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EFFECT OF DIALLEL CROSSING ON SOME GROWTH PERFORMANCE, CARCASS TRAITS AND IMMUNE RESPONSE AGAINST NEW CASTLE DISEASE VIRUS VACCINE OF JAPANESE QUAILS.

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Abstract: *Diallel cross experiment was conducted using three colored varieties of Japanese quails (Brown (BB), Golden (GG) and White (WW)) purebreds, and their reciprocal and crossbred offsprings. White Japanese quails (WW) had the highest significant body weight among purebreds at the 6th week of age (168.30 gm), and WG expressed the highest significant body weight among crossbreds (169.62 gm), and while GW had the highest body weight among reciprocal crossbreds (181.39 gm). Positive heterosis recorded for crossbreds and reciprocal on the average (1.76 % and 9.09%). Reciprocal crossbreds had the highest relative growth rate at two and three weeks (52.92 and 44.58 %). Crossbreds showed high average growth rate at 4, 5 and 6 weeks (39.30, 39.37 and 32.40%). Also positive heterosis was recorded across the preceding periods, Reciprocal crossbreds showed higher significant values than purebreds and crossbreds for shank length and keel length at the fourth and fifth weeks of age and had positive overall average heterosis percentage for shank length (6.53 and 3.18% and keel length (9.29 and 5.52%). Carcass traits did not express any significant value between purebreds, crossbreds and reciprocals. But edible percentages were the highest in purebreds (8.99%). White coturnix expressed higher antibody titer among purebreds (349.14), but its reciprocal crossbreds were non-significant high compared to crossbreds and purebreds (107.89, 103.04 and 101.62%; respectively). These results accompanied by positive heterosis of crossbreds and reciprocal crosses (1.40 and 6.20%). It was worth noted that using of White coturnix as a dam or a sire line improved performance and antibody titers against inactivated New Castle Disease (ND) virus vaccine.*

INTRODUCTION

The diallel cross is a useful genetic tool for evaluating the performance of lines and breeds in crossbred combinations. **Silversides and Crawford (1991)** found significant differences between ***albino and non***

albino quail in hatching weight, also albino weighed 12.5% less than non albinos at the first week. **Bahie El- Deen *et al.,* (1998)** estimated heterosis percentage for body weight of ***Japanese quail*** at two weeks as 30.2% but declined to 11.8% at six weeks of age. High relative growth rates (17 – 38 %) in high- low ***quail*** cross line divergently selected for 4 weeks body weight compared to the corresponding paternal lines were found by **Marks (1995).** .**Shalan (1998)** reported that means of body weight of males at 6 weeks of age in ***quails*** were higher for L4 than L3 in all generations, as well as, the average of carcass weight for L4 was larger than L3 (124.04 vs 109.95 gm) and (130.18 vs 104.56 gm) for the second and third generations. Meanwhile, the relative carcass weights were 65.50 % vs 64.05 % and 66.74 vs 64.05 for L4 and L3 on generations 2 and 3. **Shanaway (1994)** revealed that dressing percentage ranged from 60-80% with an average of 75% Percentage variations being due to species, sex, age and management. Males in general showed similar or slightly higher yield percentages than females. Moreover, **Sharaf *et al.* (1988)** reported significant genetic variations among different lines of *turkey* and recorded 7% percent more giblets (liver and heart). **El- Damarawi (1999)** reported that there were highly significant differences between sire and dam families in different breeds and commercial hybrids of chickens for antibody response to NDV vaccines.

The objectives of this research was to investigate the differences between purebred and crossbred of colored varieties coturnix for body weight, growth rate (absolute and relative), body measurement (shank and keel length), carcass traits, antibody titer against inactivated New Castle disease vaccine.

MATERIALS AND METHODS

This experiment was conducted on Japanese quail using the facilities of the Department of Animal Husbandry and Animal Wealth Development, Alexandria University through out the period from January 2004, to March 2005. Mature quail cocks and hens of three colored varieties (Brown, Golden and White coturnix) were assigned randomly to mating cages in a full 3x3 diallel cross design ***(Becker, 1985)***. 15 males and 30 females of each quail color were used in paired mating design as shown in table (1):

Table (1): Dialle cross mating design.

MALE / FEMALE	**BROWN (B)**	**GOLDEN (G)**	**WHITE (W)**
BROWN (B)	**BB**	GB	WB
GOLDEN (G)	BG	**GG**	WG
WHITE (W)	BW	GW	**WW**

- Each mating was done between 5 cocks and 10 hens.

