



## HETEROSIS AND COMBINING ABILITIES OF GROWTH TRAITS IN THREE BREEDS OF RABBITS

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### ABSTRACT

This study was conducted to evaluate heterosis and combining abilities of growth traits including body weight, relative growth rate (RGR) and average daily gain (ADG) in a complete 3x3 diallel crossbreeding experiment [Géant Blanc du Bouscat (B), Californian (C) and New Zealand White (N) Breeds]. All crossbreds and reciprocals showed negative heterosis % for body weight at all ages studied except BN crossbred showed positive heterosis % at 4 weeks age (12.34 %). All crossbreds and reciprocals showed negative heterosis % for RGR at 4-6 and 4-12 weeks of age intervals. At 6-8 weeks of age interval, all crossbreds and reciprocals showed negative heterosis % except BN crossbred (10.28 %) and NC reciprocal crossbred (0.45 %). CN crossbred showed the highest positive heterosis % at 8-10 weeks of age interval (64.55 %). NB reciprocal crossbred recorded the highest positive heterosis % at 10-12 weeks of age interval (64.55 %). All crossbreds and reciprocals showed negative heterosis % for ADG at all ages intervals studied except at 10-12 weeks of age interval all crossbreds and reciprocals. The effect of general combining ability on all studied traits was non-significant. On the contrary, the effect of specific combining ability was highly significant ( $p \leq 0.01$ ) and significant ( $p \leq 0.05$ ) except for ADG at 8-10 and 10-12 weeks of age intervals were non-significant. New Zealand White rabbit showed the highest number of positive result of general combining ability for growth traits at most ages. BN crossbred recorded the highest number of positive estimate of specific combining ability for growth traits at most ages.

**KEY WORDS:** Growth traits, Heterosis, Rabbits.

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## 1. INTRODUCTION

Egypt has superior capability for developing rabbit production with its available grassland and abundant surplus of labor. Crossbreeding has been established as breeding systems to exploit the heterosis in animal breeding and it could be fruitfully employed in rabbit breeding for increased productivity [21]. Performance comparisons between different breeds and their crosses are justified because genetic differences among strains are large relative to genetic variation within breeds [9]. These differences had an important potential

source of genetic improvement in the efficiency of human food production from rabbits through gains in performance from complementary breed effects and heterosis in crossbreeding [1].

The objective of this study was to investigate heterosis and combining abilities on some productive traits including body weight at different ages, relative growth rate (RGR) and average daily gain (ADG) for different age intervals.

## 2. MATERIAL AND METHODS

This study was conducted at the Rabbit Farm belonging to Faculty of Veterinary Medicine, Benha University, Egypt through the period from September 2009 to July 2010.

### 2.1. Experimental flock and management:

The flock composed of three rabbit breeds (New Zealand White, Californian and Géant Blanc du Bouscat). All of these breeds were obtained from San-El-Hagar Agricultural company farm, Sharkiya Governorate, Egypt. Two bucks and seven does from each breed were used in the experiment. Mature bucks and does were mated in a full 3 x 3 diallel cross design. Bucks and does were apparently healthy and vaccinated against pasteurellosis and rabbit viral hemorrhagic disease (RVHD). Rabbits were housed in an open sided house. Breeding animals were kept individually in galvanized wire rabbitries in which rows of hutches face each other. Each rabbitry consists of four rows and each row contains two hutches (50 x 50 x 50 cm) provided with nipple system for watering and manual feeder. Metal nest box (40x40x40 cm) was attached to the doe's cage.

Litters were weaned, ear tagged and separated in cages at 4 weeks of age. They were raised identically under the same managerial and nutritional conditions. Individual records were established for each breeding animal for recording all the data needed for this study as well as there is a litter production records.

Rabbits of all ages were fed commercial pelleted ration obtained from ATEMEDA Company. The ration contains Crude protein (not less than) 18.5 %. Clean fresh water was available all times to rabbits. Pregnant, lactating does and young rabbits fed ad-libitum, while empty does and bucks fed 130-150 g daily to avoid over fattening and consequently poor productive and reproductive performance. Environmental temperature was maintained as possible around 18-28°C. Good ventilation and fresh air was also

provided to reduce ammonia concentration in the house as well as hygienic disposal of wastes. Moreover, 12-14 hours light per day were provided.

