overall mean, G_i = i^{th} Effect of genotype(i = 1, 2,3. . 9), S_j = j^{th} Effect of sex (j=1, 2) and e_{ijk} = Random error assumed to be N.I.D (0, σ2e).

General and specific combining abilities were estimated by GSCA 1.0 program package software (Tong *et al*., 2012) with Griffing's method I according to the following model:

$$Y_{IJM} = \mu + G_i + G_j + S_{ij} + R_{ij} + e_{ijm}$$

Where:

Y_{ijm} = The m^{th} observation of the ij^{th} cross; μ is the overall mean,

G_i and G_j = Effect of general combining ability of the i^{th} and j^{th} parents, respectively,

S_{ij} = The specific combining ability effect of the i^{th} and j^{th} parents that satisfies $S_{ij}=S_{ji}$ if both exist,

R_{ij} = Reciprocal effect for the i^{th} and j^{th} parents, and

e_{ijm} = The error term assumed to be N.I.D (0, $\sigma^2 e$)

RESULTS AND DISCUSSION

Means and coefficients of variation:

Mean and coefficient of variation (CV%) for growth performance attributes are showed in Table 1. It appeared that the higher the age of animal, the smaller the variability in growth characteristics. As general trend, BW_4 was found to be more variable than older ages (BW_8 and BW_{12}) for all genotypes. For example, in pure breeds, the CV% of live body weight ranged from 14.70 to 28.41, 12.30 to 30.98 and 5.45 to 8.15 in NN, PP and FF, respectively. Comparable trend of variability for body weight was previously reported by Ezzeroug *et al.* (2019) on synthetic line, Peiró *et al.* (2019) on synthetic line and Sakthivel *et al.* (2017) on New Zealand rabbits for weaning weight (CV% = 28, 23.9 and 25.35, respectively) and marketing weight (CV%= 21, 13.8 and 14.45, respectively).

With few exceptions, the same trend of phenotypic variation was observed for daily gain and relative growth rate (Table 1, Sakthivel *et al.*, 2017). The higher variability at early age compared to the older age may be due to the maternal effect on the kids through pre-weaning age, which extends until weaning at 4 weeks.

Simple correlation among growth performance attributes:

Simple correlation among the growth performance attributes is presented in Table 2. The results showed that rabbits which appeared to be heavier through the older age at 8wks (r = 0.704) and at marketing at 12 wks (r = 0.627) were heavier at weaning weight.

Table1. Means and coefficients of variation (CV) of growth performance attributes in the present study

Genetic group	*Live body weight (g) at:*						*Daily weight gain from:*						*Growth rate (%) from:*					
	4 wks		8 wks		12 wks		4 –8 wks		8 –12 wks		4-12 wks		4 –8 wks		8 –12 wks		4-12 wks	
	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
Pure breeds																		
NN	537.92	28.41	1104.17	15.60	1687.08	14.70	20.22	15.98	20.82	22.12	20.52	10.61	70.74	19.69	41.89	17.07	104.8	10.59
PP	443.08	30.98	1123.46	14.04	1759.23	12.30	24.3	15.52	22.71	19.55	23.5	7.54	88.8	17.98	44.29	16.83	121.04	9.73
FF	496.42	8.15	1182.5	3.85	1860.42	5.45	24.5	7.21	24.21	8.68	24.36	7.31	81.85	7.92	44.48	4.55	115.74	5.13
Direct crosses																		
NF	483.33	27.65	1009.17	19.88	1572.22	17.02	18.78	26.57	20.11	19.18	19.44	16.71	71.35	24.28	44.07	16.97	106.91	12.15
NP	432.08	27.9	990.42	15.84	1616.67	7.41	19.94	23.08	22.37	18.27	21.15	12.01	80.12	31.08	48.77	23.12	116.64	16.9
FP	439.33	11.91	1031.67	13.66	1700.33	9.67	21.15	22.79	23.88	13.06	22.52	11.86	79.9	18.03	49.32	16.15	117.75	6.55
Reciprocal crosses																		
FN	458.08	11.9	1129.23	9.06	1891.54	5.95	23.97	9.99	27.23	19.15	25.6	9.07	84.7	7.00	50.55	20.44	121.97	7.19
PN	440	24.04	1026.43	19.08	1900.36	17.03	20.95	19.41	31.21	17.76	26.08	16.32	80.72	13.48	60.07	10.33	125.43	6.91
PF	443.93	31.88	1133.57	24.31	1857.86	24.78	24.63	22.99	25.87	28.6	25.25	23.56	88.26	12.86	48.51	16.85	123.61	5.64

a: NN= New Zealand White; PP = Papillon; FF= Flemish Giant; NF= New Zealand White x Flemish Giant; NP = New Zealand White x Papillon; FP = Flemish Giant x Papillon; FN = Flemish Giant x New Zealand White; PN = Papillon x New Zealand White; PF = Papillon x Flemish Giant

