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4.2. Post-weaning growth traits (body weight and daily gain):

5-SUMMARY

Fourteen different genetic groups of rabbits (represented by 4022 crossbred and 4208 NZW, 255 Gabali purebred weaned rabbits) were used for the present study. Data of growth traits and litter traits were recorded during the experimental period, conducted for five consecutive production years, on all offspring produced from different sires and dams at weaning 4 weeks up to 12 weeks of age. Post-weaning livability traits were also studied. Coefficients of expected contribution for genetic effects in eight groups of purebreds and crossbreds obtained according to **Dickerson (1969, 1973)** and **Hill (1982)**. Samples of hair were obtained by plucking from the side regions of each individual from all offspring at 12-weeks of age for determining the hair length, diameter, medulla diameter and percentage of medullation of down and guard hair.

One gramme of rabbit hair, from the hair, samples for determination of magnesium, zinc, copper, iron, cobalt and cadmium mineral contents. Blood samples of approximately 7 ml. were collected immediately after slaughtering broilers at 12 weeks of age, in strile evacuated tubes containing 10.5 mg EDTA. Plasma of blood samples were used for determining the same minerals.

Data of growth, litter traits, livability, fur hair traits and some trace minerals content for different genetic group were analyzed using multi-trait animal model. Variances and covariances obtained by **REML** method of **VARCOMP** procedure **(SAS, 1996)** were used as starting values (guessed values) for the estimation of variance and covariance components heritabilities of all the traits studied were computed. Coefficients of genetic, common, environmental and phenotypic correlation also estimated the results could be summarized as follows:

1. For post-weaning growth traits (body weight and daily body gain) and livability.
    1.1. The purebreds G had higher body weight at 4, 8 and 12 weeks of age than N. the crossbred breed group contained 75% of G blood was the heaviest in body weights at 4, 8 and 12 weeks of age and followed by crosses contained different percentages of G blood. These results explain the good mothering ability of G rabbit breed. The differences among body weights at the three ages, due to crossbred groups, sire within breed group, dam within sire within breed group, and season-year effect were significant. While the differences at the three ages, due to sex and sex X season-year interaction, were non-significant. Post-weaning growth performance of rabbits born during spring were generally higher than those rabbits born in other seasons

    Coefficients of variation were 25-83% at 4 weeks of age and decreased gradually with advance of age. R^2 values were nearly equal for the three ages (40-42%).

1.2 Analysis of variance revealed that the differences among averages of daily body gain during the period 4-8, due to breed group effect was significant ($P<0.01$), while those differences, due to the same effect during 8-12 and 4-12 weeks, were non-significant. The differences between averages of daily gain during the periods 4-8, 8-12 and 4-12 weeks of age, due to the effects of sire / breed group, dam / sire / breed group and season-year were significant ($P<0.01$ & $P<0.001$). while differences due to sex and sex X season-year effect, were non-significant. C.V coefficients during the intervals of 4-8, 8-12 and 4-12 weeks of age were 22.3, 26.94 and 16.58%, respectively. R^2 was 0.37, 0.27 and 0.34 for the three periods respectively.

1.3 The differences between means of post-weaning daily gain and livability during the period from 4 to 8 weeks of age for purebred N and G were non-significant, while during the period from 8 to 12 weeks were significant ($p<0.001$). The differences between means of livability, during the two periods, due to the effect of sire within breed group, dam within sire within breed group, season-year of birth, sex and sex X season-year interaction were significant ($P<0.01$ & $P<0.001$). Estimates of V% of livability showed that the coefficients were 38.87 and 81.35% during the periods from 4 to 8 and 8 to 12 weeks of age. R^2 during the period of 4-8 weeks of age (28%) was higher than R^2 during the period of 8 to 12 weeks of age (22%).