Table 1 Mating System and number of litters for each mating (between parents)

Females	Males		
	N	C	B
N	NN (32)	CN (29)	BN (34)
C	NC (40)	CC (30)	BC (41)
B	NB (30)	CB (35)	BB (45)

### 2.2. Studied productive traits:

#### 2.2.1. Body weights.

#### 2.2.2. Relative growth rate.

It was calculated according to [7].

$$\text{Relative Growth Rate (RGR)} = \frac{W_2 - W_1}{1/2(W_2 + W_1)} \times 100$$

Where:  $W_1$  = body weight at the beginning of period.  $W_2$  = body weight at the end of period.

#### 2.2.3. Average daily gain.

### 2.3. Data handling and statistical analysis:

Data were analyzed by the General Linear Model (GLM) procedure of the SAS statistical analysis system package [23].

$$Y_{ijk} = \mu + B_i + C_j + e_{ijk}$$

Where:  $Y_{ijk}$  = any observed value,  $\mu$  = overall mean,  $B_i$  = effect of breed ( $i = 1, 2$  and  $3$  i.e. New Zealand White, Californian and Géant Blanc du Bouscat).  $C_j$  = effect of crossing ( $j = 1, 2, 3 \dots 6$ ).  $e_{ijk}$  = random deviation due to unexplained source.

Least Squares Means (LSM)  $\pm$  standard errors were calculated and tested for significance using "T" test [24].

$$Y_{ijk} = \mu + C_i + e_{ijk}$$

Where:  $Y_{ijk}$  = Any observed value,  $\mu$  = Overall mean,  $C_i$  = fixed effect of purebred versus crossbred ( $i = 1, 2$ ),  $e_{ijk}$  = Random deviation due to unexplained source.

#### 2.4. Heterosis (Hybrid Vigor)

Heterosis or hybrid vigor will be estimated for the different crossbreds and reciprocal crossbreds based on the following formula [15].

$$H\% = \frac{\bar{X}_{F_1} - 1/2(\bar{X}_{P_1} + \bar{X}_{P_2})}{1/2(\bar{X}_{P_1} + \bar{X}_{P_2})} \times 100$$

#### 2.5. General and specific combining abilities:

General and specific combining abilities were estimated according to previous authors [16, 17].

$$Y_{ijk} = \mu + g_i + g_j + s_{ij} + m_i - m_j + r_{ij} + e_{ijk}$$

Where:  $Y_{ijk}$  : variable analyzed,  $\mu$  : overall mean,  $g_i$  : effect of the general combining ability of the  $i^{th}$  breed,  $g_j$  : effect of the general combining ability of the  $j^{th}$  breed,  $s_{ij}$  : effect of the specific combining ability of the cross (i, j),  $m_i$  : maternal effect of the  $i^{th}$  breed,  $m_j$  : maternal effect of the  $j^{th}$  breed,  $r_{ij}$  : reciprocal (sex-linked) effect of the cross (i, j),  $e_{ijk}$  : random error.

### 3. RESULTS AND DISCUSSION

#### 3.1. Body weights:

##### 3.1.1. Heterosis %:

For body weights at different ages studied, heterosis was not evident and all estimates were negative except for BN crossbred was positive heterosis % at 4 weeks of age (12.34 %) (Table 2). This indicates that means of crosses were lower than that of purebreds so crossing does not improve body weights at different ages studied generally. From the economical point of view and for the commercial production, it was recommended that rabbit producer must use New Zealand White, Californian and Géant Blanc du Bouscat on its pure state (no crossing between them). These results agreed with previous work [25], but contradicted with those obtained formerly [5, 8, 18-20).