Table 2. Simple correlation among growth performance attributes [a]

Traits	Ages	BW			DG			RG		
		4 wks	8 wks	12 wks	4-8wks	8-12wks	4-12wks	4-8wks	8-12wks	4-12wks
BW	4 wks	-								
	8 wks	0.704**	-							
	12wks	0.627**	0.835**	-						
DG	4-8wks	0.106^{NS}	0.781**	0.617**	-					
	8-12wks	0.281**	0.301**	0.777**	0.175**	-				
	4-12wks	0.263**	0.672**	0.916**	0.710**	0.818**	-			
RG	4-8wks	-0.682**	0.01^{NS}	-0.042^{NS}	0.613**	-0.083^{NS}	0.299**	-		
	8-12wks	-0.239**	-0.451**	0.0108^{NS}	-0.421**	0.702**	0.256**	-0.11^{NS}	-	
	4-12wks	-0.757**	-0.217**	0.014^{NS}	0.361**	0.272**	0.406**	0.866**	0.397**	-

a: BW= Body weight, DG= Daily weight gain, RG= Relative growth rate,
NS= Not significant, ** P<0.001.

There is negative relationship between weaning weight and relative growth rate during all age intervals (r = - 0.239 to -0.757). In case of marketing at fixed age, the rabbits with faster daily gain during the period 8-12 wks of age seemed to have faster relative growth rate during the same period (r = 0.7). Similar previous results, in agreement with present study, were reported positive highly correlation between weaning weight and slaughter weight (Ezzeroug *et al*., 2019 and Hanaa *et al*., 2014). However, in contrast, Shemies and Abdallah (2000) obtained negligible phenotypic correlation between weaning weight and marketing age on New Zealand White rabbit breed (r =0.11).

Breed effect on growth performance attributes

1. Body weight (BW):

Table (3) cleared that breed effect was significant (P<0.05) on body weight at 8^{th} and 12^{th} weeks of age and insignificant at 4^{th} weeks of age (P>0.05).

However, PN and FN crosses rabbits were recorded to have the heaviest market weight at 12 weeks of age (1900.5236 and 1891.54 g, respectively). Eady (2003) observed significant breed difference for weaning weight in a crossbreeding experiment involved New Zealand White, Californian, and Flemish Giant breeds. Rania Hassan (2005) worked with Gray Giant Flander in a crossbreeding experiment and observed that, it was the heaviest breed at 8 and 10 weeks of age.

The superiority of FN and PN crossbred rabbits at weaning and marketing weight indicates superiority of New Zealand White rabbits as dam breed (Prayaga and Eady, 2002; El-Bayomi *et al.*, 2012). These findings illustrated the good mothering ability of New Zealand White breed.

Effect of sex (Table 3) on live body weight (g) of growing rabbits was not significant at different studied ages.

2. Daily weight gain (DG):

Table (4) showed that, breed effect was highly significant (P<0.001) on DG_{4-8}, DG_{8-12}, and DG_{4-12}. The means of PP and FF as purebreds were higher significantly faster gain than NN for DG at different periods studied.

On the other hand, PN crossbred rabbits during the period from 8-12 weeks of age and FN rabbits from the periods 4-12 wks were recorded to be the faster DG (g/day) as compared to the other genetic groups (Table 4). Eady (2003) reported significance differences for weaning weight in a crossbreeding experiment involved N, C and F.

