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EFFICIENCY OF CROSSING PATERNAL LINE MALES AND MATERNAL LINE FEMALES OF RABBITS ON GROWTH PERFORMANCE

SHORT TITLE: CROSSBREEDING TO MAXIMIZE RABBIT PRODUCTION

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ABSTRACT: This study was carried out at the nucleus breeding rabbit farm, Poultry Research Center, Faculty of Agriculture, Alexandria University. The main objectives of this study was to evaluate the efficiency of crossing between two lines of rabbits under selection programs on the productive performance of cross rabbits. Three genetic groups of rabbits were used in the investigation. Alexandria line (A) as a synthetic paternal line, V line (V) as a synthetic maternal line and crossing between A line males and V line females (AV). The studied traits used to evaluate productive performance in these three genetic groups were individual body weight at weaning and at marketing age (BW4 & BW9), daily weight gain (DWG), daily feed intake (DFI), feed conversion ratio (FCR), viability rate (VR) and economic efficiency (EE). A total number of 493, 1602 and 1123 from V, A and AV rabbits, respectively were used in the investigation. The results showed that AV cross rabbits were heavier than pure line rabbits (AA and VV) for BW at two ages studied and DWG during fattening period. On other words, AV genetic group attained the marketing body weight earlier than other two groups. Also, the value of FCR improved in AV growing rabbits compared with those obtained for AA & VV rabbits. Moreover, the VR during fattening period in AV rabbits was the highest, while the lowest one was recorded in V line rabbits. It is clear apparent from these results that, AV group recorded higher values for EE than the other genetic groups. In conclusion, mating between males of the paternal line A and females of the maternal line V gave a cross that saved time and costs in order to reach marketing.

Keywords: Maternal line, Paternal line, Crossbreeding, Growth performance, Rabbits

INTRODUCTION

Rabbits as a meat producer animal, seems to be a good solution to solve the lack in dietary protein for the increasing human population all over the world, especially in developing countries. In comparison to other livestock species virtues of rabbits are meat of rabbits is distinguished by a high protein and low fat and cholesterol content and it is considered a titbit and a health food product (Dalle Zotte, 2000). Shortening the time spent on the production of commercial carcasses and improving feed conversion ratios, dressing proportions and muscle properties are the most important optimization criteria for rabbit meat production (Gondret *et al.*, 2005). The rabbit is characterized by higher rates of return on capital and a fast turnover of capital (El-Sheikh & Atallah, 1998). These advantages make rabbits seem to have a good potential as a meat producing animal, especially when its productive and reproductive ability is considered (El-Raffa, 1994).

Recently, the conventional, approach to a breeding program for meat rabbit production improvement has been the establishment of specialized lines through selection, dam liens or maternal lines and sire lines or paternal lines. These lines are subsequently combined in a crossbreeding program to obtain market fryers that expect to save time and food in their fattening period (Baselga, 2004).

Crossbreeding is one of the fast tools offered to breeders to improve the performance of growth or litter of their rabbits (Nwakpu *et al*., 2015). In this respect, Piles *et al*., 2004 reported that, the efficiency of commercial meat production can be enhanced by adopting certain breeding strategies associated with the chance of diversification of rabbit breeds. Through crossbreeding or lines within breeds the number of kits born (litter size) can be improved and is mainly controlled by genetics (Abou Khadiga, 2004 and Nofal *et al.*, 2005). Moreover, El-Sheikh & Atallah (1998) concluded that, the crossbreeds were outperforming the purebred breeds in weaning weight, price value and slaughter weight. Mortality rate was lower in crossbreeds than in purebreds. Also, economically efficient (total revenue and net profit) were higher in the crossed breeds than in the purebred breeds (Ali & Tarabany, 2013).

The aim of the study was to determine the impact of crossbreeding between paternal line bucks and maternal line does on the productive performance and economic efficiency of growing rabbits. These parameters will be estimated on a synthetic maternal line of rabbit, V line, a synthetic paternal rabbit line, Alexandria line & cross between Alexandria line males and V line females, at the nucleus breeding rabbit farm of Poultry Research Center, Faculty of Agriculture, Alexandria University over two consecutive season of production from 2019 to 2020.

