Tropical Animal Production 1982 7:217-225

SELECTION EXPERIMENT ON GROWTH AND LITTER SIZE IN RABBITS. I . EFFECT OF LITTER SIZE ON GROWTH [1]

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An experiment was carried out to study the effect of selecting for body weight and litter size in New Zealand White rabbits. The results presented are derived from the unselected base population (generation 0). Body weight at 28, 42, 56, 84 and 112 days were 384 ± 87, 551 ± 121, 785 ± 149, 1180 ± 202, 1528 ± 279 g respectively.

The mean weight at 28 days ranged from 618 g for individuals born in litter sizes of 1, to 344 g for individuals born in litter sizes of 11. At the age of 42 days the weight range was from 890 g for individuals born in litters of 1, to 513 in litters of 11. At 112 days , the body weight was highest in litters of 2 (1906 g) and lowest in litters of 12 (1434 g).

There were significant differences ($P < 0.001$) on body weight due to litter size up to the age of 112 days. The variance component between litter sizes decreased from 21.7% at 28 days of age to 5.4% at the age of 112 days. Splitting the material into litter size groups, gave significant ($P < 0.01$) differences for weight at 28, 84 and 112 days only between litter sizes of 4 and above.

Key words: rabbits, body weight, litter size

Several studies on litter size in rabbits and various other species have indicated a favourable positive phenotypic correlation between post-weaning growth rate or mature size of dam, and the litter size and litter weight she produces. (Rollins et al 1963; Rollins & Casady 1960; Harvey et al 1961; and Venge 1950, 1953 & 1963). It is rather difficult to know the exact nature of the correlation because of the associated environmental influences acting on the dams (Castle 1929; Venge 1950, Yao & Eaton 1954; Rollins & Casady 1960; Leplege 1970; MacArthur 1949; Falconer 1953, 1960, 1965; Bradford 1971, Eisen 1974, 1978; Revelle & Robinson 1973; and Vangen 1980). Therefore, selection for increased growth rate or increased mature size of the dam is expected to increase litter size and litter weight at birth. On the other hand, Doolittle et al (1972) and El Amin (1974) showed that young born in large litters tend to be smaller at birth and at weaning. Thus, selection for increased postweaning growth rate will produce larger litters, but with smaller individual birth weights.

According to Bakker (1974) litter size influence consists of:

- a deviation of the average of the additive genetic value of the parents from the population mean
- non-additive genetic effects by specific interaction (dominance and epistatic)
- maternal effects partially determined genetically
- influence of the litter itself, for instance the litter size.

[1] Supported by funds from the University of Dar es Salaam, Tanzania and the International Foundation for Science (IFS), Stockholm, Sweden

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The last two points can determine most of the variance, especially in the traits observed about the age at weaning. With the data available only the influence of the litter itself on weight up to the age of 112 days is given.

Materials and Methods

Breeding stock and mating procedure: In 1976 a population of 80 females and 50 males of the New Zealand White breed was established by collecting rabbits from different areas in Morogoro, Tanga and Kilimanjaro regions of Tanzania. From these rabbits random mating was carried out once to give a foundation stock of 180 females and 100 males which were randomly mated to give progenies whose growth performance is reported here, whereas reproductive data is based on the performance of the 80 females.

Mating was performed when all rabbits reached the age of 182 days by taking 1 - 2 females to the randomly chosen male. The females allocated to the male were left in the males' cage for five days in order to allow for oestrus cycle of the rabbits and to let the rabbits get used to each other.

About thirty days from the time of mating, the nest boxes were checked between 0800 h and 1600 h. Numbers of young born alive or dead were counted. No further disturbance took place in the first few weeks, since it appeared from previous kiddings that handling the rabbits at an earlier age led to some of the does rejecting their litters, or even eating them.

Identification was by ear-notching, and sexing was done at the age of three weeks. At the age of 42 days kids were weaned and grouped by sex into two or three kids per cage.