Table 3. Effect of genetic group and sex on live body weight (g) of rabbits from weaning to marketing

		Live body weight (g)[a] at		
Genetic groups	**No.**	**4wks**	**8wks**	**12wks**
NN	12	537.92	1104.17 [ab]	1687.08 [ab]
PP	13	443.08	1123.46 [ab]	1759.23 [ab]
FF	12	496.42	1182.5 [a]	1860.42 [a]
NF	18	483.33	1009.17 [b]	1572.22 [b]
NP	12	432.08	990.42 [b]	1616.67 [b]
FP	15	439.33	1031.67 [b]	1700.33 [ab]
FN	13	458.08	1129.23 [ab]	1891.54 [a]
PF	14	443.93	1133.57 [ab]	1857.86 [a]
PN	14	440.00	1026.43 [b]	1900.36 [a]
Sig. test		NS	*	*
Sex				
Male	59	465.08	1069.41	1736.95
Female	64	461.52	1084.30	1771.41
Sig. test		NS	NS	NS

a: Means in the same column within the same classification have bearing different letters, differed significantly (P<0.05); NS= Not significant and * = P<0.05;
NN= New Zealand White; PP = Papillon; FF= Flemish Giant; NF= New Zealand White x Flemish; NP = New Zealand White x Papillon; FP = Flemish Giant x Papillon; FN = Flemish Giant x New Zealand White; PF = Papillon x Flemish Giant; PN = Papillon x New Zealand White

In a crossbreeding experiment, Rania Hassan (2005) found that the Gray Giant Flander was the heaviest breed at 8 and 10 weeks of age. The superiority of PN and FN crossbred rabbits indicates the superiority of N as dam breed for improving DG at marketing age. Eman (2011) recorded similar significant breed difference for DG in a crossbreeding experiment at 8-10 weeks of age.

Insignificant effect of sex on body weight gain (g/day) of growing rabbits was noticed at different studied ages.

3. Relative growth rate (RG):

Data in Table (5) showed that, breed effect was highly significant (P<0.01 or 0.001) on RG, during all interval ages. The means of PP and FF as purebreds were significantly faster growing than NN. However, PN

Table 4. Effect of genetic group and sex on daily weight gain (g/day) of rabbits from weaning to marketing.

Genetic group		Daily weight gain (g/day)[a] at		
	No.	**4weeks**	**8weeks**	**12weeks**
NN	12	20.22 [c]	20.82 [de]	20.52 [de]
PP	13	24.30 [ab]	22.71 [cde]	23.50 [abc]
FF	12	24.50 [ab]	24.21 [bcd]	24.36 [ab]
NF	18	18.78 [c]	20.11 [e]	19.44 [e]
NP	12	19.94 [c]	22.37 [cde]	21.15 [cde]
FP	15	2 1.15 [abc]	23.88 [bcde]	22.52 [bcd]
FN	13	23.97 [ab]	27.23 [b]	25.60 [a]
PF	14	24.63 [a]	25.88 [bc]	25.25 [a]
PN	14	20.95 [bc]	31.21 [a]	26.08 [a]
Sig. test		***	***	***
Sex				
Male	59	21.58 ± .60	23.84 ± .71	22.71 ± .48
Female	64	22.24 ± .58	24.54 ± .73	23.39 ± .52
Sig. test		NS	NS	NS

a: Means in the same column within the same classification have bearing different letters, differed significantly (P<0.05); NS= Not significant and ***= P<0.001;
NN= New Zealand White; PP = Papillon; FF= Flemish Giant; NF= New Zealand White x Flemish; NP = New Zealand White x Papillon; FP = Flemish Giant x Papillon; FN = Flemish Giant x New Zealand White; PF = Papillon x Flemish Giant; PN = Papillon x New Zealand White

crossbred rabbits were recorded 60.07 and 125.43 % of relative growth rate, during intervals of 8-12 and 4-12 weeks of age, respectively, when compared the other breed groups. Abdel-Hamid (2007) recorded superiority of crossbred New Zealand White x Californian (70.97%) over than reciprocal crossbred Cal x NZW (54.22%) during period 4-6 weeks of age. On the contrary, Eman (2011*)* reported superiority of Cal x NZW (52.71%) cross over than NZW x Cal (47.56%) cross, during 4-6 wks of age and recorded significant breed difference for RG.

Effect of sex on RG of growing rabbits were not significant at studied ages (Table 5).

