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TABLE OF CONTENTS

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POSSIBILITY OF EARLY DIRECT AND INDIRECT SELECTION FOR DOE LITTER PERFORMANCE OF BAUSCAT AND GIZA WHITE RABBITS

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Introduction

Increasing the numbers and weight of kits weaned per doe per year might be accomplished by reducing preweaning litter mortality and/or by increasing litter size, litter gain and mean kit weight. Although these traits are very important from the economic point of view, only litter size has been recently subjected to extensive quantitative genetic studies (Garcia et al., 1982a; Lahiri and Mahajan, 1982; Lahiri, 1984; Kadry and Afifi, 1984). Estimates of genetic parameters for preweaning mortality, litter gain and mean kit weight at weaning are very few (Rollins and Casady, 1967; Lampo and Broeck, 1975; Randi and Scossiroli, 1980).

The purpose of this study was to detect the possibility of early direct and indirect selection for litter traits measured at weaning in Bauscat (B) and Giza White (G) rabbits and to assess the direct and correlated responses expected from selection for these traits.

Materials and Methods

In the preceding paper (Khalil et al., 1987), population, management, breeding plan and data were discussed in detail. Fifty-one sires and 209 daughters (paternal half-sisters) were used to estimate the genetic and phenotypic parameters of litter traits studied. The same mixed linear model (Khalil et al., 1987) which included the effects of sire of doe, doe within sire, parity and month of kindling was used to analyze the year-adjusted litter traits data. Litter weight at birth was included as a covariate in the model. Sire of doe, does within sire and remainder error effects were assumed random with mean zero and variances σ_s^2, $\sigma_{D:s}^2$ and σ_e^2, respectively. All other effects were assumed fixed. Estimates of sire, does within sire and remainder components of variance and covariance were computed according to Method III of Henderson (1953). Estimates of genetic and phenotypic variances and covariances used to estimate the genetic and phenotypic parameters are presented in Table 1.

Heritabilities were estimated for weaning litter traits by the paternal half-sib (h_s^2) method as:

$$h_s^2 = \frac{4\,\sigma_s^2}{\sigma_s^2 + \sigma_{D:s}^2 + \sigma_e^2}$$

Genetic and phenotypic correlations were estimated according to computational techniques described by Harvey (1970). Approximate standard errors for the heritability and genetic correlation estimates were computed by the LSML 76 program of Harvey (1977). The expected direct and correlated responses per generation from single-trait selection for size, mean kit weight and gain of the litter were estimated according to Falconer (1981).

Results and Discussion

Heritability estimates:

The estimates of heritability with their corresponding standard errors are presented in Table 2. These estimates showed that litter traits measured at weaning are moderately or highly heritable with the exception of preweaning mortality in Bauscat rabbits. Heritabilities for litter traits in Bauscat are generally substantially lower than the corresponding estimates in Giza White rabbits. This may be due to reduction in the genetic variability within Bauscat rabbits through previous selection in this breed.

Heritability estimates for litter size (Table 2) were in general agreement between the two breeds in this study and were higher than the range of previously reported estimates for different breeds of rabbits (Garcia et al., 1980; Randi and Scossiroli, 1980; Lahiri and Mahajan, 1982; Lahiri, 1984), with some estimates being negative or zero. On the other hand, Kadry and Afifi (1984) reported a higher estimate of 0.318 + 0.012 for litter size at weaning in Bauscat rabbits.

The moderate or high estimates of heritability for preweaning litter gain (Table 2) in both Bauscat and Giza White rabbits suggest that direct selection for preweaning litter gain will give effective genetic improvement in this trait. This is because litter gain was shown to be an excellent criterion for the lactational performance of the doe. The higher estimate of heritability for litter gain in Giza White rabbits than Bauscat indicates that mothering and milking ability during the suckling period in Giza Whites were higher than for Bauscats. However, these estimates for litter gain in both breeds appear to be within the range of 0.250 and 0.637 reported by Randi and Scossiroli (1980).