#### 3.1.2. General and specific combining ability (GCA and SCA):

The analysis of variance for the effect of GCA on the body weights of rabbits was non-significant for body weight at all ages studied. On the contrary, the effect of SCA was significant ( $p \leq 0.05$ ) at weaning age and was highly significant ( $p \leq 0.01$ ) at 6<sup>th</sup>, 8<sup>th</sup>, 10<sup>th</sup> and 12<sup>th</sup> weeks ages studied (Table 3). For GCA, Géant Blanc du Bouscat rabbits recorded the highest negative values for body weight 4<sup>th</sup>, 6<sup>th</sup>, 8<sup>th</sup>, 10<sup>th</sup> and 12<sup>th</sup> weeks of age (-26.60, -26.33, -16.49, -20.72 and -20.04, respectively). Californian rabbits showed the highest positive values at weaning, 6<sup>th</sup> and 8<sup>th</sup> weeks of age (22.45, 27.10 and 8.48, respectively). New Zealand White rabbits showed positive GCA at all ages except at 6<sup>th</sup> week age (-0.77) and showed the highest positive GCA at 10<sup>th</sup> and 12<sup>th</sup> weeks age (11.37 and 19.99, respectively) (Table 4). CN crossbreds showed the highest negative values of the SCA for body weights at all ages studied (-17.97, -114.30, -137.13, -117.29 and -111.13) at 4, 6, 8, 10 and 12 weeks of age, respectively. Also, BC crossbreds showed negative values at all ages studied (-7.84, -72.07, -105.65, -104.53 and -95.38) at 4, 6, 8, 10 and 12 weeks of age, respectively. On the other hand, BN crossbreds showed negative values of the SCA at all ages studied except at weaning age (17.38) (Table 4). The results agreed with those recorded formerly [11, 14, 22], but contradicted with the results obtained by other authors [3, 12].

#### 3.2. Relative Growth Rate (RGR %):

##### 3.2.1. Heterosis %:

For RGR, heterosis % had not been evident at most of age intervals studied and the estimates were negative. Heterosis was evident only for RGR at 8-10 and 10-12 weeks intervals and manifested by positive estimates ( at 8-10 weeks interval, all crossbreds showed their superiority recording positive heterosis % of RGR except BN crossbred was negative

estimate (-11.32%) and at 10-12 weeks interval, all crossbreds showed their superiority recording positive heterosis % of RGR and NB crossbreds showed the highest positive heterosis % (44.66 %) which indicate superiority of crosses over purebreds (Table 5). These results agreed with former results [2], but contradicted with results were obtained by earlier studies [13, 20].

### 3.2.2. General and specific combining ability (GCA and SCA):

The analysis of variance for the effect of GCA on the RGR % was non-significant at all age intervals. On the contrary, the effect of SCA was highly significant ( $p \leq 0.01$ ) at 4-6 weeks age interval and was significant ( $p \leq 0.05$ ) at 10-12 and 4-12 weeks of age interval but was non-significant at 6-8 and 8-10 weeks of age intervals (Table 6).

Géant Blanc du Bouscat rabbits had positive value of GCA for RGR % at 4-6,

6-8, 8-10, 10-12 and 4-12 weeks of age intervals (2.92, 1.30, 0.22, 0.08 and 2.91, respectively). Californian rabbits had negative value of general combining ability for RGR % at 4-6, 6-8, 8-10, 10-12 and 4-12 weeks of age intervals (-2.28, -2.29, -0.08, -0.48 and -2.90, respectively). On the other hand, New Zealand White recorded positive estimate at 6-8 and 10-12 week age intervals (0.99 and 0.40, respectively) but recorded negative value at 4-6, 8-10, and 4-12 week age intervals (-0.64, -0.14 and -0.01, respectively) (Table 7).

SCA was negative for RGR at 4-6 and 4-12 weeks intervals but was positive 8-10 and 10-12 weeks intervals. At 6-8 week interval, the only positive SCA was for BN (0.08) (Table 7). Nevertheless, these findings contradicted with results were obtained by previous authors [14].

Table 2 Heterosis % of Body Weights for Crossbreds and Reciprocal Crossbreds due to Crossing Between Géant Blanc du Bouscat (B), Californian (C) and New Zealand White (N) Breeds.