Separate wire cages (25x25x25cm.) were used for single pair mating. Males and females were wing banded, and provided with feed and water ad libitum, as well as 16 - hours light. Pedigreed eggs of each sire family within each group were collected daily and stored at 13°C and 75% RH then moved to the incubator weekly. Hatched birds were brooded on the floor and at four weeks of age. They were immunized twice with two weeks interval (0.5 ml) by intramuscular injection of inactivated Newcastle Disease virus vaccine ***(Takahashi et al., 1984).*** Seven days after the Booster dose (7 weeks of age), blood samples were collected from all birds pure and crossbred in separate labled centrifuge tubes and numbered according to their sire families in each genotype ***(Helal 1999)*** And prepared for Hemagglutination inhibition test.

Studied Traits: Body weights at the 1st, 2nd, 3rd, 4th, 5th, and 6th week of age, and relative Growth rate were calculated according to ***(Broody, 1945).***

Body Measurements; shank and keel lengths at age of four and five weeks were measured by using a caliper according to ***Mahmoud et al. (1981).*** Slaughter traits were measured at the age of marketing (six weeks of age) by using five birds as a random sample from each line pure and crossbred (males and females). The following data were recorded: percentage of live body weights, liver weight percentage, gizzard weight percentage, heart weight percentage, spleen percentage, edible percentage, dressing weight percentage (DP) percentage were estimated as relative to live body weight.

Antibody titers to inactivated New Castle Disease virus vaccine at seven weeks of age expressed as log 2 of the reciprocal of the last dilution showing HI.

Statistical analysis:

Data were analyzed by the General Linear Model (GLM) procedure using **(SAS, 2002).** All percentage data were transformed to their arcsine values according to **Snedecor and Cochran (1981).**

The following linear models were used:

$\mathbf{Y_{ijk} = U + G_{ij} + e_{ijk}}$

Where

$\mathbf{Y_{ijk}}$ is the K^{th} observation on the quail from the ith breed of sire and j^{th} breed of dam.

U is the overall mean

$\mathbf{G_{ij}}$ is the fixed effect of different genotypes within each genotypic group

$\mathbf{e_{ijk}}$ is the randome error

Estimation of heterosis percentages (H%) was calculated according to **(Lasley, 1978).**

H%= 100* (Crossbred average – Purebred average) / purebred average

RESULTS AND DISCUSSION

Effect of crossing on body weight:

Purebred lines: Average body weight of White Coturnix (WW) was significantly the highest, from first week (19.9 gm) to the sixth week of age (168.30 gm); while Brown coturnix recorded the lowest average throughout the period of 1-6th week. The overall average of purebreds represented lower significant differences than crossbreds and reciprocal crossbreds from one to five weeks of age (Table 2). Six week body weights of reciprocal crossbreds were non-significant higher than crossbreds (165.78 gm vs. 157.6 gm); while purebred average showed the lowest (151.94 gm). Superiority of crossbreds over the purebreds was reported, also by ***Mandal et al. (1997)*** and ***Mohamed (2003)*** while crossing native chicks.

Crossbreds and Reciprocal crossbreds: It was noticed that WG expressed higher significant ($p < 0.05$) body weights among crossbreds from one to six weeks of age (20.20 to 169.62 gm), while the lowest values were detected for GB crossbred (17.23 to 140.55 gm). Moreover, BG showed non-significant high estimates than its reciprocal GB during 1st, 2nd and 3rd week of age (21.97, 45.15 and 74.20 gm) vs (21.40, 42.55 and 70.97 gm). GW had non-significant high values compared to BW during the 4th, 5th and 6th week of age (106.27, 147.83 and 181.39 gm) vs. (106.06, 146.19 and 176.08 gm). On the other hand, the lowest body weight was shown by BG among reciprocals from one to six weeks of age. White coturnix used as a dam line with either Golden or Brown sires gave the best results. The positive effect of crossing agrees with the finding of ***Mohamed (2003)*** in chickens.

Heterosis percentage:

The highest positive heterosis from one to six weeks of age was shown by WG compared to other crossbreds (4.90, 8.55, 12.12, 15.58, 16.57 and 6.66 %); Table (2). On the other hand; BW and GW recorded high positive heterosis from one to six weeks of age among reciprocals. Overall averages of reciprocal crosses during the 1st, 2nd, 3rd, 4th, 5th and 6th weeks of age (8.81, 20.17, 23.12, 19.97, 14.36 and 9.09 %) were higher than the corresponding ones of the crossbreds (1.09, 5.35, 8.35, 10.52, 8.04 and 1.76 %); respectively. ***Moritsu et al. (1997) and Bahie El-Deen et al. (1998)*** recorded positive heterosis for crossbreds and reciprocal crosses.