The higher estimate of heritability for mean kit weight at weaning in Giza White rabbits than the corresponding estimate in Bauscats (Table 2) indicates that selection for increased mean kit weight at weaning in Giza White rabbits could increase kit weight at birth. However, these estimates were higher than values reported in the literature (Garcia et al., 1982b).

The moderate estimate of heritability of 0.27 ± 0.17 for preweaning mortality in Giza White rabbits is sufficiently high to indicate that selection for decreased mortality to weaning should be effective in this breed. This estimate appears, however, to be higher than the estimate of 0.12 obtained by Rollins et al. (1963) for New Zealand White Rabbits. Although no other estimates appear to have been published for rabbits, this estimate is in keeping with estimates (based on sire component) found for some other polytocous species. In swine, for example, Rico and Gomez (1982) obtained lower estimates of 0.06 ± 0.03 and 0.05 ± 0.03 for birth-to-21 days and birth-to-weaning mortality, respectively. Also, the lower estimate of 0.10 for mortality of piglets per litter up to weaning was reported by Lobke et al. 1983).

Interrelationships among litter traits:

Phenotypic and genetic correlations among litter traits at weaning in Bauscat and Giza White rabbits are given in Table 2. Implications of these correlations are discussed with some reserve in order to provide an interpretation of potential biological implications. It can be seen in Table 2 that some of the correlations were greater than one and most had larger standard errors. This lack of precision was apparently due to the small number of degrees of freedom for sires and the small variance component estimates for sires (Table 1), i.e. upward bias due to the large effect of random sampling. However, due to unreliability and the discrepancy between the two breeds of the present study in some estimates of genetic correlations involving preweaning mortality, these estimates cannot be further discussed.

(i) Phenotypic correlation: The estimates of phenotypic correlation between litter size and litter gain were positive and large (Table 2). This could indicate that litter size has a high positive effect on preweaning litter gain, and the increase in litter size could lead to an increase in litter gain. Accordingly, it could be stated that increases in preweaning litter gain were positively associated with increases in reproductive rates and, consequently, these traits can be improved simultaneously. Estimates of most investigators (Afifi et al. 1980; Lukefahr, 1982; Lukefahr et al., 1983) showed a similar trend indicating that litter size and litter gain were highly positively phenotypically correlated.

Estimates of the phenotypic correlation between litter size and mean kit weight were relatively low (Table 2), i.e. large-sized litters had lighter mean kit weight at weaning than small-sized litters. Similar low estimates were obtained by Rouvier et al. (1973). Also, Lampo and Broeck (1975) reported that the phenotypic correlation between percent of young weaned and individual weaning weight in Dendermonde White rabbits was negative and small, the estimate being -0.082 ± 0.039.

The positive phenotypic correlations given in Table 2 between litter gain and mean kit weight were moderate in magnitude. This is due to their part-whole relationship.

ii) Genetic correlation: The genetic correlations among different litter traits for both breeds showed that most of these relationships were generally similar (in magnitude and sign) to the corresponding estimates of phenotypic correlations (Table 2).

Estimates of genetic correlations between litter size and litter gain were positive and relatively large (Table 2). These part-whole results indicate that genes affecting litter size also have an effect on preweaning litter gain. Similarly, positive and large estimates between litter gain and mean kit weight were observed (Table 2), suggesting a high and favorable genetic associaton between these traits. Therefore, estimates of genetic correlation in the present study together with the corresponding phenotypic ones offer encouragement to the rabbit breeder to select for litter size and litter gain traits at earlier ages, i.e. during the preweaning period.

However, the correlations among litter size, litter gain and mean kit weight during lactation may be related to maternal effects, even when growth of the young rabbit is made independent from the dam. Maternal effects due to the common environment during the suckling period could be added as another cause in this respect. In addition to these components there may also be involved direct genetic effects determined by differences among paternal families controlling the vitality and growth characteristics of the genotypes of the young rabbits.

The usefulness of phenotypic and genetic correlations among the different litter traits studied (with the exception of preweaning litter mortality) as a predictor of doe performance is clear. At the same time, therefore, the values of these correlations as an aid in selection for doe productivity traits seem to depend on the accuracy of predicting breeding values for doe litter traits. These observations need to be evaluated in an experimental situation where correlated responses in doe litter traits are measured when selection is for doe productivity.