General and specific combining abilities for growth performance attributes:

1. Body weight

Table 6 showed insignificant differences for General combining ability (GCA), specific combining ability (SCA) and reciprocal cross effects for all studied traits, except for the reciprocal cross BW_{12} (P< .001). Similar results for GCA on body weight were previously reported (El-

Table 5. Effect of genetic group and sex on relative growth rate of rabbits from weaning to marketing

Genetic group		Relative growth rate[a] from :		
	No.	**4weeks**	**8weeks**	**12weeks**
NN	12	70.74 ± 4.02 [b]	41.89 ± 2.06 [c]	104.80 ± 3.21 [b]
PP	13	88.80 ± 4.43 [a]	44.27 ± 2.07 [bc]	121.04 ± 3.27 [a]
FF	12	81.85 ± 1.87 [ab]	44.48 ± .58 [bc]	115.74 ± 1.71 [a]
NF	18	71.35 ± 4.08 [b]	44.07 ± 1.76 [bc]	106.91 ± 3.06 [b]
NP	12	80.12 ± 7.19 [ab]	48.77 ± 3.25 [bc]	116.64 ± 5.69 [a]
FP	15	79.90 ± 3.72 [ab]	49.32 ± 2.06 [b]	117.75 ± 1.99 [a]
FN	13	84.70 ± 1.64 [a]	50.55 ± 2.86 [b]	121.97 ± 2.43 [a]
PF	14	88.26 ± 3.03 [a]	48.51 ± 2.18 [bc]	123.61 ± 1.86 [a]
PN	14	80.72 ± 2.91 [ab]	60.07 ± 1.66 [a]	125.43 ± 2.32 [a]
Sig. test		***	**	***
Sex				
Male	59	79.81 ± 2.21	47.83 ± 1.27	116.20 ± 1.83
Female	64	81.06 ± 1.73	48.22 ± 1.1	117.60 ± 1.43
Sig. test		NS	NS	NS

a: Means in the same column within the same classification have bearing different letters, differed significantly (P<0.05); NS= Not significant and **= P<0.01, ***= P<0.001;
NN= New Zealand White; PP = Papillon; FF= Flemish Giant; NF= New Zealand White x Flemish; NP = New Zealand White x Papillon; FP = Flemish Giant x Papillon; FN = Flemish Giant x New Zealand White; PF = Papillon x Flemish Giant; PN = Papillon x New Zealand White.

Bayomi *et al*., 2012; Eman, 2011; Abdel-Hamid, 2007; El-Shiehk *et al.*, 1992 and Hemeda *et al.*, 1992). The higher insignificant GCA at marketing age for FF (28.12) as compared to PP and NN (8.39 and -36.51, respectively) illustrated the higher additive effect for FF breed genes.

On the other hand, use of New Zealand White as sire breed with Papillon as dam breed (NP), showed superiority in marketing body weight rather than NF and FP crossbreds (29.42 vs -32.32 and -14.64, respectively) indicating higher magnitude of dominance and epistatic effect for NP genes at marketing. The negative significant effect of reciprocal crossing on body weight at marketing of ages revealed the important role of breed utilization as a dam breed in crossbreeding program in case of improvement body weight at older age.

2.Daily gain weight (DG)

General and specific combining ability and reciprocal cross were found to be significant (P< 0.05 or 0.001) on daily weight gain (DG), during 8-12 and 4-12 weeks of age (Table 7).

Table 6. General combining ability, specific combining ability and reciprocal cross effects for live body weight (BW) on rabbits from weaning to marketing

Breeding groups	BW (g)[a] at:		
	4 weeks	**8 weeks**	**12 weeks**
General combining ability			
NN	17.6728	-21.1811	-36.5182
PP	-23.3754	-8.4811	8.3975
FF	5.7026	29.6622	28.1207
Significance test	**NS**	**NS**	**NS**
Specific combining ability			
NF	-17.06	-24.65	-32.32
NP	-21.88	-41.90	29.42
FP	-4.32	-18.54	-14.64
Significance test	**NS**	**NS**	**NS**
Reciprocal cross			
FN	13.40	-54.65	-144.27
PN	-3.96	-18.01	-141.85
PF	-2.30	-50.95	-78.76
Significance test	**NS**	**NS**	*******

a: Means in the same column within the same classification have bearing different letters differed significantly; *** = P < 0.001; NS= Not significant

NN= New Zealand White; PP = Papillon; FF= Flemish Giant; NF= New Zealand White x Flemish; NP = New Zealand White x Papillon; FP = Flemish Giant x Papillon; FN = Flemish Giant x New Zealand White; PF = Papillon x Flemish Giant; PN = Papillon x New Zealand White

The results obtained showed higher additive effect and superiority of PP than NN and FF breeds in DG through the fattening interval of 4-12 wks (0.53 g/day vs 0.47 and -1.00 g/day, respectively). On contrary, El-Bayomi *et al*. (2012) reported that breed differences in GCA for DG were non-significant at different ages.