1.4. Genetic parameters:

1.4.1. The percentage of additive genetic variance (σ_a^2) for post-weaning body weight was moderate at 4 weeks (23.5%) and decreased thereafter at 8 and up to 12 weeks of age (15.1 and 0.005%, resp.). The percentage of (σ_a^2) for post-weaning daily gain in body weight and livability during different intervals tended generally to increase as the rabbit advanced in age (from 2.5% to 9.2% for daily gains and from 0.09% to 4.9% for livability during the two periods.

1.4.2. The percentages of common litter variance (σ_c^2)for post-weaning body weight were large at weaning (73.2%), declined thereafter gradually as the rabbit grew older (55.2 and 47.3% at 8 and 12 weeks of age). The percentages of σ_c^2 for post-weaning daily gain in body weight, during different intervals tended generally to increase as the rabbit advanced in age (from 21.4 at 4-8 weeks to 38.4% at 8-12 weeks

1.4.3. The percentages of σ_e^2 for post-weaning growth traits were low, moderate or high.

1.4.4. Estimate of heritability using Animal model for body weight was higher at 4 weeks (0.23) than at 8 and 12 weeks (0.15 and 0.00 resp.). Estimate of heritability for post-weaning daily gains, during the periods from 4 to 8 and from 8 to 12 weeks were very low (0.02 and 0.09 resp.). Estimates of heritability for livability from 4 to 8 to weeks (L8) was markedly lower (0.06) than that for livability from 8 to 12 weeks of age, i.e. L12 (0.24).

1.5. Correlations:

1.5.1. Estimates of genetic correlation (r_G)between body weights at weaning and at 8 weeks was 0.95 and between 8 and 12 weeks was 0.01. Estimates of r_G was 0.14 between DG 4-8 and DG 8-12 weeks, 0.28 between DG 4-8 and DG 4-12 weeks and 0.98 between DG 8-12 and DG 4-12 weeks of age. An estimate of r_G for post-weaning livability was -0.37 between L8 and L12.

1.5.2. Estimates of common litter correlation (r_c) between body weights at 4 and 8 weeks was 0.92 while between 4 and 12 weeks was 0.85 and between 8 and 12 weeks was 0.94. Estimates of (r_c) was 0.46 between DG 4-8 and DG 8-12 weeks, 0.70 between DG 4-8 and DG 4-12 weeks, 0.94 between DG 8-12 and DG 4-12 weeks. Estimate of (r_c) was 0.59 between L8 and L12.

1.5.3. Estimate of r_E was 0.55 between BW4 and BW8, 0.93 between BW4 and Bw12 and was 0.82 between BW8 and BW12. Estimates of r_E was 0.46 between DG 4-8 and DG 8-12 weeks, and was 0.84 between DG 4-8 and DG 4-12 weeks. The estimate of r_E was 0.50 between L8 and L12

1.5.4. Estimates of r_P was 0.95 between BW4 and BW8 ; 0.63 between BW4 and Bw12 and 0.80 between BW8 and BW12. The estimate of r_P was 0.42 DG 4-8 and DG 8-12 weeks, 0.78 between DG 4-8 and DG 4-12 weeks and 0.89 between DG 8-12 and DG 4-12 weeks. The estimate of r_P was 0.50 between L8 and L12.

1.6. Estimates of crossbreeding effects:

1.6.1. For body weights of crossbred from N (NZW) and G (Gabali) breeds at 4, 8 and 12 weeks of age:

(a) using sub-models of **Dickerson Model** were as follows:

1- The additive (direct genetic) effects were almost negative and significant in all four sub-models and the negative values amounted to from -2.1 to -4.2% of the means. These results confirm the use of Gabali as terminal sire breed for the engendering of broiler rabbits.

2- In the four sub-models, dominance effect (heterosis) was almost positive and significant at 4 weeks of age and non-significant at 8 and 12 weeks of age. The percentage of the positive values was higher at 4 weeks compared to the positive percentages at 8 and 12 weeks. These positive heterosis estimates may notify us to focus on using Gabali as the terminal sire breed with NZW does to secure appreciable heterotic effect.