Relative growth rates (RGR):

Purebred lines: White coturnix (WW) showed the highest significant ($p < 0.05$) growth rate at week intervals (1 - 2 and 2 - 3) followed by BB coturnix (52.76 vs. 45.83) and (45.13 vs. 43.47). BB coturnix showed the highest growth rate at weeks intervals (3-4, 4-5 and 5-6); (40.17, 38.04 and 31.37%; respectively) with non-significant differences among the three purebred lines. (Table 3)

Reciprocal crossbreds had higher significant average than, crossbreds and purebred lines during the (1-2) and (2-3) weeks average (52.92% and 44.58%). While crosses showed higher growth rates at 3 - 4, 4 - 5 and 5 - 6 week) periods (39.30, 39.37 and 32.40%; respectively) these finding agree with those ***Marks (1995)*** who reported higher relative growth rates (17-36%) in high & low quail cross line divergently selected for 4 weeks body weight compared to the corresponding parental lines.

Crossbreds and reciprocal crossbreds: GB crossbred showed the highest significant estimates among crossbreds at week interval (5 - 6) (46.05%), while high non-significant estimates were recorded for the WB crossbred at week intervals 0 - 1, 1 -2, 3 - 4 and 4 - 5 weeks (51.27, 44.88, 40.53 and

47.96%; respectively). In addition, BW crossbred had high non-significant values among reciprocal crossbreds at 1 - 2 week interval (55.67%); GW at 2 - 3, 3 - 4 weeks intervals (45.01 and 39.07%), while BG showed high significant values at 4 - 5 weeks (39.19%) but non-significant differences at 5-6 weeks (29.51%). Similar results were detected by ***Anthony et al. (1986)*** who found that, LH crossbreds quail grew at higher rate than reciprocal HL quail from 25 to 56 days of age. ***Mohamed (2003)*** reported higher chicken growth rates for crossbreds than their purebreds from hatch to two weeks of age.

Heterosis percentage: The overall average of heterosis were positive for crossbreds at weeks intervals 1 - 2, 2 - 3, 3 - 4, 4 -5 and 5 - 6 weeks (5.83, 4.46, 2.45, 4.85 and 7.04%; respectively) (Table3). Negative and positive heterosis were recorded for all reciprocals during different week intervals. The overall mean heterosis was positive at 1 - 2 and 2 - 3 weeks intervals (12.09 and 5.29%), while negative heterosis was recorded at 3 - 4, 4 - 5 and 5 - 6 weeks (-1.41, -4.23 and –9.88%; respectively). ***Abou El-Ella (1982)*** estimated a positive relative heterosis for growth rate. Also, ***Khalil et al. (1999)*** recorded positive heterosis of crossbreds at early ages (0 - 6 weeks), while at later ages of 8 - 12 weeks, crossbred chickens recorded negative heterosis (-0.34 to –4.85%).

Effect of crossing on body measurements:

Shank length:

Purebred lines: White coturnix showed high significant values than the other two lines for shank length at the 4th and 5th week of age (3.63 and3.98 cm). The overall average of shank length at the 4th and the 5th week of age of reciprocal crosses were significantly more than crossbreds and purebreds (3.59 and 3.89 cm), (3.46 and 3.77cm) and (3.37 and 3.77); respectively. This finding agreed with ***Mahmoud et al. (1981).***

Crossbreds and reciprocal crossbreds: Non-significant ($p>0.05$) differences were observed among different crossbreds. However, WG crossbred expressed higher values during the 4th and 5th week of age for shank length than the other two crossbreds (3.57 and 3.90 cm). BW and GW showed significant longer shanks than BG at the 4th and the 5th weeks of age (3.70, 3.70 vs. 3.40 cm) and (3.98, 3.99 vs. 3.73 cm) respectively. So, using of WW as a female line with either BB or GG males would improve shank length leading to high body weight and body gain (Table 3 & 4).

Heterosis percentage:

Positive heterosis were recorded for all crossbreds at the 4th week, shank length heterosis and ranged from (0.38 to 4.75 %) for WB and GB with overall average (2.75%). While at the 5th week positive heterosis was recorded only by WG and GB (2.02% and 3.25%). On the other hand; all reciprocal crossbreds showed positive heterotic percentage at the 4th and 5th week of age for shank length with an average 6.53% and 3.18%. This finding agreed with***, Padhi et al. (1998)*** and ***Nestor et al. (2001)*** who reported positive heterosis for shank length.

Keel length:

Purebred lines: White coturnix expressed higher significant values among purebreds for keel length at the 4th and 5th weeks of age (4.59 and 5.20 cm). The overall averages of reciprocal crossbreds were significant over crossbreds and purebreds at the 4th and 5th weeks of age (4.59, 4.39 and 4.20 cm) and (5.16, 4.96 and 4.89 cm); respectively.