The SCA effect showed superiority of F♂ x P♀ in DG during interval of 4-12 wks (1.52 g/day) than N ♂ X P ♀ (0.38 g/day) and N ♂ X F ♀ (0.48 g/day). Similar results were reported by El-Bayomi *et al*. (2012) who recorded positive estimates of SCA for DG at most considered ages.

Table 7. General combining ability, specific combining ability and reciprocal cross effects for daily weight gain (DG), on rabbits from weaning to marketing

Genetic group	DG (g)[a] from :		
	4-8 weeks	8-12 weeks	4-12 weeks
General combining ability			
NN	-0.73	-0.77	-1.00
PP	0.28	1.40	0.53
FF	0.45	-0.63	0.47
Significance test	**NS**	****	****
Specific combining ability			
NF	0.40	0.57	0.48
NP	-0.32	1.08	0.38
FP	1.72	1.32	1.52
Significance test	**NS**	*****	******
Reciprocal cross			
FN	2.02	0.91	1.47
PN	0.04	-5.49	-2.73
PF	-0.42	0.23	-0.09
Significance test	**NS**	******	******

a= Means in the same column within the same classification have bearing different letters, differed significantly; * = P < 0.05 and *** = P < 0.001; NS= Not significant
NN= New Zealand White; PP = Papillon; FF= Flemish Giant; NF= New Zealand White x Flemish; NP = New Zealand White x Papillon; FP = Flemish Giant x Papillon; FN = Flemish Giant x New Zealand White; PF = Papillon x Flemish Giant; PN = Papillon x New Zealand White

Present results cleared that use of F♂ x N ♀ cross is better than PN and PF crosses in enhancement of DG through interval 4-12 wks (1.47 g/day vs -2.73 and -0.09 g/day, respectively), which indicated, conclusively, importance of maternal effect on DG in rabbits. Previous results for different cross-combinations, showed some degree of variability in daily weight gain (Hemeda *et al*., 1992; Abdel-Hamid, 2007 and Eman, 2011). They concluded that the effects of SCA were highly significant on DG at most considered intervals ages. On contrary, El-Bayomi *et al.* (2012) found insignificant effect for the reciprocal crosses for DG. present results revealed the importance role of P breed in general and specific combining ability to improve of DG.

3. Relative growth rate% (RG)

In General, Table 8 exhibited significant effect for GCA, SCA and RC on RG during fattening intervals of 8-12 and 4-12 wks of age. The results illustrated the higher additive effect of P genes as compared to F and N genes (3.35 unit, -0.21, -3.15 unit, respectively). In an opposite result, El-Bayomi *et al*. (2012) reported that breed differences in GCA for BW, were insignificantly through considered studied ages.

Table 8. General combining ability, specific combining ability and reciprocal cross for relative growth rate % (RG) of rabbits from weaning to marketing

Genetic group	RG[a] at:		
	4-8 weeks	**8-12 weeks**	**4-12 weeks**
General combining ability			
NN	-2.84	-1.09	-3.13
PP	1.84	2.51	3.35
FF	1.00	-1.42	-0.21
Significance test	**NS**	******	******
Specific combining ability			
NF	2.61	1.34	2.98
NP	1.03	2.48	2.48
FP	3.53	-0.57	2.72
Significance test	**NS**	**NS**	******
Reciprocal cross			
FN	2.07	1.53	0.93
PN	-0.61	-8.28	-6.20
PF	-1.80	0.43	-1.23
Significance test	**NS**	*******	*****

a: Means in the same column within the same classification have bearing different letters differed significantly; * = P < 0.05*** = P < 0.001; NS= Not significant

NN= New Zealand White; PP = Papillon; FF= Flemish Giant; NF= New Zealand White x Flemish; NP = New Zealand White x Papillon; FP = Flemish Giant x Papillon; FN = Flemish Giant x New Zealand White; PF = Papillon x Flemish Giant; PN = Papillon x New Zealand White

The NF crossbred was found to be the best cross compared to NP and FP crosses as result to SCA on RG through fattening interval (2.98 unit vs 2.48 and 2.48 unit, respectively). In similar findings, Hemeda *et al.* (1992), Abdel-Hamid (2007) and Eman (2011) reported highly significant effect of SCA on RG at different studied ages.

Reciprocal cross effect revealed that FN crossbred is better than PN and PF for RG during intervals fattening interval at 4-12 weeks of age (0.93 unit vs -

6.2 and -1.23 unit, respectively). This result highlights the importance of choosing the New Zealand White as a dam breed in crossbreeding program in case of desire to improve the relative growth rate.