MATERIALS AND METHODS

The present study was carried out at the nucleus breeding rabbit farm and Laboratories of Poultry Research Center, Faculty of Agriculture, Alexandria University, during the period about two years. All treatments and rabbits care procedures were approved by the Institutional Animal Care and Use Committee in AU-IACUC, Alexandria University, Egypt, with the review report number AU08190625236. Authors declare that the procedures imposed on the rabbits were carried out to meet the

Directive 2010/63/EU of the European Parliament and of the Council of 22 September 2010 on the protection of animals and birds used for scientific purposes.

Population

The number of 1602, 493 & 1123 growing rabbits used in the present study belonging to three genetic groups (A, V & AV) and coming from 82, 27 ; 37, 14 and 87, 26 does and bucks of line A , V & AV; respectively. The first genetic group, Line A (Alexandria) is a synthetic paternal line originated in 2007 at department of poultry production, Faculty of Agriculture, Alexandria University, Egypt. Daily weight gain was considered as the criterion for selection in this line in addition to adaptation for Egyptian environmental condition. Second genetic group was V line rabbits. The second genetic group, Line V is a synthetic maternal line originated in 1982, and was developed at the Department of Animal Science of the Universidad Polytechnic de Valencia, Valencia, Spain. Litter size at weaning was considered as the criterion for the selection goal in this line. A set of V line rabbits was imported to the Poultry Research Center, Alexandria University at the end of year 1998 (El-Raffa, 2000). Multiplied for five years and after that, the selection was continued under the same criterion. The third genetic group was AV rabbits that is a cross between A line bucks and V line does.

Housing

The rabbits were housed in a windowed rabbittry, with a one level design cages having galvanized wire. Breeding rabbits were kept individually, whereas the growing rabbits were raised in collective cages (4 kits per cage) after weaning, so that the group size effect on body weight and daily weight gain was reduced. Each cage for breeding rabbits was 60 cm length × 50 cm width × 35 cm high, whereas the dimensions of the growing rabbit's cage were 40 × 50 × 35 cm for length, width and height, respectively. Each cage was equipped with a feeder, and water supply of nipple drinkers and a plastic plate on the floor protected against sore hocks. On the day 28th of gestation, metal nesting boxes (40 × 30 × 30 cm) were attached to the cages of pregnant does, and were fixed outside the cages and supplied with a thin layer of wood shaving to provide a comfortable and warm nest for the kindled. All the flock was kept under the same managerial, environmental and hygienic conditions.

Young rabbits and breeding stock were fed with the same formulated commercial pellet rations, in which a minimum content of crude protein is 18 %, while the maximum rate of crude fiber is 14 %. Bucks and non-pregnant does and non-lactating ones were fed restricted amount of food (130 g/ day) to kept them in a good condition but not fat. Pregnant does after 15 days of pregnancy, lactating ones and growing rabbits were fed ad libitum. Clean fresh water were available for rabbits all the time. Manures were dropped from the cages on the floor and were collect and removed daily. A minimum temperature of 10°C was maintained during the winter, but in summer the temperature may reach of 40°C. The relative humidity was around 60% ± 10%. A period of 14-16 hours of day light was provided.

Reproductive management

The females were first mated at a mean age of 5 months. At the beginning of the breeding season, during September, the breeding rabbits were divided into groups for within group mating. Each group was made up by four does and one buck that were chosen to avoid mating between close relatives (avoiding full-sib, half-sib and parent-offspring mating). Each doe was transferred to the buck's cage to be mated. Does were palpated 15-day post mating to detect pregnancy and those remained not pregnant were returned to the same buck at the next mating date. At 33^{th} day of pregnancy, the birth was released by an injection of oxytocin in case of the doe had not littered until then.

During the pre-weaning period, the does had free admission to their litters. During this period, unrestricted access for litter to food and water was allowed. The offspring were weaned at 28^{th} day of age. At weaning, young rabbits were removed from doe's cages and raised in groups. The kits were individually ear tagged at weaning. Fattening period lasted 5 weeks after weaning. Young does and bucks were added to the herd as needed to replace those lost by death or by culling.

