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EFFECT OF CROSSING CALIFORNIA WITH GABALI RABBITSON LITTER WEIGHT, LITTER SIZE AND MILK PRODUCTION.

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ABSTRACT:

The aim of this search was to study changes in litter weight (LW), litter size (LS), and milk production (MP) by crossing between the Sinai- Gabali (GAB) and California (CAL) rabbits. Data collected from a total number of 80 does and 20 bucks were divided into four groups (GAB × GAB), (CAL× CAL), (CAL × GAB), and (GAB × CAL). The result showed a significant improving in LW at the cross (CAL × GAB) 23%, 44%, 65%, 67%, 37%, and 32% at birth, 7, 14, 21, 28, and 35 days of age respectively. Mating type affected significantly (P ≤ 0.01) in LS at birth, 7, 14, 21, 28, and 35 days, where the Genotype (CAL × GAB) and (CAL) were superior to (GAB) and (GAB × CAL) at different age. On the other side, there were affected significantly (P ≤ 0.01) in MP at 7, 14, 21, 28, and 35 days of grown period. The cross (CAL × GAB) was the highest milk production at most periods, followed by CAL, GAB and GAB × CAL, respectively. The direct heterosis was significantly positive for body weights at 8, 9, 10, 11, and 12 weeks but it was negative at 7 weeks. The direct heterosis was significantly positive for milk production at 7, 14, 21, 28, and 35 days, Its highest at weaning 35 days.

In conclusion crossing between CAL and GAB improved litter weight, litter size, and milk production provided when male California is used.

Key words: Crossbreeding, Heterosis, Litter size, Litter weight, Milk production.

INTRODUCTION:

There is a gap between the demand and supply of animal protein, rabbits' industry can play an essential role in solving a part of the meat shortage and overcoming it. Some developing countries are beginning to utilize rabbit meat as a main source of meat **(Mahsoub, 2007).**In this countries, rabbit does not competing with human for food **(McNitt *et al*., 2013). Zotte, 2000** reported that rabbit meat is suitable for feeding children and old people because it is a delicacy and healthy food product, easy to digest, high protein, and low in fat, cholesterol, and calories. Also, rabbit meat contains calcium and phosphorus with a percentage higher than other meats and it is rich in B vitamins group **(Nistor *et al*., 2013),** Rabbits are small body size and have short reproductive cycles **(Martßnez, 1999).**

Crossbreeding is one of the fast methods to improve breeds in many qualities performance in farm animals.(**El-Domyati *et al,* 2018 and Fadare and Fatoba, 2018).**Crossbreeding is used to improve the overall production efficiency by using some breeds with high genetic merit for different economic traits with local rabbits which low genetic merit. (**Iraqi *et al*., 2008 and Youssef *et al*., 2009**).

One of the most important economic traits is litter size.**(Egena *et al,* 2012),** it's the major factor to improve meat production **(Akinsola *et al,* 2014)**. It provides the number of functional mammary glands through their suckling simulative effects. When litter size increases, milk production is increase too **(Never Assan 2018)**.On the other hand, body weight as an economically important character in the commercial meat rabbit industry was found to be improved by a crossing of local breeds with exotic standard breeds **(Piles *et al* 2004 and Saleh *et al* 2005).**

The aim of this study to evaluate the effect of crossbreeding between Gabali and California strains on rabbit performance traits such as litter weight, litter size, and milk production, during the growing and productive periods.

MATERIALS AND METHODS:

The present experiment was carried out at the Faculty of Agriculture Damanhour University Animal and Poultry Production Department and El-Sabahia Poultry Research Station in Alexandria, Animal Production Research Institute, Agricultural Research Center, Ministry of Agriculture. during the period from November, 2020 up to May, 2021

Breeding plan

Two rabbit strains were used in this study, the first one represents a native Egyptian breed (Sinai Gabali; GAB) and the other represents a standard exotic strain (California; CAL). Does and bucks of the exotic strain (California; CAL) are acclimatized descendants of the American strain. A total 1397 kits were produced of 80 does and 20 bucks (20 does and 5 bucks for each strain), Which were mated as 4 groups(GAB × GAB), (CAL × CAL), (CAL × GAB) and (GAB × CAL).The first mating is GAB mated with CAL bucks (CAL♂ X GAB♀) to produce F1 and reciprocal crosses (GAB♂ X CAL♀). Weaning was performed at 35 days of kits age. Each doe was inserted to the buck's cage for mating after 10 days of birth.