Genotype	Body weight traits at				
	4 weeks	6 weeks	8 weeks	10 weeks	12 weeks
BC	-0.59	-16.98	-21.06	-12.48	-9.25
BN	12.34	-16.18	-12.68	-14.92	-12.79
CB	-6.67	-25.92	-23.78	-21.11	-17.19
CN	-3.31	-17.53	-23.94	-11.20	-7.26
NB	-1.65	-14.19	-18.74	-7.75	-2.23
NC	-9.80	-26.71	-26.43	-23.83	-20.92

Table 3 The Analysis of Variance for General and Specific Combining Ability for Body Weights at Different Ages due to Crossing Between Géant Blanc du Bouscat (B), Californian (C) and New Zealand White (N) Breeds.

S. O. V.	D.F	Body weight traits at				
		4 weeks	6 weeks	8 weeks	10 weeks	12 weeks
GCA	2	1.49	2.78	0.28	0.72	0.69
SCA	3	12.66*	134.27**	94.51**	219.89**	175.19**
Error	3	2467.55	1540.74	4408.40	2702.54	3488.99

\*Significant at level (0.05), \*\* Highly significant at level (0.01)

Table 4 General And Specific Combining Ability for Body Weights at Different Ages due to Crossing Between Géant Blanc du Bouscat (B), Californian (C) and New Zealand White (N) Breeds.

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Trait Age period	Body weights				
	4 weeks	6 weeks	8 weeks	10 weeks	12 weeks
	----- General combining ability -----				
BB	-26.60	-26.33	-16.49	-20.72	-20.04
CC	22.45	27.10	8.48	9.35	0.05
NN	4.15	-0.77	8.01	11.37	19.99
	----- Specific combining ability -----				
BC	-7.84	-72.07	-105.65	-104.53	-95.38
BN	17.38	-28.39	-42.23	-39.96	-20.58
CN	-17.97	-114.30	-137.13	-117.29	-111.13

### 3.3. Average Daily Gain (ADG):

#### 3.3.1. Heterosis %:

At 4-6, 6-8 and 4-12 weeks intervals all crossbreds showed negative heterosis % of ADG. At 8-10 weeks interval, BC crossbred, CN crossbred and NB crossbred showed their superiority recording positive heterosis % (18.66, 34.45 and 31.00 %, respectively) while the other crossbreds were negative estimate. At 10-12 weeks interval all crossbreds showed their superiority recording positive heterosis % of ADG and NB crossbred showed the highest positive heterosis % (36.17 %) (Table 8). Similar results were obtained formerly [2, 10]. However, our findings were contradicted by results obtained in previous studies [4, 6].

#### 3.3.2. General and specific combining ability (GCA and SCA):

The analysis of variance for the effect of GCA on the ADG was non-significant at all age intervals. On the contrary, the effect of SCA was highly significant ( $p \leq 0.01$ ) at 4-6 and 4-12 weeks age intervals and was significant ( $p \leq 0.05$ ) at 6-8 weeks of age interval but was non-significant at 8-10 and 10-12 weeks of age intervals (Table 9). Géant Blanc du Bouscat rabbits

had positive value of GCA for ADG at 4-6, 6-8 and 4-12 weeks age intervals (0.67, 0.49 and 0.08, respectively) but showed negative values at 8-10 and 10-12 weeks of age intervals (-0.24 and -0.05, respectively). Californian rabbits had negative value of GCA for ADG at 4-6, 6-8, 10-12 and 4-12 weeks age intervals (-0.33, -1.25, -0.61 and -0.36, respectively) but show positive values at 8-10 weeks of age interval (0.03). On the other hand, New Zealand White recorded positive estimate at 6-8, 8-10, 10-12 and 4-12 week of age intervals (0.76, 0.21, 0.66 and 0.28, respectively), but recorded negative value at 4-6 weeks age interval (-0.34) (Table 10). In general, all crossbreds showed negative values of SCA for ADG at 4-6, 6-8 and 4-12 weeks of age intervals while at 8-10 and 10-12 weeks intervals, they recorded positive values. This reflect high growth rate at these periods due to compensatory growth. CN crossbred recorded the highest positive value of SCA at 8-10 weeks of age interval (1.26) while BN crossbred recorded the highest value at 10-12 weeks of age interval (1.30) (Table 10). Similar results were obtained formerly [14].