Health caring

The occurrence of disease could be largely avoided by a high standard of hygiene and careful management. So, the rabbits in our farm have never been treated with any kind of systematic vaccination. In case the growing rabbits had digestive problems, they were treated with antibiotics in order to overcome these troubles.

Studied traits

For the three genetic groups under investigation, the growth traits studied were individual weight at weaning (28d at WW, in grams), individual weight at the end of the fattening period (63d at MW, in grams), individual daily gain during the age intervals from 4-6, 6-8, 8-9 and 4-9 weeks of age (DWG, in grams/day), daily feed intake (DFI) during the age intervals from 4-6, 6-8, 8-9 and4-9 weeks of age (DFI, in grams) and feed conversion ratios at the same periods (FCR, in g DFI/ g DWG). Also, Mortality and Viability rates during the fattening period (MR & VR, %) were recorded.

Statistical procedure

Best linear unbiased estimates (BLUE) is the method most frequently used in animal breeding for estimation of fixed effects (Weigel *et al.,* 1991). To drive BLUE of the fixed effects, least squares procedures and the type III method described by Statistical Analysis System (SAS version 9.2, 2004) was used. Significance of the effects was tested at level $P < 0.05$ (*), $P < 0.01$ (**) and $P < 0.001$ (***) with the appropriate F statistic. Values of probability higher than 5% were considered to be not significant.

To study the effect of the three genetic groups included in the present study on growth performance of rabbits. Data for studied traits were analyzed by adopting the following fixed linear model:

$$Y_{ijklm} = \mu + G_i + SE_j + S_k + PO_l + b(NBA - \bar{x}) + e_{ijklm}$$

Where:

Y_{ijklm} is the observed value of the dependent variable**.**

μ is the general mean.

G_i fixed effect of the i^{th} genetic group (1, 2, 3).

SE_j fixed effect of the j^{th} season (winter , spring , summer , autumn).

S_k fixed effect of the l^{th} sex (1,2).

PO_l fixed effect of the m^{th} parity order.

NBA linear regression coefficient of the covariance, for number born alive.

e_{ijklm} the random error.

Each of SE, S, PO &, NBA were included in the previous model in order to increase the model R^2. This make the estimation of genetic group effect more accurate.

Growth curves for the three genetic groups were obtained by the regression of body weight values on age at weighing. Same procedure was used in case of estimate daily feed intake curves and the curves of feed conversion ratio during the fattening period.

Economic efficiency

The economic efficiency of feeding (EE) for growing rabbits in three genetic groups studied were calculated as the ratio between profitability and cost of feed consumed during the fattening period, according to the following formulas:

Profitability (C) = Total revenue (A) - Total feed cost (B)

Where:

Total revenue (A) the selling price of the obtained live weight

= *live body weight x rabbit Price per kg (40 LE).*

Total feed cost (B)the feed cost

= *Total feed intake x feed Price per kg (6 LE).*

The value of the economic efficiency was calculated as profitability per unit of total feed costs. The prices of experimental diets and live body weight were calculated according to the prices of the local market at the time of the experiment.

EE = (Profitability (C) / Total feed cost (B)) x 100

RESULTS AND DISSCUSION

Body weight and daily weight gain

Only the results directly concerned with genetic group effect on productive performance are presented. For the three genetic groups studied, least square means and standard errors for weaning weight, weight at 6, 8 & 9 weeks of age are presented in Table (1), whereas Table (2) contains the least square means of daily weight gain through 4-6, 6-8, 8-9 & fattening period (4-9) weeks of age. Analysis of variance indicated that individual body weight was significantly different ($P<0.001$) by genetic group. It is also apparent from these results that daily weight gain depends on genetic group.

Least square means in Table (1&2) revealed that rabbit's body weight and daily gain were significantly higher in AV group than in A and V groups. For WW, MW & DWG through the fattening period, AV cross group were higher than A and V group by about (4.59, 7.70 and 9.36 %) and (20.19, 17.12 and 14.25 %), respectively.