Conclusively, the results obtained in present study suggested that Papillon is a promising breed in crossbreeding program regarding growth performance traits. Crossing of N as a sire breed with P as a dam breed, NP, would be recommended over other crosses to improve marketing weight in rabbits. However, crossing of F as a sire breed with N as a dam breed, FN, would be recommended over other crosses to improve growth rate in rabbits especially in case of marketing rabbits at constant weight to save time and cost.

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قدرة التوافق العامة والخاصة لخصائص اداء النمو في الارانب

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يهدف هذا العمل الي تقدير تأثير قدرة التوافق العامة والخاصة والخليط العكسي لخصائص أداء نمو الأرانب من الفطام حتى التسويق وذلك للتعرف على أفضل خليط مناسب يمكن لمربي الأرانب استخدامه في إنتاج لحومها تحت الظروف المصرية .

تم استخدام عدد 123 أرنبا من كلا الجنسين (59 ذكر ، 64 انثي) تمثل تسع مجاميع وراثية تشمل السلالات النقية وهى النيوزيلندي الأبيض (N) والبابيون (P) والفليمش چاينت (F) وستة خلطات تمثل التهجينات المختلفة فيما بينها (NF , NP , FP , FN , PN , PF) .

وكانت صفات أداء النمو موضع الاعتبار هي وزن الجسم الحي (BW)، عند عمر 4 أسابيع (عمر الفطام) ، 8 أسابيع ، و 12 أسبوع (عمر التسويق) ومعدل الزيادة اليومية (DG) بين 4 و8 اسابيع (DG_{4-8})، وبين 8 و 12 اسبوع (DG_{8-12})، وبين 4 و 12 اسبوع (DG_{4-12}) ومعدل النمو النسبى (RG) عند نفس الفترات العمرية السابقة (RG_{4-8}, RG_{8-12}, RG_{4-12}). أظهرت نتائج الدراسة علاقة ارتباط موجبة فيما بين اوزان الجسم في جميع الاعمار المدروسة ($r = 0.61$ to 0.91). سُجل ارتباط سلبي وكبير بين وزن الجسم عند الاسبوع الرابع ومعدل النمو فى الفترة العمرية 8-4 و 12-4 اسبوعاً. كان للتركيب الوراثى تأثير معنوي على وزن الجسم عند أعمار 8 و 12 اسبوع . سُجلت سلالة النيوزلندي كأثقل سلالة وزناً عند الفطام في حين كانا التراكيب الوراثية PN و FN هما الأثقل وزنا في عمر التسويق مقارنة بالتراكيب الوراثية الأخرى. كما سُجل لنوع التركيب الوراثى تأثير معنوي كبير علي الزيادة الوزنية اليومية وعلي معدل النمو النسبى خلال جميع الفترات العمرية موضع الدراسة. وعلي الجانب الاخر وجد أن تأثير الجنس علي وزن الجسم وعلي الزيادة اليومية ومعدل النمو في الأرانب النامية غير معنوي خلال اعمار الدراسة .

تم تسجيل تأثير غير معنوي لقدرة التوافق العامة والخاصة والخليط العكسي على وزن الجسم في الاعمار المختلفة، باستثناء الخليط العكسي الذي كان معنوياً في عند التسويق. وقد سجل التركيب الوراثى NP كأفضل خليط أدى لتحسن في وزن الجسم. كان لقدرة التوافق العامة والخاصة والخليط العكسى تأثيرا معنويا على كل من الزيادة الوزنية اليومية ومعدل النمو النسبى وقد تبين أن التركيب الوراثى FN هو أفضل خليط في هاتين الصفتين.

التوصية : بينت النتائج السابقة ان سلالة البابيون هي سلالة واعدة عند استخدامها في برامج الخلط المختلفة. حيث يوصى باستخدام سلالة النيوزيلندى كسلالة أبيه مع البابيون كسلالة أمية (NP) عند الرغبة فى تحسين الوزن عند التسويق في الارانب. بينما يوصى بخلط الفليمش جاينت كذكور مع النيوزيلندى الأبيض كإناث (FN) عند الرغبة في تحسين معدلات النمو في حال ما إذا أرد المربى ان يسوق أرانبه عند وزن تسويقى ثابت وذلك لتوفير الوقت وتكلفة التربية.

الكلمات المفتاحية: أرانب ، صفات النمو ، قدرة التوافق العامة والخاصة .