Housing and management

Animals were kept under similar management and hygienic conditions. The lighting system provided 16 hr of light per day. The range of temperature and relative humidity throughout the period from November to May were 18º C (13 ºC as Min. and 23 ºC as Max.).

Feed and water were provided *ad libitum*. The Composition of fed was a commercial lactating- pelleted-diet containing approximately 18.8% crude protein with 2680 Kcal/kg ration as digestible energy; 13% crude fiber and 3% fat.

Studied traits.

Body weight (g)

The following traits were evaluated:

Individual live body weight at morning (BW) of does and kits in grams were recorded at birth, 7, 14, 21, 28, and 35 days.

Individual live body weight at morning (BW) of rabbits in grams were recorded at 7, 8, 9, 10, 11, 12 and 13 weeks.

Reproductive traits:

Total litter size at birth

Total litter size was recorded at birth, 7, 14, 21, 28, and 35 days of age were calculated.

Milk production

Milk production per dam at birth, 7, 14, 21, 28, and 35 days after parturition were measured in grams by weighing the dam before and after suckling, so on control days it is only necessary to allow access to the dams once per day for about 5-10 min. Daily milk production was computed as the difference between pre-and post-suckling doe weight. Daily milk yield for each week was calculated as the average of daily milk production measurements for that week **(EL-Nagar *et al*, 2014)**

Heterosis (H^I)

Heterosis (H^I) for all traits studied was estimated according to Dickerson theory **(Dickerson, 1992)**. Such genetic model permits to derive of a selected set of linear contrasts as for flowing:

H^I (%) = [(CAL×GAB + GAB×CAL) - (CAL×CAL + GAB×GAB)] / [CAL×CAL + GAB×GAB] X (100).

Where H^I (%) heterosis in percentage.

Statistical analysis:

Data were analyzed as one-way ANOVA design, using the GLM procedure of SAS 9.2**(SAS Institute Inc., 2008).** The model for growth traits, feed intake, and feed conversion were analyzed by using the following univariate linear model:

$$\mathbf{Y_{ijkl} = BYS_i + OP_j + \beta(NBA)_k + lo_l + e_{ijkl}}$$

where: $\mathbf{Y_{ijkl}}$ is the record of the growth trait of animal l; $\mathbf{BYS_i}$is the effect of breed-year-season combination, line of animal l and the year-season of parity (one year-season every three months: nine levels for all breeds); $\mathbf{OP_j}$ is the effect of the order of parity (five levels: 1st, 2nd, and >2nd), $\mathbf{NBA_k}$ is the number of born alive in the litter in which the young rabbit was born and β is the regression coefficient on this covariate; $\mathbf{lo_l}$ is the random effect of the litter in which the animal was born and $\mathbf{e_{ijkl}}$ is the residual effect.

Concern in milk production, the analysis model was

$$\mathbf{Y_{ijkl} = BYS_i + \beta(N)_j + e_{ijk}}$$

where: $\mathbf{Y_{ijkl}}$ is the record trait; $\mathbf{BYS_i}$ is the effect of line-year-season combination; $\mathbf{N_k}$ is the number of young rabbits per doe β is the regression coefficient on this covariate and $\mathbf{e_{ijk}}$ is the residual effect.The different groups were compared by using Duncan´s multiple range test where significance differences were detected as first class error at $P \leq 0.05$.