The means of weaning weight, weight at 9 weeks of age and daily weight gain through the fattening period obtained in the current study were heavier than that those reported by (El-Raffa, 2005; Mahsoub, 2007; Abou Khadiga *et al*., 2008; Zaghloul *et al*., 2019) for the V line rabbits, raised under Egyptian environmental conditions, and by (Ghada, 2018) for A line. Whereas, the observed values of growth performance founded in our study tended to be lower than those recorded by (García & Baselga, 2002; Hanaa, 2014). It must be noted that, the value of marketing weight obtained in the current study seems to be suitable for the costumers needed in our country. Therefore, marketing rabbits at 9 weeks is quietly recommended under Egyptian environmental conditions.

The differences in least square means of growth performance traits recorded in different studies might possibly be attributed to differences in genetic background of rabbits used, differences in amount of amount and nutritive value of feed stuffs used, managerial procedures, labor system, rabbittry design & environmental conditions (Hanaa, 2014; Ghada, 2018).

The growth curves for three genetic groups studied were provided graphically in Figure (1) and revealed that the growth of cross rabbits (AV) was higher compared to A and V lines. In this respect, Brahmantiyo & Raharjo (2011) illustrated that change of growth curve caused by selection of weaning weight. Also, Brahmantiyo *et al.* (2018) showed that the crossed sire line and dam line were potential to be developed as the genetic resources of does adaptive to tropical climate due to its good hybrid vigor in litter size traits a $P<0.001$ and its growth.

Feed intake and Feed conversion ratio

The study of genetic group effect on daily feed intake (DFI) and feed conversion ratio (FCR) during the fattening period show that there was a clear effect of this factor on DFI and FCR during different periods studied except for DFI from 4-6 weeks of age (Table 3). It can be shown from these results that total feed intake during the fattening period are 3581, 3479 & 3416 grams for V, A & AV genetic groups, respectively. Significant differences have existed between three genetic groups for DFI & FCR and revealed that the highest value of DFI was observed in V line whereas the lowest one were recorded in AV genetic group. Moreover, AV genetic group was better in FCR during different periods studied compared with those obtained for A & V lines.

In this respect, Ouyed *et al.* (2011) showed that the genotypes affect feed consumption and feed efficiency ratio. Also, (Szendrő *et al.,* 2016) found that the cross genotype was fewer in number of feeding days than pure rabbit strains. The feed intake curves in three genetic groups studied were presented in Figure 2. It revealed that the feed intake (FI) of cross group rabbits was lower compared to the A and V lines groups. These results matching with those obtained by Szendrő *et al.,* 2016. On the contrary, Al-Dobaib (2010) and Belabbas *et al.* (2019) showed that non- significant difference was found between rabbit genetic groups for the daily feed intake.

Figure 3 graphically presented the feed conversion ratio curves for three genetic groups studied. It indicated that the FCR of the cross group was preferred compared to the A and V groups. In this respect, Szendrő *et al.* (2016) and Lakabi (2010) reported that the crossbreed was better in the feed conversion ratio than the other pure genetic groups.

Mortality and viability rates

The carry over effect of genetic group difference (A, V & AV growing rabbits) used in the present study on mortality & viability rates through the fattening period are presented in Table (4). These results proved significant effect for genetic groups on the mortality (MR) and viability (VR) rates. The results show that, AV & A growing rabbits had better value for VR and MR when comparing with those record obtained for V line. It may be reflecting the ability of AV & A rabbits to adopt with environmental conditions.

The previous results are not agreement with those reported by Khamis, (2014) who noted that there are no significant influence on MR between Alexandria and V line rabbits during the fattening period from 4 to 10 weeks of age.

Economic efficiency

In accordance with guide of economic evaluation, each of total feed cost/ rabbit, selling price/ rabbit, profitability and economic efficiency are presented in Table (5). It is clearly apparent that AV genetic group rabbits recorded higher values for profitability and economic efficiency compared with A & V line rabbits. On other words, profitability and economic efficiency in AV genetic group increased by (27.93% & 34.11%) and (11.72% & 13.78%) than those obtained for V and A line rabbits, respectively. It may be due to decrease the amount of feed intake and increase weight gain for AV genetic group as compared with those of other the two genetic groups.