Crossbreds and reciprocal crossbreds: Higher significant keel length values were recorded by WG than the other two crossbreds during the 4th and 5th weeks of age (4.57 and 5.21cm). BW and GW showed higher significant values than BG during the 4th and 5th weeks of age (4.87, 4.71 vs. 4.24 cm), and (5.42, 5.41 vs. 4.72 cm); respectively.

Heterosis percentage: WG expressed high heterosis percentage within crossbreds at the 4th and 5th weeks of age for keel length (6.57% and 5.02%) while negative heterosis was shown by WB (-1.69 and –4.22%), With an overall average (4.52 and 1.43%). For reciprocal crossbreds, heterosis percentage at the 4th week ranged from (3.62% to 10.96%) for BG and BW. The overall average heterosis at the 4th and 5th weeks were (9.29 and 5.52%). ***Padhi et al. (1998)*** found variation in means and heterosis percentages in different crossbreds for keel length, while ***Nestor et al. (2001)*** observed low heterosis (-2.7-2.6 %) of turkey keel length.

Effect of crossing on carcass traits:

Purebred lines:

Dressing percentage :

Dressing percentages were non-significant among average crossbreds, purebreds and reciprocals (72.61, 72.11 and 71.56%; respectively).

Liver weight percentage:

BB coturnix showed the highest liver percentage than GG with non-significant differences (4.47 and 4.37%), while the lowest percentage was for WW one (3.33%). Moreover, non-significant differences were shown between average purebred, reciprocals and crossbreds for liver percentage (4.11, 3.80 and 3.60%; respectively). (Table 5)

Gizzard weight percentage:

Gizzard percentage ranged from 3.23 - 4.07 % with non-significant differences among purebreds. The average of purebreds was non-significantly higher than reciprocals but highly significant than crossbreds (3.56, 3.21 and 3.04%; respectively) (Table 5).

Heart weight percentage:

Heart percentage ranged from 1.08 - 1.16 % with non-significant differences among purebred lines. Moreover there were non-significant differences in heart percentage for average reciprocals purebred and crossbreds (1.16, 1.11 and 1.07%; respectively).

Spleen weight percentage:

Spleen percentage showed non-significant differences between purebred lines with nearly the same values (0.12%). Also, non-significant differences between average purebred, crossbreds and reciprocal crossbreds (0.12, 0.13 and 0.15%; respectively) were found.

Edible percentage (liver, gizzard, heart and spleen):

Purebred BB Coturnix expressed higher non-significant differences in edible percentage than GG coturnix (9.75 vs. 8.98%), while WW coturnix had the lowest edible percentage (7.759%). Averages of purebreds were higher non-significant than reciprocal crossbreds (8.99 vs. 8.33%), while being highly significant than crossbreds (7.92%). Table (5).

Crossbreds and reciprocal crossbreds:

Crossbreds:

Live body weight ranged from 147.48 to 178.40 gm for GB and WB ($P< 0.05$) and **dressing percentage** ranged from 72.17- 72.94 % for WB and GB with non-significant differences. Similar results were recorded by ***Shalan (1998)*** who reported non-significant differences in dressing percentage due to crossing of two lines of Japanese quails.

Liver weight percentage: Non-significant differences between crossbreds were recorded with range (3.55-3.84%) for GB and WB crossbreds. This result disagreed with ***the last author*** who found significant differences for liver percentage between line 3 and line 4 due to crossing in Japanese quail.

Gizzard weight percentage: Non-significant differences were shown with range 2.79 to 3.18% for GB and WB. These findings agreed with those reported by ***Shalan (1998)*** between two quail crossbreds of line 3 and line 4 at the second generation.

Edible percentage ranged from 7.55 to 8.21% for GB and WB ($P< 0.05$) and 7.83 to 8.72% for BG and BW ($P> 0.05$). Non significant differences were also recorded by ***Shalan (1998).***

Heterosis percentage:

Crossbreds:

Positive heterosis was recorded for body weight (10.91%). Negative heterosis in dressing percentage was observed for WB (-1.29%) while positive heterosis was recorded for the other two crosses (0.69%). These results agreed with those of ***Khalil et al. (1991)*** who recorded a positive (22.8%) and a negative (-0.9%) heterosis for different crosses in crossing experiments in chickens. On the other hand, negative heterosis was recorded for all crossbreds in liver weight percentage (-10.46%).

Reciprocal crossbreds:

Positive heterosis average for reciprocals was observed for body weight (5.32%). The highest positive heterosis was recorded for BW (14.52) while negative one was observed in BG (-2.27%). In addition, negative heterosis for dressing percentage was observed for BG (-4.53) while positive heterosis was recorded for BG and GW (1.46 and 1.08%) with an average heterosis (-0.76%). The results indicated that WB and its reciprocal BW did not exhibit positive heterotic value for dressing percentage over their parents. These results were in close agreement with those recorded by ***Khalil et al. (1991)*** who reported positive and negative heterosis for different crossbreds in crossbred chickens experiment.