Table 5 Heterosis % of Relative Growth Rate at Different Age Intervals for Crossbreds and Reciprocal Crossbreds due to Crossing Between Géant Blanc du Bouscat (B), Californian (C) and New Zealand White (N) Breeds.

Genotype	Relative growth rate % traits at
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	4 – 6 weeks	6 - 8 weeks	8 - 10 weeks	10 - 12 weeks	4 – 12 weeks
BC	-25.16	-17.03	44.74	32.74	-4.60
BN	-35.24	10.28	-11.32	16.39	-12.95
CB	-31.09	-0.69	17.70	40.21	-6.19
CN	-22.54	-21.47	64.55	34.79	-1.21
NB	-16.65	-19.82	50.39	44.66	-1.81
NC	-30.11	0.45	17.21	35.57	-6.96

Table 6 The Analysis of Variance for General and Specific Combining Ability for Relative Growth Rate % at Different Age Intervals due to Crossing Between Géant Blanc du Bouscat (B), Californian (C) and New Zealand White (N) Breeds.

S. O. V.	D.F	Relative growth rate % traits				
		4 - 6 weeks	6 - 8 weeks	8 -10 weeks	10 -12 weeks	4 -12 weeks
GCA	2	1.57	2.63	0.01	0.18	1.28
SCA	3	38.93**	8.17	9.16	16.54*	15.19*
Error	3	26.97	9.02	20.25	6.41	39.48

Table (7): General and Specific Combining Ability for Relative Growth Rate % at Different Age Intervals due to Crossing Between Géant Blanc du Bouscat (B), Californian (C) and New Zealand White (N) Breeds.

Trait	Relative growth rate %				
	4 - 6 weeks	6 - 8 weeks	8 -10 weeks	10 -12 weeks	4 -12 weeks
----- General combining ability -----					
BB	2.92	1.30	0.22	0.08	2.91
CC	-2.28	-2.29	-0.08	-0.48	-2.90
NN	-0.64	0.99	-0.14	0.40	-0.01
----- Specific combining ability -----					
BC	-7.20	-1.17	2.63	1.56	-2.16
BN	-6.36	0.08	0.83	1.28	-4.02
CN	-5.56	-1.57	3.93	1.53	-0.97

Table 8 Heterosis % of Average daily gain at Different Age Intervals for Crossbreds and Reciprocal Crossbreds due to Crossing between Géant Blanc du Bouscat (B), Californian (C) and New Zealand White (N) Breeds.

Genotype	Average daily gain traits at				
	4 – 6 weeks	6 - 8 weeks	8 - 10 weeks	10 - 12 weeks	4 – 12 weeks
BC	-31.79	-31.78	18.66	14.86	-11.88
BN	-41.12	-5.61	-22.86	1.30	-20.06
CB	-43.31	-23.10	-11.38	12.11	-20.57
CN	-31.60	-37.01	34.45	21.64	-8.03
NB	-25.22	-32.27	31.00	36.17	-3.38
NC	-44.33	-25.79	-14.08	5.02	-24.54

Table 9 The Analysis of Variance for General and Specific Combining Ability for Average Daily Gain at Different Age Intervals due to Crossing Between Géant Blanc du Bouscat (B), Californian (C) and New Zealand White (N) Breeds.

Trait	Average daily gain				
	4 - 6 weeks	6 - 8 weeks	8 -10 weeks	10 -12 weeks	4 -12 weeks

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	----- General combining ability: -----					
BB	0.67	0.49	-0.24	-0.05	0.08	
CC	-0.33	-1.25	0.03	-0.61	-0.36	
NN	-0.34	0.76	0.21	0.66	0.28	
	----- Specific combining ability: -----					
BC	-4.57	-2.82	0.12	0.61	-1.57	
BN	-3.26	-1.29	0.20	1.30	-0.79	
CN	-4.56	-3.76	1.26	0.65	-1.61	

Table 10 General and Specific Combining Ability for Average Daily Gain at Different Age Intervals due to Crossing Between Géant Blanc du Bouscat (B), Californian (C) and New Zealand White (N) Breeds.