3- The maternal negative effects were in sub-model 3, while the paternal positive effects were in sub-model 4 and both were significant at 4 weeks and non-significant at 8 & 12 weeks. Percentages of the values for both were found only at 4 & 8 weeks of age and ranged from 2.7 to 4.8% of the mean Gabali-dammed crosses excelled those mothered by NZW for body weight at 4 and 8 weeks. These results lead to state that does of Gabali are better concerning their mothering ability on post-weaning body weight. Therefore it may be recommended to use Gabali does as a terminal dam-breed in crossing programs that comprise these two breeds.

4- Estimates of negative recombination loss values in additive X additive interaction were in sub-model 3 at 4 weeks (-8.5%) and sub-model 4 at 8 weeks (-27.5%). Positive estimates of additive X additive maternal and paternal interaction were on sub-models 3 & 4 and the percentages of the values ranged from 3.1 to 4.5% of the means, respectively.

5- Estimates χ^2 revealed that the third and fourth sub-models of **Dickerson Model** at 4 weeks were suitable to fit the hypothesized normal probability distribution for body weight of crossbred rabbits.

b) Sub-models of Hill-Model for body weights:

1- The additive (direct genetic) effects were negative and significant and percentages of absolute values were -16.7%, (-2.6 to -11.62%) and (-2.2 to -6%) at 4, 8 and 12 weeks of age.

2- The dominance effects (heterosis) were positive and significant at 4, and 8 weeks and values at 4 weeks was obviously higher (17.4-32.3%) than at 8 weeks (3.6-13.9%).

3- The maternal and paternal effects were only in sub-model 3 & 4 (non-significant).

4- The value of recombination loss values in additive X additive interaction were in sub-model 3, 4 weeks and higher than the mean with (31.7-58.6%); (58.6-26%) and (22.5-28.9%) at 4,8 and 12 weeks of age.

5- All the four **Hill sub Models** were fit at 4 weeks of age and with 3 & 4 sub-models at 8 weeks and non of them at 12 weeks of age.

1.6.2. For daily body gains of crossbred from NZW and Gabali breeds at the periods from 4-8, 8-12 and 4-12 weeks of age:

(a) Sub-models of Dickerson Model were as follows:

1- The additive genetic effects were negative and almost significant in the first three sub-models and the negative values amounted to from -2.2 to -8.8% of the mean.

2- From 4-8 weeks the dominance effect (heterosis) was positive and significant in model 1 (2.4%). The F_1 epistatic effect was in sub-model 2 (11.3%) and the parental epistatic effect in sub-model 3 amounted to 15% of the mean. While from 8-12 weeks and from 4 to 12 weeks the heterosis effects were negative and non-significant.

3- The additive maternal effects were positive and significant in sub-model 3 and values amounted to from 2.9 to 11.1% of the mean. The additive paternal effects in sub-model 4 were positive and significant from 4 to 8 weeks (3-18% of the mean) and negative and significant from 8 to 12 and from 4 to 12 weeks -11.1% and -2.9% of the mean respectively.

4- The estimate of maternal and paternal recombination loss (in sub-model 3 and 4 respectively) were positive and significant the values amounted to from 11.1 to 18% of the mean.

5- None of the four sub-models gave fit in the three periods.

<u>(b) Sub-models of Hill-Model for daily body gains</u>:

1- The direct additive genetic effects were negative and significant in the first three sub-models during the periods from 4 to 8 and 4 to 12 weeks of age and values amounted to from -3.2 to -14.6% of the means.

2- The dominance effects (heterosis) were positive (P<0.01) in the period of 4-8 weeks of age in sub-model 1 and the value amounted to 1.2% of the mean, while the values were negative and significant during the period 8-12 weeks in sub- models 2 and 4 and values amounted to -13.8% and -17.3% of the means, respectively. In the same period the dominance X dominance interaction were in sub-models 2, 3 and 4 and the positive significant values amounted to 12.3, 11.7and 11.7% of the means.