Finally, the individual heterosis was estimated by generalized least squares according to the Dickerson's model **(Dickerson, 1969).**

RESULTS AND DISCUSSION

Kit body weight (g)

Litter weight at different ages of growing period of kit was shown in table (1). The results showed that there was a significant improved in litter weight (LW) at the cross CAL × GAB in all ages of grown period compared with GAB strain, this improved was 23%, 44%, 65%, 67%, 37% and 32% at birth, 7, 14, 21, 28 and 35 days of age respectively.

Table (1): Means ± stander errors (SE) of litter weight (gm) (LW) at different age of grown period.

Groups	LW at birth	LW at 7 day	LW at 14 day	LW at 21 day	LW at 28 day	LW at 35 day
CAL	433 ^{A} ± 13.24	964.92 ^{A} ± 27.2	1488.55 ^{A} ± 34.51	2047.55 ^{A} ± 41.68	2752.33 ^{A} ± 56.38	3648.9 ^{A} ± 84.27
GAB	363.08 ^{B} ± 8.27	611.17 ^{C} ± 8.43	941.58 ^{C} ± 13.6	1272 ^{C} ± 21.45	2030.75 ^{C} ± 39.65	2787.92 ^{C} ± 60.93
CAL × GAB	446.67 ^{A} ± 12.53	885.08 ^{B} ± 22.29	1556.1 ^{A} ± 38.38	2130.32 ^{A} ± 47.08	2795.17 ^{A} ± 57.06	3688.33 ^{A} ± 76.44
GAB × CAL	297.25 ^{C} ± 6.27	645.75 ^{C} ± 18.91	1129.5 ^{B} ± 19.61	1780.08 ^{B} ± 29.85	2389.92 ^{B} ± 39.85	3146.33 ^{B} ± 41.02

(LW) Litter weight at birth, 7 , 14 , 21 , 28 and 35 days of age , A,B and C Means within the same column in the same age with different superscripts are significantly different ($P \leq 0.05$).

There was a significant improved in the cross GAB × CAL compared with GAB strain, this improved was 5 %, 19%,39%,17% and12% at 7, 14, 21, 28 and 35 days of age respectively. These results agree with **Abdel- Azeem *et al* 2007** reported that crossbred litters showed higher LW at birth and weaning compared with those of purebred litters. Also, **Nwakpu *et al*, 2015** reported that the weight from birth to weaning of crossbred kits were heavier than the purebred kits.

Body weight at different ages of fattening period of rabbits was shown in table (2). The results showed that the cross CAL × GAB superior than GAB in body weight at 10, 11 , 12 and 13 weeks of age 12.5% ,8.7%, 10.3% and 16.4%, respectively agree with **Zaghloul *et al* 2019** where the cross surpassed one of the parents at 10 and 12 weeks of age on the other hand this cross was exceeded CAL at 12 and 13 weeks of age 6.8% and 8%, respectively. this was agree with **Iraqi *et al* 2008** reported that F1 was superior than both parents, These results agree with **Abdel- Azeem *et al* 2007** reported that heterosis percentages for all post-weaning weights was positive where the cross was The highest body weight from weaning to marketing.

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Table (2) : Means ± stander errors (SE) of body weight (BW) at during different age of fattening period.

Groups	BW at 7 week	BW at 8 week	BW at 9 week	BW at 10 week	BW at 11 week	BW at 12 week	BW at 13 week
CAL	582.8 ^{A} ± 6.69	926.79^{A} ± 33.84	1312.5^{A} ± 31.13	1514.64^{A} ± 33.64	1608.93^{A} ± 29.56	1721.79^{B} ± 27.22	2047.14 ^{B} ± 16.6
GAB	596.2 ^{A} ± 5.33	891 ^{A} ± 24.68	1273.57 ^{A} ± 19.56	1393.85 ^{B} ± 32.28	1528.85 ^{B} ± 25.99	1666.15 ^{B} ± 21.69	1900 ^{C} ± 10.32
CAL × GAB	576.3 ^{A} ± 8.18	933.21 ^{A} ± 20.32	1324.64 ^{A} ± 14.84	1568.93 ^{A} ± 25.71	1663.21 ^{A} ± 20.2	1838.93 ^{A} ±26.17	2212.5 ^{A} ± 24.42

(BW) Body weight at 7 , 8 , 9 , 10 , 11 , 12 and 13 weeks of age A,B and C Means within the same column in the same age with different superscripts are significantly different (P≤0.05).