Heterosis percentage for liver weight percentage of reciprocals showed negative values (-7.54%) on average as BG had high negative heterosis (-18.18%), while positive heterosis for reciprocal crossbreds was recorded by BW and GW (1.05 and 0.10%). This reflects that using of white coturnix (WW) as a dam line increased liver weight percentage. These results were in close agreement with those of ***Katanabf et al. (1988)*** who reported heterosis percentage <15% for liver weight percentage in crossing experiment of chickens.

Effect of crossing on the immune response to inactivated ND virus vaccine:

Purebred lines:

White Coturnix expressed higher immune response (349.14) than Brown coturnix (82.41), while the lowest antibody titer was shown by Golden Coturnix (58.61). These significant differences ($P<0.05$) were also detected by those of ***Hemeda and El-Fiky (1993).*** The overall mean of crossbreds (103.04) and reciprocal crossbreds (107.89) were non-significant compared to the pure bred lines (101.62). These differences between pure and crossbreds agreed with those indicated by ***Mohamed (2003)*** while working on chickens.

Crossbreds and reciprocal crossbreds:

Crossbred individuals (WG) showed the highest significant antibody titer against inactivated ND virus vaccine among all crossbreds (142.89) followed by WB (119.40), while GB had the lowest titer (55.98). GW reciprocal crossbred showed the highest significant value for antibody titer (194.98) than BW (93.11), on the other hand; BG was the lowest one (66.68) (Table 7). Negative heterosis was noticed for both crossbreds and reciprocal crossbreds, but the overall average of reciprocal crossbreds was positive 6.20% and higher than overall averages of crossbreds (1.40 %). The highest negative heterosis was recorded for GB (-49.90%) among crossbreds and BW (-56.8%) among reciprocal crossbreds. The same trend was noticed by ***Gyles et al. (1985), Miller et al. (1992) and Mohamed (2003).*** These results indicated that crossing of either White male or female with either male or female Brown and Golden coturnix would improve antibody titer against inactivated ND virus vaccine.

Table (2): Least square means ± standard errors (LSM± SE) and heterosis % for body weights recorded for Brown (BB), Golden (GG), and White (WW) Coturnix, their crossbreds and reciprocal crossbreds, resulted from a diallel crossing.

Age in weeks *Genotype*	Body weight (LSM±SE)											
	W$_1$		**W$_2$**		**W$_3$**		**W$_4$**		**W$_5$**		**W$_6$**	
Purebreds												
BB	17.17±0.7^{y}		29.96±1.4^{y}		49.06±2.6^{y}		73.57±3.4^{y}		107.41±4.6^{y}		143.75±4.2^{y}	
GG	18.60±0.5^{y}		31.70±1.2^{y}		49.52±2.5^{y}		74.12±3.9^{y}		111.97±5.5^{y}		148.89±6.0^{y}	
WW	19.91±0.5x		38.64±2.0^{x}		65.14±3.8^{x}		96.10±5.1^{x}		136.24±6.6^{x}		168.30±7.0^{x}	
Mean	18.39±0.2^{B}	H%	32.68±0.9^{B}	H%	52.95±1.8^{B}	H%	79.27±2.6^{C}	H%	116.61±3.4^{C}	H%	151.94±3.5^{B}	H%
Crossbreds												
GB	17.23±0.3^{b}	-3.67	30.79±1.1^{b}	-0.14	51.95±2.1^{b}	5.46	79.30±3.0^{b}	7.38	112.74±4.0^{b}	2.78	140.55±7.5^{b}	2.78
WB	18.34±0.4^{b}	-1.08	34.44±1.3^{ab}	0.41	55.83±2.7^{b}	-2.26	84.77±3.4^{b}	-0.08	119.90±5.2^{b}	-1.58	154.71±4.1^{ab}	-1.58
WG	20.20±0.5^{a}	4.90	38.18+1.3^{a}	8.55	64.28±2.6^{a}	12.12	94.37±3.5^{a}	15.58	144.66±5.2a	16.57	169.62±8.5^{a}	16.57
Mean	18.59±0.2^{B}	1.09	34.43±0.8^{B}	5.35	57.37±1.5^{B}	8.35	87.61±2.1^{B}	10.52	125.99±3.1^{B}	8.04	157.66±3.4^{AB}	8.04
Reciprocal crossbreds												
BG	17.03±0.5^{b}	-4.81	31.18±1.4^{b}	1.12	51.99±2.4^{b}	5.47	75.35±3.2^{b}	2.04	110.20±3.8^{b}	0.3	143.07±3.8^{b}	0.3
BW	21.97±0.6^{a}	18.50	45.15±1.8^{a}	31.63	74.20±3.1^{a}	29.95	106.06±3.5^{a}	25.02	146.19±3.9^{a}	20.0	176.08±5.3^{a}	20.0
GW	21.40±0.5^{a}	11.15	42.55±1.0^{a}	20.72	70.97±1.9^{a}	23.80	106.27±2.9^{a}	24.86	147.83±3.2^{a}	19.1	181.39±3.3^{a}	19.1
Mean	20.01±0.4^{A}	8.81	39.27±1.0^{A}	20.17	65.19±1.8^{A}	23.12	95.10±2.5^{A}	19.97	133.36±2.9^{A}	14.36	165.75±3.2^{A}	14.36