3- The negative significant maternal dominance (-9.7%) of the mean was only in sub-model 3 in the period of 4-8 weeks and the negative significant parental dominance and additive X additive paternal interaction amounted to -9.7 and -28.2% of the mean were in sub-model 4 during the same period. Maternal heterosis and additive X additive maternal interaction in sub-model 3 were negative (-19.2 and -39% of the mean) during the period of 8-12 weeks of age. The same effects (-14.8 and -27.85% of the mean) were dring the period of 4-12 weeks of age. Paternal heterosis and additive X additive paternal interaction in sub-model4 were negative (-19.2, -37.8% of the mean) during the period of 8-12 weeks. The same effects (-14.8 -31.2% of the mean) were in the period of 4-12 weeks.

4- Perantal epistatic effect was positive and significant in sub-model 2, 3, 4 in the period 8-12 weeks and values 12.3%, 11.7% and 11.7% of the mean.

5- The 1^{st} and 2^{nd} sub-model did not give a good fit (in the periods 4-8 and 4-12 weeks) and fit being better in sub-models 3 and 4

1.6.3. For livability at 4-8 and 8-12 weeks of crossbred from NZW and Gabali rabbit breeds using sub-models of Hill-model the results could be summarized as follows:

1- The direct additive genetic effects were negative and non-significant in the four sub-models for the livability from 4 to 8 weeks of age while negative and significant from 8 to12 weeks of age and values amounted to from -10.9 to -95%.

2- The dominance effects (heterosis) were positive, significant in sub models 1, 2 and 4 for livability from 4 to 8 weeks and values amounted to from 5.8 to 43.8% of the mean. While from 8 to 12 weeks, heterosis effects were negative (-35.9%--95%) in sub-models 2 and 3 and positive in sub model 4 (40%).

3- Sub-models 2, 3 and 4 for livability during the period of 8-12 weeks contained negative and positive epistatic effects with large values (-87.1, -80.0 and 31.25% of the means.

4- Non-significant effects with respect to maternal and paternal effects in sub-models 3 and 4 from 4 to 8 weeks. While from 8-12 weeks the positive additive maternal was found in sub model 3 (61.6-120%) and also positive additive paternal in sub-model 4 (67-71.7%).

5- The positive recombination loss of additive X additive interaction were the highest in sub-models 2 and 4 (70.4 and 76.3%) for livability from 4-8, while it was with large negative values (-78%) in sub-model 2, and 201.7% in sub-model 3, and with large positive value 67-68.3% due to the same interaction effects in sub model 4

6- For livability during the periods of 4-8 and 8-12 weeks of age, sub-models 1 and 2 did not give a good fit, while the sub-models 3 and 4 gave a good fit.

2. Litter traits:

2.1. The differences between means of litter size and weight in both NZW and Gabali at birth and at weaning were non-significant. The differences among means of LSB and LWB, due to the effect of the different genetic breed group, were non-significant. The highest mean of LSW was that of NG x NG. The differences between LWW, due to sire of dam was significant. The values of litter traits increased gradually from the first parity to the fourth and decreased thereafter

2.2. Genetic parameters for LSB, LWB, LSW and LWW:

2.2.1. The percentages of additive genetic variance estimates were somewhat low or moderate and values were 4.75, 1.24, 9.28 and 8.13%, respectively.

2.2.2. Variances of permanent effect were low and the percentages were 0.88, 1.55, 0.48 and 3.30%, respectively.

2.2.3. Eperimental error variance estimates were very high and values were 94.37, 97.21, 90.24 and 88.5%, respectively.

2.2.4. Heritability estimates were low and the values were 0.05, 0.01, 0.09 and 0.08, respectively.

2.2.5. The coefficients of each of genetic correlation, common correlation environmental and phenotypic correlation among these traits were positive and moderate to high in values

2.3. Estimates of crossbreeding effects for LSB, LSW, LWB and LWW were:-

a) Hill using sub-models:

The direct additive genetic effect, the dominance effect, the epistatic, the maternal and paternal effects were non-significant. The recombination loss additive X additive interaction in LSB was in sub-model2 and its negative significant value accounted for -30% of the mean, values of χ^2 test for goodness of fit were different among litter traits and among the four sub-models of **Hill**.