S. O. V.	D.F	Average daily gain traits at				
		4 - 6 weeks	6 - 8 weeks	8 -10 weeks	10 -12 weeks	4 -12 weeks
GCA	2	1.61	0.76	0.03	0.31	0.41
SCA	3	798.11**	24.36*	3.81	8.74	81.84**
Error	3	0.45	9.40	11.01	7.81	1.55

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## تأثير قوة الهجين وقدرات الجمع بين صفات النمو في ثلاث سلالات من الأرناب

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<sup>4</sup> قسم رعاية و سلوكيات الحيوان - كلية الطب البيطري - جامعة بنها

### الملخص العربي

أجريت هذه الدراسة في مزرعة الأرناب التي تنتمي إلى كلية الطب البيطري، جامعة بنها، خلال الفترة من سبتمبر 2009 إلى يوليو 2010. القطيع الذي تم عليه اجراء التجربة مكون من ثلاث سلالات من الأرناب، وهما النيوزيلندي الأبيض، الكاليفورنيا و البوسكات الفرنسي. السلالات الثلاثة تم الحصول عليها من مشروع صان الحجر التابع لمحافظة الشرقية. أظهرت جميع الأفراد الخليطة والخليطة العكسية نتائج سلبية لقوة الهجين لوزن الجسم في جميع الأعمار باستثناء الخليط من ذكورالبوسكات فرنساوى مع إناث النيوزيلندي الأبيض أظهرت قوة هجين إيجابية في الاسبوع الرابع (12.34%). أظهرت جميع الأفراد الخليطة والخليطة العكسية نتائج سلبية في قوة الهجين لمعدل النمو النسبي في الفترة من الاسبوع الرابع إلى السادس و الرابع إلى الثاني عشر. في الفترة من الاسبوع السادس إلى الثامن أظهرت جميع الأفراد الخليطة والخليطة العكسية نتائج سلبية لنسبة الهجين باستثناء كل من الخليط من ذكور البوسكات فرنساوى مع إناث النيوزيلندي الأبيض (10.28%) والخليط العكسي من ذكور النيوزيلندي الأبيض مع إناث الكليفورنيا (0.45%). الخليط من ذكور الكليفورنيا مع إناث النيوزيلندي الأبيض أظهر أعلى نسبة هجين إيجابية في الفترة من الاسبوع الثامن الى العاشر (64.55%). الخليط العكسي من ذكورنيوزيلندي الأبيض مع إناث البوسكات الفرنسي سجلت أعلى قوة هجين إيجابية في الفترة من الاسبوع العاشر إلى الثاني عشر (64.55%). أظهرت جميع الأفراد الخليطة والخليطة العكسية نتائج سلبية لقوة الهجين في جميع الأعمار باستثناء الفترة من الاسبوع العاشر إلى الثاني عشر كانت جميع النتائج للأفراد الخليطة والخليطة العكسية موجبة. تأثير قدرة التوافق العامة على كل الصفات التي تم ذكرها سابقا كانت غير معنوية، على العكس من ذلك تأثير قدرة التوافق الخاصة كان معنويا ومعنويا جدا إلا في صفتان لم تكن معنويه (متوسط الزيادة اليومية خلال الفترتان وهما الفترة من الاسبوع الثامن إلى العاشر و الفترة من الاسبوع العاشر إلى الثاني عشر). أظهر النيوزيلندي الأبيض أكبر عدد من القيم الإيجابية لقدرة التوافق العامة لصفات النمو عند معظم الأعمار و كما سجل الخليط من ذكور البوسكات الفرنسي مع الإناث النيوزيلندي الأبيض أكبر عدد من القيم الإيجابية لقدرة التوافق الخاصة لوزن الجسم عند معظم الأعمار.

(مجلة بنها للعلوم الطبية البيطرية: عدد 22 (2)، ديسمبر 2011: 169-177)