X- Z= different litters between purebred genotypes are significant ($P<0.05$)
(a-b)= different litters between crosses and reciprocal crossbred genotype are significant (within group) ($p<0.05$)
A-C= different litters between overall genotypic averages are significant ($p<0.05$)

Table (3): Least square means ± standard errors (LSM± SE) for relative growth rate* of Brown (BB), Golden (GG), and White (WW) Coturnix, Crossbreds and their Reciprocal crossbreds resulted from diallel crossing

Genotype	**Weeks interval**									
	1-2 week		**2-3 weeks**		**3-4 weeks**		**4-5 weeks**		**5-6 weeks**	
Pure breeds										
BB	45.83±2.40^{y}		43.47±0.28^{x}		40.17±0.92^{x}		38.04±1.07^{x}		31.37±1.73^{x}	
GG	45.32±2.05^{y}		39.85±0.60^{y}		36.79±1.08^{y}		37.85±0.95^{x}		30.71±1.51^{x}	
WW	52.76±2.05^{x}		45.13±1.27^{x}		38.46±1.23^{y}		36.39±0.00^{x}		28.40±1.51^{x}	
Mean	47.21±1.13^{C}	**H%**	42.34±0.88^{B}	**H%**	38.36±0.64^{A}	**H%**	37.55±0.58^{A}	**H%**	30.27±0.85^{A}	**H%**
Cross breeds										
GB	47.96±1.50	5.24	45.26±1.48	8.63	38.30±0.85	-0.46	44.81±5.84^{a}	29.19	46.05±2.31^{a}	43.34
WB	50.82±1.34	3.09	42.32±1.31	-4.47	39.22±0.99	0.26	37.69±0.91^{b}	1.20	30.44±1.02^{b}	1.86
WG	51.27±1.14	4.55	44.88±1.43	5.63	40.53±1.19	7.72	47.96±8.56^{a}	18.02	42.36±2.67^{b}	48.35
Mean	49.96±0.78^{B}	5.83	44.23±0.82^{AB}	4.46	39.30±0.60^{A}	2.45	39.37±2.59^{A}	4.85	32.40±3.20^{A}	7.04
Reciprocals crosses										
BG	49.03±1.80^{b}	7.58	44.70±1.20	7.30	37.43±0.89	-2.74	38.19±0.78^{a}	0.57	29.51±0.92^{a}	-4.94
BW	55.67±1.10^{a}	12.92	44.00±1.04	-0.67	37.01±0.92	-5.87	34.62±0.69^{b}	-7.03	24.61±1.00^{a}	17.63
GW	54.52±1.30^{a}	11.18	45.01±0.74	5.94	39.07±0.67	3.85	34.72±0.90^{b}	-6.48	26.83±0.78^{a}	-9.22
Mean	52.92±0.90^{A}	12.09	44.58±0.59^{A}	5.29	37.8±20.50^{B}	-1.41	35.96±0.49^{A}	-4.23	27.28±0.58^{B}	-9.88

X- Z= different litters between purebred genotypes are significant ($P<0.05$)

(a-b)= different litters between crosses and reciprocal crossbred genotype are significant (within group) ($p<0.05$)

A-C= different litters between genotypes averages are significant ($p<0.05$)

* According to Broody (1945).

Table (4): Least square means + standard errors (LSM+ SE) shank length and keel length at the fourth and fifth week of age from diallel crossing of Brown (BB), Golden (GG), and White (WW) Coturnix.