B) Dickerson using sub-models:

With respect to LSB, the direct additive genetic effect was significant (P<0.01) and the percent of low negative value amounted to -1.8% of the mean. The dominance effect was of moderate importance and the negative value was -4% of the mean in sub-model2. the maternal effects were in low negative values as the additive maternal additive X additive maternal interaction amounted to -1.4 and -15.1% of the mean. The same paternal effects were low in sub-model 4. All the crossbreding effect in LSW and LWW were non-significant were in very low values. In case of LWB sub-model2 contains significant ($P<0.05$) additive X additive interaction in negative value (-9.4% of the mean). The additive X additive maternal and paternal interaction were negative and its value amounted to -16.4% of the mean.

All the four sub-models gave a good fit in case of LSW (except sub-model 2), LWB and LWW. while in case of LSB none of the four sub-models gave a good fit.

3. Fur traits:

3.1. Physical hair characteristics:

1- The means of hair length, medulla diameter and percent of medulla diameter of down hair of Gabali breed was significantly higher than those in NZW breed. With respect of means of hair length, hair diameter, medulla diameter and percent of medulla diameter of guard hair in NZW breed were higher than in Gabali breed also the mean of hair diameter in down hair of NZW was significantly higher than in Gabali breed.

2- The highest means of hair length in down and guard hair, and the mean of medulla diameter of down hair were in G X N crossbreeds. Also the highest means percent of medullation in down and guard hair were in the NG X NG crossbred. The highest diameter of down and guard hair and medulla diameter of guard hair were in G-GN X G-GN crossbred. The lowest means of down hair diameter, medulla diameter of down and guard hair and were in percent of medullation in guard hair in the N X G crossbreds. Also, the lowest mean of hair diameter in guard hair was in GN-N X GN-N crossbred. The lowest length of guard and hair percent of medullation of down hair were in G-GN X G-GN crossbred

3- Most means of down and guard hair length, hair diameter, medulla diameter and percent of medulla diameter were higher in males than in females.

4- The highest means, due to season-year effect, were in spring 1997 for down hair length and percent of medulla diameter and in spring 1999 for down hair diameter and medulla diameter and also for guard hair length and diameter. Rabbits born in winter 1997 showed highest means for guard hair medulla diameter and percent of medulla diameter

5- Analysis of variance showed that differences between means of hair diameter, medulla diameter and percent of medulla diameter and guard hair length, due to effect of breed group, sire / breed group, dam / sire / breed group, season-year and sex X season-year were significant ($P<0.001$). Also the differences between means of guard hair diameter, medulla diameter, percent of medulla diameter, and down hair length, due to the same effects were significant ($P<0.01$). Coefficients of variation for all traits studied ranged between 1.97 to 11.32% and coefficients of determination were relatively high except for guard hair diameter (20%) and medulla diameter (29%).

3.2. Genetic parameters:

Variance components [additive genetic (σ_a^2), common effect variance (σ_c^2), error variance (σ_e^2) and phenotypic variance (σ_p^2)] heriatability (h_a^2) for hair traits in NZW, Gabali and their crosses are shown in **Table ( ).**

Direct additive genetic variance (σ_a^2), common effect variance(σ_c^2), error variance (σ_e^2) and phenotypic variance (σ_p^2) heritability (h_a^2) for fur traits in N, G am their crossbred groups at 12 weeks of age.

The percentages of additive genetic variance for hair length of down and guard hair were high. The percentages of σ_a^2 relative to total phenotypic variance were 88.74% and 90.16% resp. The values of h^2 were high (0.89 and 0.90

resp.). The percentages of direct additive genetic variance for hair diameter and medulla diameter of down and guard hair were moderate which represented by moderate or low estimates of h^2. The percentages of direct additive genetic variance for percent of medulla diameter of down and guard hair were somewhat high.