Prediction of response to selection:

As mentioned earlier, estimates of genetic and phenotypic parameters obtained for weaning litter traits in the present study indicate, in general, the importance of additive genetic variance for these traits. In relation to Egyptian environmental conditions, these estimates suggest that single-trait selection could generally improve these traits in these two breeds of rabbits. The expected direct and correlated responses per generation from single trait selection for large size and gain of litter and heavy kit weight are summarized in table 3. However, due to the discrepancy between two breeds of the present study in estimates of heritability and genetic and phenotypic correlations involving preweaning litter mortality, estimates of expected direct and correlated responses including this trait were not discussed.

Figures given in Table 3 indicate that the theoretical maximum rate of direct genetic progress per generation in rabbit herds selected solely for litter size at weaning and preweaning litter gain are 0.3 young (6.3%) and 384.5 grams (23%) per litter per generation, respectively. Consequently, the gain in mean kit weight at weaning per generation will be approximately 45 grams (10.4%). However, the expected direct selection gave greater improvement in preweaning litter gain and mean kit weight than indirect selection.

Selection for litter size has been generally associated with a decreasing correlated response in mean kit weight while maintaining a high rate of response in preweaning litter gain (Table 3). These results reflect the direction and magnitude of genetic correlations among these particular traits. Selection for preweaning litter gain in Bauscat and Giza White rabbits would be almost as effective (64.2% and 111.4%, respectively) as direct selection for improving mean kit weight at weaning.

Maximum improvement in litter size was obtained when this trait was selected for indirectly through pre-weaning litter gain (Table 3). In this respect, selection for increased gain of litter, in which the dam was weaned, is expected to increase her litter size and gain at weaning. This is because dams from large-gain litters would have bigger weights at the age of their first mating, would have higher milking ability and, consequently, would produce large and heavy litters at weaning. Selection for heavy weight of kits at weaning would cause litter size at weaning to decrease (Table 3). On the other hand, selection for mean kit weight in Bauscat and Giza White breeds could be 64% and 76%, respectively, as effective as direct selection for improving preweaning litter gain. Therefore, preweaning litter gain could be improved somehwat more rapidly if selection were based on mean kit weight at weaning.

Conclusion and Future Research Needs

Generally speaking, the estimates of genetic and phenotypic parameters and the studies reviewed in this study for Egyptian rabbits (Giza White) are substantially higher than the corresponding estimates for the foreign breed (Bauscat). This gives encouragement for rabbit breeders in Egypt to use and give more attention to the Giza White breed.

Estimates of heritability obtained for weaning litter traits in the present study indicate the importance of additive genetic variance for these traits, i.e. the total score method of selection (Selection index) could generally improve these traits in this population of rabbits.

Further phenotypic and genetic analyses of the correlations of numbers of kits to kit weight as well as growth rate must also be investigated in order to plan selection patterns for an overall improvement of rabbit stocks in Egypt and other countries.

There is a deficiency in the current state of knowledge regarding correlated responses to selection for litter traits in rabbits. Further research is needed to identify direct and correlated responses due to selection for litter traits of different breeds and in different herds of rabbits.

Summary

Data on 51 sires and 209 daughters (paternal half-sisters) of Bauscat (B) and Giza White (G) rabbits were used to obtain heritability estimates for some litter traits (litter size and gain at weaning, preweaning litter mortality and mean kit weight at weaning) and the genetic and phenotypic correlations among these traits. Estimates of heritability for litter traits studied (except preweaning mortality in B rabbits) were moderate or high. Heritabilities for litter traits studied in G were substantially higher than the corresponding estimates in B rabbits. Genetic and phenotypic correlations between litter size and litter gain were positive and relatively large. The genetic and phenotypic correlations between litter size and mean kit weight of B rabbits were negative while the reverse was observed for G rabbits. Litter gain and mean kit weight were positively correlated both genetically and phenotypically. As expected, direct selection was shown to give greater improvement in litter gain and mean kit weight than indirect selection. Selection for litter size has been generally associated with a predicted correlated decrease in mean kit weight while giving a high positive response in litter gain.