Litter size (LS)

Litter size at different ages of growing period of kit was shown in Table (3). Results showed that, CAL × GAB was the highest in litter size, this is superior because of heterosis power.

Rabbits LS and birth weight are traits of economic importance that should be given prominence in rabbit breeding programs or enterprises. litter size is the most important economic character in rabbit production. **(Egena *et al*, 2012).** This trait is the best contributor to litter weight of rabbits. Crossbreeding was associated with the improvement in LSB, LSW **(Abdel- Azeem *et al* 2007), I**n crossbreeding use (CAL) as maternal breed to improve (LS) at birth and (LS) at weaning **(García *et al*. 2012)**

Table (3): Means ± stander errors (SE) of litter size (LS) (number) at different age of grown period.

Groups	LS at birth	LS at 7 day	LS at 14 day	LS at 21 day	LS at 28 day	LS at 35 day
CAL	7.45 ^{A} ± 0.2	7.23 ^{AB} ± 0.19	7.17 ^{A} ± 0.19	7.07 ^{A} ± 0.19	7.05 ^{A} ± 0.19	7 ^{A} ± 0.19
GAB	5.88 ^{C} ± 0.13	5.13 ^{C} ± 0.11	4.95 ^{C} ± 0.1	4.58 ^{C} ± 0.09	4.47 ^{C} ± 0.08	4.38 ^{C} ± 0.08
CAL × GAB	7.55 ^{A} ± 0.14	7.38 ^{A} ± 0.15	7.22 ^{A} ± 0.15	7.15 ^{A} ± 0.14	7.15 ^{A} ± 0.14	7.15 ^{A} ± 0.14
GAB × CAL	6.98 ^{B} ± 0.14	6.82 ^{B} ± 0.14	6.63 ^{B} ± 0.14	6.58 ^{B} ± 0.13	6.52 ^{B} ± 0.13	6.38 ^{B} ± 0.12

(LS) Litter size at birth, 7 , 14 , 21 , 28 and 35 days of age A,B and C Means within the same column in the same age with different superscripts are significantly different ($P \leq 0.05$).

Milk production

Milk production (MP) at different ages of growing period of kit was shown in table (4). The results showed that MP was a significant increase in the cross CAL × GAB in all ages of grown period compared with GAB strain, this increase was 76%, 33%, 44%, 36%and 53% at 7, 14, 21, 28 and 35 days of age respectively, and it was above from CAL strain at 7,21, 28 and 35 days of age about 3%, 2%, 5% and 21% respectively. MP in CAL × GAB was higher significant than CAL, GAB strains and cross GAB × CAL in all ages of grown period except CAL strain at 14 and 21 days of age there was no significance. The cross GAB × CAL was higher than GAB strain in milk production at all ages in of grown period around 45%,12%, 22%, 15% and33% at 7, 14, 21, 28 and 35 days of age respectively.

Table (4): Means ± stander errors (SE) of Milk production (MP) (g) at different age of grown period.

Groups	MP at 7 day	MP at 14 day	MP at 21 day	MP at 28 day	MP at 35 day
CAL	96 ^{B} ± 1.75	167.33 ^{A} ± 3.72	182.58 ^{A} ± 3.01	133.75 ^{B} ± 3.02	66.42 ^{B} ± 2.25
GAB	56.58 ^{D} ± 0.66	120.58 ^{C} ± 0.55	130.25 ^{C} ± 0.6	103.75 ^{D} ± 0.55	52.83 ^{C} ± 0.47
CAL × GAB	99.83 ^{A} ± 1.51	161.33 ^{A} ± 3.08	187.92 ^{A} ± 2.47	141.58 ^{A} ± 3.11	81 ^{A} ± 1.96
GAB × CAL	82.25 ^{C} ± 1.05	136 ^{B} ± 1.92	159.17 ^{B} ± 1.49	119.58 ^{C} ± 1.66	70.75 ^{B} ± 1.23

(MP) Milk production at 7 , 14 , 21 , 28 and 35 days of age A,B,C and D Means within the same column in the same age with different superscripts are significantly different ($P \le 0.05$).