The percentage of the error variance (σ_e^2) for hair traits were low for hair length, moderate for hair diameter and medulla diameter of down hair and high for hair diameter and medulla diameter of guard hair. Percentages of medulla diameter were moderate for both types.

3.3. Correlations:

A genetic relationship of hair length was positive and at a medium and high levels. Estimates of r_g between hair traits show that traits were positively correlated to each other and have high coefficients. The highest environmental coefficients (0.92 & 0.96) were with respect to the relationship between hair diameter and medulla diameter. The coefficient of phenotypic correlation between hair traits of rabbit coat were positive and of different values.

3.4. Estimates of crossbreeding effects for hair physical characteristics of down and guard hair of crossbred NZW and Gabali at 12 weeks of age

3.4.1. Using Hill model for hair length as follows:

1- The direct additive genetic effects were negative and significant in sub-models 1, 2 and 3 for hair length of down (values from -1.1 to -12.9% of the mean) and guard hair (values from -1.1 to 15.4% of the mean).

2- The dominance effects (heterosis) were positive in moderate values. in sub-model 1 & 2. These values amounted to from 5.4 to 10.7% of the means for down hair and from 1.9 to 7.4% of the mean for guard hair. Heterosis was negative in sub-model 3 in both hair types and value accounted for -14.7% of the means. The positive estimate of dominance X dominance interaction in sub-model 3 (9.3% of the mean) indicated the existence of parental heterotic effects on guard hair length.

3- The epistatic effects (F_1 epistatic) were of mjor importance in sub-models 2, 3 and 4 having negative values amounted to from -10 to -43.4% of the means for down hair length and from -7.8 to -41% of the means for guard hair length.

4- The maternal effects, in sub-model 3 were positive ($P<0.01$) and values amounted to from 3.2 to 15% of the means for down hair length. The maternal and paternal effects in sub-model 3 & 4 were in small values for length of both hair types. The paternal effects, in sub-model 4, were in different signs ($P<0.01$) and values accounted to from -12.2 to 7.5% of the means for down hair. and the same trend for guard hair length was observed but the values were small.

5- The positive significant estimates of recombination loss in additive X additive maternal interaction indicate the influence of NZW in improvement hair length of down and guard hair.

6- All the four sub-models did not give a good fit as χ^2 was highly significant in calculated value.

3.4.2. Using Hill model for hair diameter as follows:

1- The direct additive genetic effects were negative and significant in the four sub-models in both hair types and the values accounted for -17.7, -32.8 and -11.7% of the means in sub-model 2, 3 and 4 for down hair and -7.8, -4.8 and 0.3% of the means.

2- The dominance effects (heterosis) were moderate, different in values and sings for down hair while were positive significant with low estimates (1.3-5.7% of the mean) for guard hair.

3- The epistatic effects (F_1 esistatic) were of considerable negative values accounted to from -21.1 to -25.8% of the mean for down hair while the negative values were of little importance and the values -3.5 and -8.6% of the means of guard hair.

4- The maternal effects, in sub-model 3, were in moderate values and accounted for 2.3 and 6.3% of the mean. The paternal heteosis in sub-model 4 was positive (6.3% while the rest paternal heterosis were negative (-8.3 and -18.8% of the mean) in down hair. In guard hair the maternal heterosis, were in negative moderate values (-11.2 and -13.5%) of the mean while paternal heterosis. The low negative value (-3.8% of the mean) was in dominance X dominance maternal interaction. The same paternal heterosis in sub-model 4 as the values of additive paternal and additive X dominance paternal accounted for -18.8% and -13.5% of the mean.

5- The recombination loss in additive X additive interaction was -51.5% in down hair while the same crossbreeding effect in guard hair was in low value.