These results are similar to those obtained by (Sakr *et al.*, 2020 and Ali & El-Tarabany, 2013). They found a significant effect of different genetic groups on economic efficiency measures for growing rabbits during 4 to 12 weeks of age. Moreover, Khamis (2014) found significant differences in economic efficiency between V line and Alexandria line growing rabbits. On the contrary with the present results, Abdel-Hamid *et al.* (2013) indicated that no significant difference was observed among different breeds for net profit**.**

CONCLUSION

Results obtained from this study revealed that the cross between paternal line (Alex line) as bucks and maternal line (V line) as dams may have profitable impacts on growth performance, feed intake, viability and economic efficiency of growing rabbits.

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Table (1): Least square means and standard errors (SE) for the effect of genetic groups on body weights of growing rabbits

Genetic Groups[+]	Body weight[++] (g)											
	WW			BW6			BW8			MW		
	NO	LSM	S.E.	NO	LSM	S.E.	NO	LSM	S.E.	NO	LSM	S.E.
AA	1602	628.87[b]	5.53	1573	1087.23[b]	7.02	1441	1547.58[b]	09.09	1367	1758.63[b]	10.23
VV	493	547.26[c]	7.57	0483	1005.40[c]	9.57	409	1426.96[c]	12.45	395	1617.17[c]	14.48
AV	1123	657.73[a]	8.00	1048	1162.00[a]	10.11	975	1620.42[a]	13.11	975	1894.08[a]	14.88
Sig.	***			***			***			***		

[+]AA: Alexandria line VV: V line AV: Alexandria line male X V-line female
[++]WW = Weight at 4 weeks; BW6 = Weight at 6 weeks; BW8 = Weight at 8 weeks; MW = Weight at 9 weeks.
[a, b, c, …..] Means with different letters on the same column differ significantly (P≤ 0.001).

Table (2): Least square means and standard errors (SE) for the effect of genetic groups on daily weight gain of growing rabbits.

Genetic Groups[+]	Daily weight gain [++] (g/day)											
	DWG 4-6			DWG 6-8			DWG 8-9			DWG 4-9		
	NO	LSM	S.E.	NO	LSM	S.E.	NO	LSM	S.E.	NO	LSM	S.E.
AA	1573	32.62[b]	0.34	1441	32.89[a]	0.42	1367	33.20[b]	0.69	1367	32.69[b]	0.26
VV	0483	32.39[b]	0.46	0409	30.10[b]	0.58	395	32.24[b]	0.97	0395	31.29[c]	0.36
AV	1048	35.39[a]	0.49	0975	33.17[a]	0.61	0975	40.10[a]	0.99	0975	35.75[a]	0.37
Sig.	***			***			***			***		

[+]**AA**: Alexandria line **VV**: V line **AV**: Alexandria line male X V-line female
[++]DWG during 4-6, 6-8, 8-9 and 4-9 = daily weight gain from 4 to 6, 6 to 8, 8 to 9, 4 to 9 weeks of age, respectively.
[a, b, c, …..] Means with different letters on the same column differ significantly (P<0.001).

Table (3): Least square means and standard errors (SE) for the effect of genetic group on daily feed intake (DFI), feed conversion ratio (FCR) of growing rabbits.

Genetic group[+]	DFI (Age intervals; wk)			
	4-6 wk	6-8 wk	8-9 wk	4-9 wk
AA	91.34 ± 1.34	98.34[b] ± 1.39	117.86[b] ± 2.27	99.40[b] ± 1.05
VV	96.84 ± 1.56	99.33[b] ± 1.44	124.77[b] ± 2.54	102.32[c]±1.15
AV	86.71 ± 0.79	96.87[a] ± 0.83	115.89[a] ±1.35	97.60[a] ± 0.64
Sig.level	NS	**	*	**
Genetic group[+]	**FCR (Age intervals; wk)**			
	4-6 wk	**6-8 wk**	**8-9 wk**	**4-9 wk**
AA	2.80[b] ± 0.054	2.99[b] ± 0.076	3.55[b] ± 0.10	3.02[b] ± 0.045
VV	2.99[b] ± 0.060	3.30[c] ± 0.084	3.87[c] ± 0.11	3.27[c] ± 0.049
AV	2.45[a] ± 0.033	2.92[a] ± 0.047	2.89[a] ± 0.60	2.73[a] ± 0.027
Sig.level	***	***	***	***

[+] **AA** = Alexandria line; **VV** = V line; **AV** = Alexandria line male x V line female.
[a, b, c...] Means in the same column followed by different letters are significantly different at NS = P >0.05; * = P≤ 0.05; ** = P ≤ 0.01; *** = P ≤ 0.001

Table (4): Least square means and standard errors (SE) for the effect of genetic groups on mortality and viability rates.