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Table 1. Phenotypic and genetic components of variance (on diagonal)[a] and covariance (off diagonal)[b] for litter traits in Bauscat and Giza White rabbits.

Traits[c]	LS (young)	LG (grams)	MKW (grams)	PM (%)
Bauscat				
LS	2.32 (0.44)	169.76	-6.96	-6.68
LG	710.16	455495 (87307)	8572	-1132
MKW	-45.51	27874	12805 (2076)	168
PM	-24.78	-8463	472	842.51 (14.56)
Giza White				
LS	2.28 (0.48)	409.2	32.96	-5.92
LG	935.30	643573 (509088)	60568	-5592
MKW	6.77	58598	15782 (8568)	-552
PM	-24.49	11354	-375	642.00 (170.8)

[a] Genetic variances are presented in parentheses.

[b] Phenotypic covariances are below the diagonal; genetic covariances are above the diagonal.

[c] Where LS = litter size, LG = litter gain, MKW = mean kit weight and PM = pre-weaning mortality.

Table 2. Estimates of heritability (on diagonal) and genetic (below diagonal) and phenotypic (above diagonal) correlations for litter traits in Bauscat and Giza White rabbits.

Traits	1[a]	2	3	4
Bauscat				
1) Litter size	0.20 ± 0.14	0.69	-0.26	-0.84
2) Litter gain	0.91 ± 0.15	0.20 ± 0.14	0.37	-0.65
3) Mean kit weight	-0.24 ± 0.53	0.64 ± 0.35	0.20 ± 0.13	0.21
4) Preweaning mortality	-1.69 ± 1.29	-0.77 ± 0.89	0.63 ± 0.52	0.02 ± 0.07
Giza White				
1) Litter size	0.21 ± 0.17	0.77	0.04	-0.88
2) Litter gain	0.83 ± 0.15	0.79 ± 0.29	0.58	-0.76
3) Mean kit weight	0.52 ± 0.39	0.92 ± 0.09	0.54 ± 0.25	-0.16
4) Preweaning mortality	-1.10 ± 1.10	-1.01 ± 0.60	-0.77 ± 0.46	0.27 ± 0.17

[a] Numbers in column headings correspond to row-numbered traits.

Table 3. Direct (on diagonal) and correlated (off diagonal) response+ expected per generation from single-trait selection in Bauscat and Giza White rabbits.

Selected Trait	Item++	Correlated Trait							
		Bauscat				Giza White			
		LS	LG	MKW	PM	LS	LG	MKW	PM
Litter size (LS)	a	0.3	122.8	-5.4	-1.8	0.3	271.2	22.0	-6.0
	b	100.0	91.0	-23.9	-300.0	100.0	42.8	32.4	-88.2
	c	6.1	7.0	-1.2	-6.2	6.5	16.4	5.1	-21.3
Litter gain (LG)	a	0.3	135	14.5	-1.4	0.5	634	75.5	-11.7
	b	100.0	100.0	64.2	-233.3	166.7	100.0	111.4	-172.1
	c	6.1	7.8	3.3	-4.8	10.9	38.3	17.4	-41.6
Mean kit weight (MKW)	a	-0.1	86.4	22.6	1.2	0.3	482.1	67.8	-9.0
	b	-33.3	64.0	100.0	200	100.0	76.0	100.0	-132.3
	c	-2.0	5.0	5.2	4.1	6.5	29.1	15.6	-32.0
Preweaning mortality (PM)	a	-0.1	-32.9	4.5	0.6	-0.4	-370.5	-36.9	6.8
	b	-33.3	-24.4	19.9	100.0	-133.3	-58.4	-54.4	100.0
	c	-2.0	-1.9	1.0	2.1	-8.7	-22.4	-8.5	24.2

+ Selection intensity equals 1.0 for estimated response, no selection on male side.

++ Where a = response in actual units of measurements, b = response as a percent of direct response, and c = response (a) per generation as expressed as a percent of the overall mean of the trait (calculated from the row data).