6- None of the four sub-models gave a good fit.

3.4.3. Using Hill model for medulla diameter:

1- The direct additive genetic effects were negative and significant (P<0.01) in most sub-models and the percentages of values accounted for higher (from -6.1 to -44.8% of the means) for medulla diameter of down hair than for guard hair (from -0.5 to -10.8% of the means).

2- The dominance effects (heterosis) were positive (P<0.01) in sub-models 1, 2 and 4 and values for medulla diameter of down hair was higher (5.1 to 17.7% of the mean) than the values of guard hair (from 3.2 to 9.4% of the means). The heterosis effect in sub-model 3 were negative and value for down hair accounted to -19.9% of the mean and -5.5% of the mean for guard hair.

3- The F_1 epistatic effects were negative in sub-models 2, 3 and 4 and values for medulla diameter of down hair were higher (from -17.4% to -30.5% of the mean) than values of guard hair (from -7.8 to -8.4% of the means). The parental epistatic effect was extremely higher in sub-model 3 for down hair (-65.6%) than for guard hair (-16.8%).
4- The maternal effects, in sub-model 3, were positive in large values (17.7- 49.2% of the means) in down hair, while in guard hair values were in small values expect the additive X additive maternal effect (16.2% of the mean). The paternal heteosis, in sub-model 4 were positive ($P<0.01$) in large values (18.32-24.1% of the means) for medulla diameter of down hair, while values were in small values for guard hair.
5- Negative significant effect of recombination loss in sub-model 3 in additive X additive interaction and value for medulla diameter of down hair (-65.6% of the mean) was higher than for guard hair (-16.8% of the mean). The effect of recombination loss, in sub-model 4, with respect to additive X additive paternal interaction was positive and value amounted to 24.1% of the mean for down hair. While for guard hair the loss value was positive and nearly the same as in down hair.

None of the four sub-models gave a good fit.

3.4.4. Using Hill model for percentage of medullation:

1- The direct additive genetic effects were negative for percent of medulla diameter in down hair (P<0.01) in sub-models 1 and 3 and values amounted to -5% and -10.7% of the means. While for guard hair the effect was positive (P<0.01) in sub-model 2 and negative in sub-model 3 and the values amounted 1.5% and -6.3% of the means respectviley.
2- The dominance effects (heterosis) were low, positive and significant in sub-model 1 and 2 (values accounted for7.2 and 5.8% of the mean) for % of medulla diameter in down hair. The same effects in guard hair in sub-models 1, 2 and 4 (values 3.7, 3.8 and 2% of the means).
3- The epistatic effects (F_1 epistatic) for percent of medulla diameter in down hair was only in sub-model 2 in small values (4.6% of the mean) and also the same effect in sub-model 3 and 4 for guard hair. The parental epistatic effect (dominance X dominance interaction) was in sub-models 2, 3 and 4, in negative small values (-3.8%). But in sub-model 3 it was negative and moderate value (-12% of the mean) for guard hair for additive X additive interaction.
4- The maternal effects in sub-model 3 were positive and relatively large in values (12.2 to 26.9% of the mean for percent of medulla diameter) in down hair. While for guard hair the same effect was in small values except the value of additive X additive interaction (14.3% of the mean). The paternal effects in sub-model 4, for down hair

were positive and relatively moderate in values (9.9 to 21.9% of the mean). While with respect to guard hair the effects in sub-model 4 were in small values.

5- Estimates of positive recombination loss in sub-model 3 and 4 for down hair and in case of additive X additive maternal interaction and additive X additive paternal interaction accounted 26.9 and 21.9% respectively. While for guard hair the estimate of recombination loss was negative in sub-model3 and in moderate value (-12.1% of the mean) in case of additive X additive interaction. In the same sub-model 3 the estimate of additive X additive maternal interaction was moderate and positive and value was 14.3% of the mean. In addition to that in sub-model 4, additive X additive paternal interaction was relatively in small value 8.2% of the mean.