Rabbit milk is characterized by high energy, lipid, and protein and low lactose (**Kolawole *et al.*, 2013**). In this respect, it explains the substantial growth potential of the rabbit kits preceding weaning.**(Effiong and Wogar 2007).** Growth rate and body weight gain are good indicators of kits doe's maternal behavior, especially in MP. Milk production increases with increased litter size. There is a predictable positive correlation of does milking capacity and productive traits **(Never Assan 2018).**

HETEROSIS (H)

Heterosis percentage of LW and LS at different ages of growing period of kit was shown in table (5). The results showed that the direct heterosis was significantly positive for litter size from birth to weaning, it was significantly positive for litter weights at 14, 21 , 28 , 35day of age while it was significantly negative at birth and 7 day of age. These results according to **Abdel- Azeem *et al* 2007** where litter size at birth (LSB) and litter size at weaning (LSW) were Positive heterosis, as well as litter weight at birth (LWB) and litter weight at weaning (LWW).

Table (5): Heterosis percentage of litter weight (LW) and litter size (LS) at different age.

Trait	Heterosis(H) (%)	Confidence interval	P value
LWB	-6.53	[-51.5 , -0.7]	0.4
LSB	9	[0.3 , 0.9]	0.07
LW7	-2.87	[-78.2 , 32.9]	0.42
LS7	14.51	[0.6 , 1.3]	0.001
LW14	10.52	[43.9 , 211.6]	0.03
LS14	14.17	[0.5 , 1.2]	0.001
LW21	17.79	[190.5 , 403]	0.001
LS21	17.84	[0.7 , 1.4]	0.001
LW28	8.4	[79 , 322.7]	0.001
LS28	18.58	[0.7 , 1.44]	0.001
LW35	6.18	[37.4 , 360.4]	0.02
LS35	18.98	[0.7 , 1.4]	0.001

(LWB) litter weight at birth,(LSB) litter size at birth,(LW7,14,21,28 and 35) litter weight at 7,14,21,28 and 35 days of age and (LS7,14,21,28 and 35)litter size at 7,14,21,28 and 35 days of age.

The results showed that the direct heterosis was significantly positive for body weights at 8, 9, 10, 11, and 12 weeks (Table 6). This result agrees with (**Zaghloul *et al* 2019, Mahran *et al* 2017 and Abdel-Hamid 2015).** Except for body weight at 7 weeks, it was negative. **(García *et al* 2013 and Falconer 1977)** reported that the presence of heterosis in favor of the California, Chinchilla, and New Zealand progenitors allows highlighting the hypothesis of the strictly additive genic action (direct and maternal).

Table (6): Heterosis percentage of body weight (BW) and average daily gain (ADG) , body weight gain (BWG) and total feed intake (TFI).

Trait	Heterosis(H) (%)	Confidence interval	P value
BW 7	-2.24	[-21.37 , -4.96]	0.001
BW8	2.75	[-7.02 , 56.9]	0.12
BW9	2.24	[4.2 , 58.9]	0.02
BW10	7.72	[73.3 , 151.6]	0.001
BW11	5.91	[61.27 , 124.42]	0.001
BW12	8.49	[113.5 , 174.3]	0.001
BW13	11.95	[207.2 , 256.2]	0.001
ADG7-10	14.49	[4.4 , 7.5]	0.001
ADG10-13	23.89	[4.3 , 7.5]	0.001
ADG7-13	17.52	[5.4 , 6.4]	0.001
BWG	17.93	[221.6 , 276.3]	0.001
TFI	-2.12	[-148 , -84]	0.001

(BW) Body weight at different ages 7,8,9,10,11,12 and 13 weeks, (ADG) Average daily gain at different periods 7-10,10-13 and 7-13 weeks, Body weight gain (BWG), (TFI) Total feed intake.