Genetic groups[+]	MR (%)		VR	
	LSM	SE	LSM	SE
AA	14.67[b]	0.02	85.33[a]	0.02
VV	19.88[a]	0.03	80.12[b]	0.03
AV	13.18[b]	0.03	86.82[a]	0.03
Sig.level	*		*	

[+] **AA** = Alexandria line; **VV** = V line; **AV** = Alexandria line male x V line female.

Table (5): Economic efficiency of growing rabbits for V, A and AV genetic groups.

	Genetic group[+]		
Trait[++]	**AA**	**VV**	**VA**
Live body weight (LBW, g)	1758.63	1617.17	1894.08
Total feed intake (g)	3479.00	3581.00	3416.00
Total revenue *(A)* (L.E)	70.35	64.69	75.76
Total feed cost *(B)* (L.E)	20.87	21.49	20.50
Profitability *(C)* (L.E)	49.47	43.20	55.27
EE %	237.00	201.06	269.65

[+]**AA**: Alexandria line **VV**: V line **AV**: Alexandria line males x V line females.
[++]Total revenue (A): LBW * Price per kg (40 L.E / kg LBW),Total feed cost (B): Total feed intake (FI) * Price per kg (6 L.E / kg Feed),Profitability (C): A - B ,EE (%): (C / B) ×100.

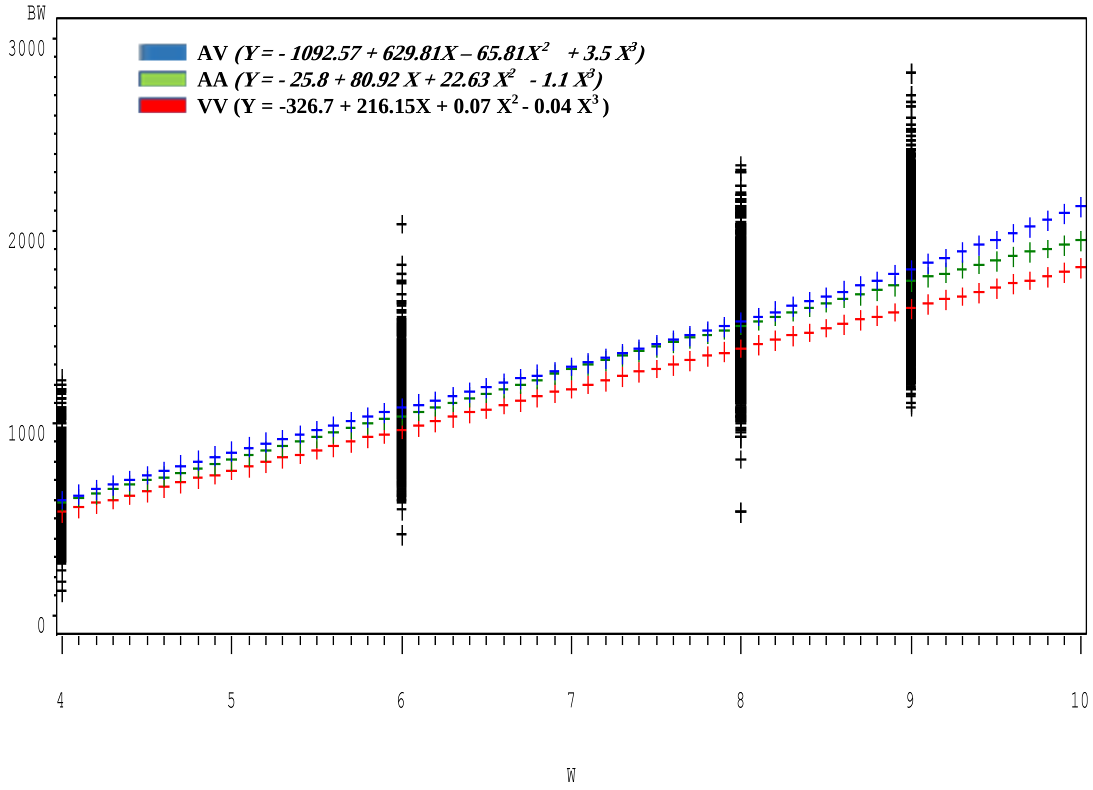

Fig. (1): Growth curve of the different genetic rabbits' groups from 4 to 9 weeks of age