Age in weeks **Genotype**	Shank length				Keel length			
	4th week		5th week		4th week		5th week	
Purebreds								
BB	3.28±0.04^{y}		3.74±0.07^{y}		4.20±0.09^{y}		4.86±0.10^{y}	
GG	3.29±0.06^{y}		3.66±0.05^{y}		3.99±0.09^{y}		4.73±0.11^{y}	
WW	3.63±0.06^{x}		3.98±0.05^{x}		4.59±0.11^{x}		5.20±0.12^{x}	
Mean	3.37±0.04^{C}	H%	3.77±0.04^{B}	H%	4.20±0.06^{C}	H%	4.89±0.07^{B}	H%
Crossbreds								
GB	3.44±0.07	4.75	3.82±0.07	3.25	3.33±0.08^{b}	5.87	4.84±0.10^{b}	1.02
WB	3.47±0.05	0.38	3.76±0.05	-2.62	4.32±0.09^{b}	-1.69	4.82±0.09^{b}	-4.22
WG	3.57±0.04	3.18	3.90±0.04	2.02	4.57±0.07^{a}	6.57	5.21±0.08^{a}	5.02
Mean	3.46±0.03^{B}	2.67	3.77±0.03^{B}	0.00	4.39±0.05^{B}	4.52	4.96±0.06^{B}	1.43
Reciprocal crossbreds								
BG	3.40±0.05^{b}	3.38	3.73±0.04^{b}	0.95	4.24±0.09^{b}	3.62	4.72±0.09^{b}	-1.52
BW	3.70±0.04^{a}	7.18	3.98±0.03^{a}	3.21	4.87±0.09^{a}	10.96	5.42±0.07^{a}	7.79
GW	3.70±0.04^{a}	7.11	3.99±0.03^{a}	4.40	4.71±0.06^{a}	9.77	5.41±0.07^{a}	8.94
Mean	3.59±0.03^{A}	6.53	3.89±0.03^{A}	3.18	4.59±0.06^{A}	9.29	5.16±0.06^{A}	5.52

X- Z= different litters between purebred genotypes are significant ($P<0.05$)

(a-b)= different litters between crosses and reciprocal crossbred genotype are significant (within group) ($p<0.05$)

A- C= different litters between genotypic averages are significant ($p<0.05$)

Table (5): Least square means ± standard errors (LSM± SE) for carcass traits from diallel crossing of Brown (BB), Golden (GG), and White (WW) Coturnix.

Genotype	***LSM±SE***						
	Live B. wt (gm)	***Dressing%***	**Liver%**	**Gizzard%**	**Heart%**	**Spleen%**	**Edible%**
Purebreds							
BB	138.44±11.59^{y}	73.40±3.68	4.47±0.42^{x}	4.07±0.76	1.09±0.06	0.12±0.01	9.75±1.15
GG	147.98±3.52^{y}	70.23±0.88	4.37±0.44^{x}	3.33±0.33	1.56±0.12	0.12±0.01	8.98±0.38
WW	171.83±4.22x	72.84±0.64	3.33±0.14^{y}	3.23±0.14	1.08±0.39	0.12±0.02	7.76±0.15
Mean	151.39±5.56	72.11±0.89	4.11±0.15	3.56±0.19^{A}	1.11±0.04	0.12±0.01	8.99±0.30^{A}
Crossbreds							
GB	147.48±5.19^{b}	72.94±1.78	3.55±0.11	2.79±0.05	1.09±0.06	0.11±0.01	7.55±0.17
WB	178.40±7.49^{a}	72.17±0.79	3.84±0.23	3.18±0.30	1.08±0.04	0.11±0.02	8.21±0.40
WG	176.17±9.15^{a}	72.70±0.45	3.66±0.06	3.13±0.12	1.05±0.04	0.16±0.02	7.99±0.11
Mean	167.90±5.49	72.61±0.59	3.68±0.08	3.04±0.11^{B}	1.07±0.03	0.13±0.01	7.92±0.15^{B}
Reciprocals							
BG	139.96±6.28^{b}	72.86±0.46	3.62±0.18	3.05±0.12	1.05±0.03^{b}	0.12±0.02	7.83±0.24
BW	177.66±6.19^{a}	69.81±1.12	3.94±0.28	3.30±0.13	1.31±0.05^{a}	0.16±0.03	8.72±0.39
GW	161.60±6.61^{a}	72.31±1.07	3.86±0.13	3.34±0.35	1.11±0.07^{b}	0.18±0.05	8.49±0.27
Mean	159.45±5.88	71.56±0.63	3.80±0.13	3.21±0.10^{A}	1.16±0.04	0.15±0.02	8.33±0.21^{A}

X- Z= different litters between purebred genotypes are significant ($P<0.05$)
(a-b)= different litters between crosses and reciprocal crossbred genotype are significant (within group) ($p<0.05$)
A-C= different litters between genotypic averages are significant ($p<0.05$)

Table (6) Heterosis percentage for carcass traits from diallel crossing of Brown (BB), Golden (GG), and White (WW) Coturnix.