The direct heterosis were significantly positive for milk production at 7, 14, 21, 28 and 35 days (Table 7), Its highest at weaning (35 days) agree with **(Al-Sobayil *et al* 2005**) weaning at (28 days).

The heterosis or hybrid vigor, for a given trait and couple of lines represents the difference between the value of the trait in the F1 obtained from crossing the two lines, and the average of the values of the parental lines(**Carlos 2014**). The genetic basis of the heterosis is different in allele frequency between lines, dominance and epistasis. The simplest model, and perhaps the most common, relies on the dominance effects (**Parson and Bodmer 1961 and Falconer and Mackay, 1996**).Positive heterosis was shown for LS at birth, at weaning, LW at birth and at weaning (**Abdel- Azeem *et al* 2007)**

Table (7): Heterosis percentage of milk production (MP) at different age of lactation period.

Trait	Heterosis (%)	Confidence interval	P value
MP 7	19.28	[10 , 19.4]	0.001
MP14	3.28	[-2.3 , 11.7]	0.001
MP21	10.93	[10.3 , 23.9]	0.001
MP28	10.03	[6.2 ,17.5]	0.001
MP35	27.35	[12.7 , 19.8]	0.001

(MP) milk production at 7, 14 , 21, 28 and 35 days.

INCONCLUSION:

Crossing improves litter weight, litter size and milk production provided when California (CAL) as a buck is use in pure mating or crossing with does of Sinai Gabali (GAB).

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تأثير خلط أرانب الكاليفورنيا مع الجبلي على وزن وحجم الخلفة وإنتاج اللبن

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الملخص:

يهدف البحث لدراسة التغيرات في وزن و حجم الخلفة و انتاج اللبن نتيجة الخلط بين ارانب الجبلي السيناوى و الكاليفورنيا حيث تم جمع البيانات من 80 ام و 20 ذكر و وزعت الي 4 تزاوجات (جبلي × جبلي) , (كاليفورنيا ×كاليفورنيا), (كاليفورنيا × جبلي) و(جبلي × كاليفورنيا).

أظهرت النتائج تحسن معنوي في وزن الخلفة في الهجين (كاليفورنيا × جبلي) في كل الأعمار بنسب 23% , 44% , 65% , 67% , 37% و 32% عند الولادة , 7 , 14 , 21 , 28 و 35 يوم من العمر علي الترتيب. وكان تأثير التزاوج معنوي لصفة حجم الخلفة عند الولادة , 7 , 14 , 21 , 28 و35 يوم من العمر، بينما الهجين (كاليفورنيا × جبلي) والكاليفورنيا كلاهما تفوقا علي الجبلي والهجين (جبلي × كاليفورنيا) في مختلف الاعمار.

علي الجانب الاخر كان هناك تأثير معنوي لصفة انتاج اللبن عند عمر7 , 14 , 21 , 28 و 35 يوم من العمر خلال فترة النمو. وكان الخليط كاليفورنيا × جبلي الأعلى في صفة انتاج اللبن في معظم الفترات يليه الكاليفورنيا ثم الجبلي ثم جبلي × كاليفورنيا على الترتيب. كما أن قوة الهجين كانت معنوية موجبة لصفة وزن الجسم في غالبية الاعمار المختلفة 8 , 9 , 10 , 11 و12 اسبوع لكنها سالبة عند عمر 7 اسابيع.، في حين أن قوة الهجين كانت موجبة ومعنوية لصفة انتاج اللبن عند عمر7, 14, 21, 28 , 35 يوم والأعلى كانت عند الفطام عمر 35 يوم.

والخلاصة يتضح أن الخلط بين أرانب الكاليفورنيا والجبلي يحسن وزن وحجم الخلفة وانتاج اللبن حينما يكون الذكور من ارانب الكاليفورنيا.

الكلمات الدالة: الخلط، قوة الهجين حجم الخلفة، وزن الخلفة، انتاج اللبن.