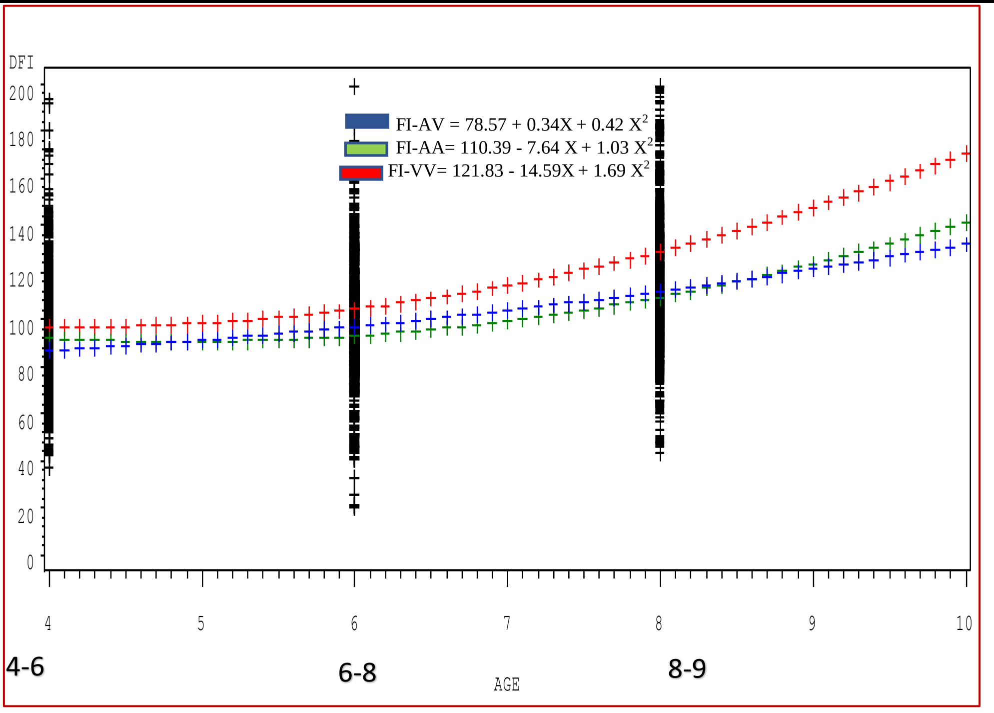

Fig (2): Daily feed intake curve of the different genetic rabbits' groups from 4 to 9 weeks of age.