Genotype	**carcass traits**						
	Live B. wt (gm)	***Dressing%***	**Liver%**	**Gizzard%**	***Heart%***	**Spleen%**	**Edible%**
Crossbreds							
GB	2.98	1.56	-19.75	-24.44	-2.66	-5.88	-19.37
WB	14.99	-1.29	-1.51	-12.96	-0.50	11.66	-6.24
WG	10.17	1.62	-5.11	-4.66	-6.45	33.89	-4.53
Mean	10.91	0.69	-10.46	-14.61	-3.60	8.33	-11.90
Reciprocals							
BG	-2.27	1.46	-18.18	-17.52	-7.19	0.00	-16.36
BW	14.52	-4.53	1.05	-9.51	20.50	35.00	-0.43
GW	1.06	1.08	0.10	1.92	-0.45	41.53	1.46
Mean	5.32	-0.76	-7.54	-9.83	4.50	25.00	-7.3

Table (7): - Geometric mean ± standard deviation (GM± SD) as well as heterosis percentage for antibody titer against Inactivated New Castle Disease virus (NDV) from diallel crossing of Brown (BB), Golden (GG), and White (WW) Coturnix.

Genotype	**GM ± SD**	
Purebred		
BB	82.41 ± 0.44^{y}	
GG	58.61 ± 0.34^{y}	
WW	349.14 ± 0.07^{x}	
Mean	101.62 ± 0.47	**H%**
Crossbreds		
GB	55.98 ± 0.47^{b}	-49.9
WB	119.40 ± 0.40^{a}	-44.7
WG	142.89 ± 0.44^{a}	-29.9
Mean	103.04 ± 0.44	1.40
Reciprocal crossbreds		
BG	66.68 ± 0.42^{b}	-40.3
BW	93.11 ± 0.56^{b}	-56.8
GW	194.98 ± 0.51^{a}	-4.4
Mean	107.89 ± 0.53	6.2

X- Z= different litters between purebred genotypes are significant ($P<0.05$)

(a-b)= different litters between crosses and reciprocal crossbred genotype are significant (within group) ($p<0.05$)

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الملخص العربى

تأثير الخلط التبادلى للسمان اليابانى على كفاءة النمو و بعض صفات الذبيحه ورد الفعل المناعى ضد التحصين بفيروس مرض النيوكاسل

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- أجريت التجربة بهجين ثلاثى وعكسى باستخدام ثلاثة أصناف من السمان اليابانى (البنى- الذهبى – الابيض) وتم الحصول على ثلاثة خطوط نقية وثلاثة خطوط هجن وثلاثة خطوط من الهجين العكسى من الابناء وأظهرت النتائج ما يلى:

- سجل السمان الابيض أعلا وزن للجسم بين الخطوط النقية (١٦٨,٣٠ جم) وسجل هجين الابيض Xالذهبى أعلى فرق معنوى لوزن الجسم (١٦٩,٦٢ جم) بين الهجن الثلاثه . بينما سجل الهجين العكسى الذهبى X الابيض أعلى الاوزان (١٨١,٣٩ جم) مع وجود قوة هجين ايجابية لكل من الهجين و الهجين العكسى بمتوسط عام (١,٧٦ %) و (٩,٠٩%).
- أظهرت الهجن العكسيه أعلى معدل نمو عند عمر أسبوعين وثلاثة أسابيع (٥٢,٩٢-٤٤,٥٨%). بينما أظهر الهجين أعلى معدل نمو عند عمر ٤ و ٥ و ٦ أسابيع (٣٩,٣٠ - ٣٩,٣٧ – ٣٢,٤٠%) . مع وجود قوة هجين ايجابية خلال هذة الفترات.
- أيضا أظهرت الهجن العكسيه أعلى فرق معنوى بالنسبة لطول عظمة الساق وعظمة القص عند الاسبوع الرابع والخامس مع وجود قوة هجين ايجابية لنفس الفترات على التوالى لطول عظمة الساق (٦,٥٣ – ٣,١٨ %) وبالنسبة لعظمة القص (٩,٢٩ – ٥,٥٢ %) عند الاسبوع الرابع والخامس.

- لم توجد فروق معنوية لصفات الذبيحة بين خطوط الهجينة والهجين العكسى.
- سجل السمان الابيض أعلى معدل لوجود الاجسام المناعية ضد لقاح النيوكاسل الميت داخل المجاميع النقية (٣٤٩,١٤) عند استخدامه كخطوط أباء أو خطوط أمهات مما أدى الى زيادة الاجسم المناعية سواء فى خطوط الهجين أو الهجين العكسى.
- ونخلص الدراسه الى أن السمان الابيض سجل أعلى الاوزان وأعلى مناعة بالنسبة للخطوط النقية وأيضا عند استخدامه كأحد الاباء فى الخطوط الهجينة أدى الى زيادة الاوزان وزيادة المناعة .