None of the four sub-models, in down and guard hair, gave a good fit.

4. Minerals content in rabbit hair and blood:

4.1.In rabbit hair:

1- Iron, cobalt and copper contents in hair of NZW rabbits were significantly higher than these mineral contents in hair of Gabali rabbit. Zinc, magnesium contents also were higher in NZW but the differences were non-significant. Cadmium was significantly higher in Gabali than in NZW rabbits. The highest averages of each of copper, zinc, cadmium and iron were in the NG X NG crossbreds.

while with respect to cobalt the highest average was in N X G crossbreds and magnesium in GN X GN crossbreds. The lowest cobalt content was in the crossbred NG X NG and for iron and copper in G X N crossbreds, for zinc, magnesium and cadmium in N X G crossbreds. Analysis of variance revealed that the differences between the contents of each of zinc, iron, cobalt, copper, magnesium and cadmium, due to the effects of breed group, sire / breed group, dam / sire / breed group were significant ($P<0.01$ or $P<0.001$).

C.V. for all minerals ranged from 15.77% (for zinc) to 44.50% (for cadmium). R^2 values ranged from 0.55 (iron) to 0.73 for cobalt content.

4.2. In serum of rabbit blood:

The difference between values of cobalt, magnesium and iron. contents in blood serum of NZW and Gabali were non-significant, while between values of cadmium, zinc and copper were higher in Gabali purebreds than the values in NZW rabbits. The highest averages of each cobalt and copper contents were in NG X NG crossbreds, while the highest averages of each magnesium and cadmium were in N X G crossbreds. The highest average of iron contents was in G X N crossbreds and average of zinc in GN X GN crossbreds, respectively. The lowest averages of each of cobalt and copper content were in N X G crossbreds, while the lowest averages of each cadmium and iron contents were the in crossbred GN X GN and of each of magnesium and zinc contents in NG X NG crossbreds. Analysis of variance revealed that the differences between the contents of each of zinc, iron, cobalt, copper, magnesium and cadmium, due to the effects of breed group, sire / breed group, dam / sire / breed group were significant ($P<0.01$ or $P<0.001$). The differences between the mineral contents of each of copper, magnesium, zinc and cobalt, due to the effect of season-year were significant ($P<0.01$ or $P<0.001$). C.V. for all minerals ranged from 15.1% to 44.85. R^2 values high from 0.59 to 0.65.

4.3. Genetic parameters:

4.3.1. In blood:

The percentages of additive genetic variance for six trace elements were almost in high levels except percentage of Zn in medium level (23.7%). Estimates of heritability were also in the same levels. The increase in the variance of common effect σ_c^2 of Zn (75.7) was associated with decrease (23.7%) in the variance of additive genetic effect and the opposite trend was clear with Ca. The highest percentage of the error variance σ_e^2 was in Cu (0.60%) and the lowest in Zn element (23.8%). The percentages of phenotypic variance ranged from 2.82 to 22.41%.

4.3.2. In hair:

The percentages of direct additive genetic variance for the six trace elements were in high levels except Zn (43.5%) and ranged from 66.2 to 87.6% for the other five trace elements. The h^2 were also in the same levels. The percentages of error variance σ_e^2 were in very low values (0.44-5.1%) except Fe (14%).

4.4.3. Correlations:

The coefficients of genetic correlation between each of the six minerals, in blood and hair of rabbits, were in low values. The coefficients (r_G) for Zn, Cu and Ca were positive and for Fe, Co and Mg were negative. The coefficients of common correlation, on blood and hair, were positive for Ca, Co and Mg and large, negative for Zn. While Cu coefficient was medium and positive (0.26). Estimates of r_E between minerals contents in blood and hair were positive for Mg and Ca (0.12 and 0.27 respectively). For Fe was negative (-0.29). Coefficients of phenotypic correlation of each of Zn, Mg and Ca were moderate and negative for Zn and positive for Mg and Ca.