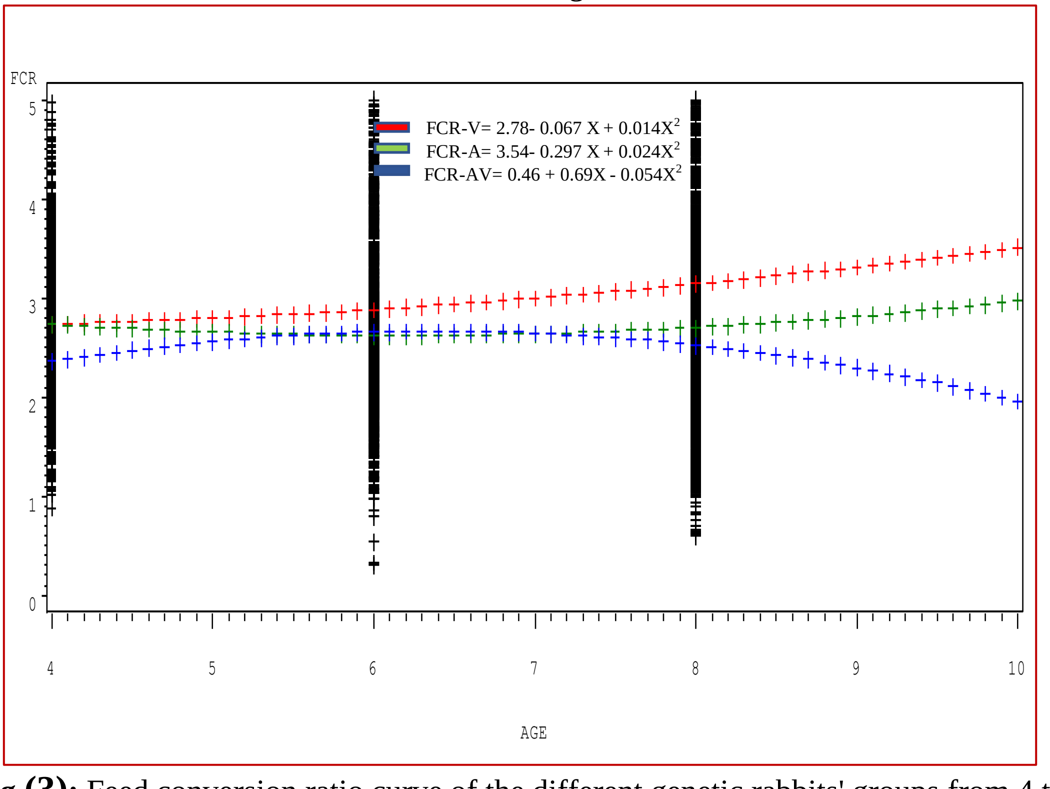

Fig (3): Feed conversion ratio curve of the different genetic rabbits' groups from 4 to 9 weeks of age.

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الملخص العربي
كفاءة خلط ذكور خط أبوي وإناث خط أموي للأرانب على أداء النمو

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أجريت هذه الدراسة بمزرعة تربية الأرانب بمركز بحوث الدواجن بكلية الزراعة جامعة الإسكندرية. كان الهدف الرئيسي لهذه الدراسة هو تقييم كفاءة الخلط بين خطين من الأرانب في إطار برامج الانتخاب على الأداء الإنتاجي للأرانب الخليطة. تم استخدام ثلاث مجموعات وراثية من الأرانب في التجربة. خط أرانب (A) الإسكندري كخط أبوي، خط (V) كخط أموي وخلط بين ذكور خط A وإناث خط V (AV). كانت الصفات المدروسة المستخدمة لتقييم الأداء الإنتاجي في هذه المجموعات الوراثية الثلاثة هي: وزن الجسم الفردي عند الفطام وعند عمر التسويق (BW4 & BW9)، وزيادة الوزن اليومي (DWG) ، والعلف المأكول اليومي (FI) ، ونسبة التحويل الغذائي (FCR)، معدل الحيوية (VR) والكفاءة الاقتصادية (EE). تم استخدام إجمالي ٤٩٣ و ١٦٠٢ و ١١٢٣ من الأرانب V و A و AV على الترتيب في التجربة.
أظهرت النتائج أن الأرانب الخليطة AV كانت أثقل من أرانب الخطوط النقية (AA & VV) في وزن الجسم عند العمرين المدروسين وفي DWGخلال فترة التسمين. بعبارة أخرى، حققت المجموعة الوراثية الخليطة وزن جسم تسويقي في وقت مبكر عن المجموعتين الأخريين.
كما تحسنت قيمة FCR لنمو الأرانب AV مقارنة مع تلك التي تم الحصول عليها لأرانب AA وVV. علاوة على ذلك، كان معدل الحيوية خلال فترة التسمين في الأرانب الخليطة هو الأعلى، في حين أن أقل معدل تم تسجيله للأرانب من خط V . ويتضح من هذه النتائج أن مجموعة AV سجلت قيمًا أعلى فى الكفاءة الاقتصادية عن المجموعات الوراثية الأخرى.
الخلاصة أن التزاوج بين ذكور الخط الأبوي A وإناث الخط الأموي V أعطى خليط وفر فى الوقت والتكاليف لكي يصل إلى التسويق.

الكلمات الدالة: خط أبوي، خط أموي، الخلط، أداء النمو، الارانب