Data: Body weight was recorded at the age of 28 (W28), 42 (W42), 56 (W56), 84 (W84) and 112 (W112) days. Weight gains/day were calculated between 28-42 (R_1), 42-56 (R_2), 56-84 (R_3), 84-112 (R_4), 28-112 (R_5), 42-112 (R_6) and 56-112 (R_7) days. Litter size at birth (NOBT) was recorded within 24 hours after birth as number of young born dead and alive.

Data analysis: The variance components were computed by using the pooled analysis of variance. The model for the pooled analysis was:

$$y_{ijk} = \mu + z_i + d_{ij} + e_{ijk} \quad \text{where}$$

y_{ijk} = weight of the individual rabbit

μ = average weight

z_i = effect of litter size (i = 1 to 12)

d_{ij} = effect of litter j within litter size i

e_{ijk} = random deviation within litter

Also a Duncan's multiple range test was used to test for differences between means of weights within age groups and between litter sizes. The

Table 1:

Mean squares and % component of variance estimated from a nested analysis of variance

	Between litter sizes		Between litters		Within litters	
df	11		151		709	
	Mean square	Variance component %	Mean square 1)	Variance component %	Mean square	Variance component %
Characters						
W28	132972 ***	21.7	17366	33.5	3457	44.8
W42	260239 ***	21.3	394o7	42.1	5470	36.6
W56	297789 ***	15.7	51042	32.1	11880	52.2
W 84	227948 ***	5.0	85810	25.8	28533	69.2
W112	500479 ***	5.4	212583	40.4	42545	54.2
R_1	138.1 ***	3.3	68.6	29.4	20.4	67.3
R_2	46.0 ns	o.0	78.9	22.5	30.8	77.5
R_3	23.6 *	o.0	33.8	17.6	15.7	82.4
R_4	106.9 *	o.5	97.3	39.0	21.8	60.5
R_5	23.6 **	o.0	25.5	39.1	5.7	60.9
R_6	16.2 *	o.0	30.9	37.2	7.4	62.8
R_7	20.6 *	o.0	39.7	38.2	9.2	61.8

ns = non significant. * = $P \leq 0.05$ ** = $P \leq 0.01$ ***= $P \leq 0.001$

1) = All mean squares were significant ($P \leq 0.001$)

computer was used to give all these estimates using the Statistical Analysis System (SAS) programmes of Helwig and Council (1979).

Results

The between litter size and between litter variances and their percentage components are presented in Table 1.

A gradual reduction of litter size influence is observed in percentage decrease of the between litter size variance component from 21.7 at W28 to 5.4 at W112.

The influence of litter size is most pronounced in daily gains before weaning. After weaning, the maternal influences and direct litter size influences diminish as the young born in larger litters tend to compensate for lost growth to attain their potential gains. It is, therefore, noted that no differences were observed in R_2, R_3, & R_4. The overall daily gains R_5, R_6, and R_7 were, however, still significantly different. The litter component of variance ranged from 17 to 42% of the total variation. No real trend with age could be observed for this component. There is a decrease up to 84 days, but for W112 and R_4 one can observe a new increase in litter variance.

The Duncan's multiple range test was applied to compare the effect of different litter size on weights within an age group. The results shown in Tables 2, 3 and 4 indicate that within a particular age group there was a decline in the mean as the litter size increased. This is also clearly shown in Figure 1.

Table 2:

Duncan's multiple range test showing differences in mean weights of different litter sizes at 28 days.

Total number born/litter	Number of individuals	Mean weight (g)[1]
1	5	618 [a]
2	10	604 [a]
3	27	491 [b]
4	56	436 [c]
5	69	401 [d]
12	39	392 [d,e]
7	125	372 [f,e]
6	131	372 [f,e]
8	193	369 [f,e]
9	89	366 [f,e]
10	84	361 [f,e]
11	46	344 [f,e]

[1] a,b,c,d,e,f represent significantly different means ($P < 0.05$)

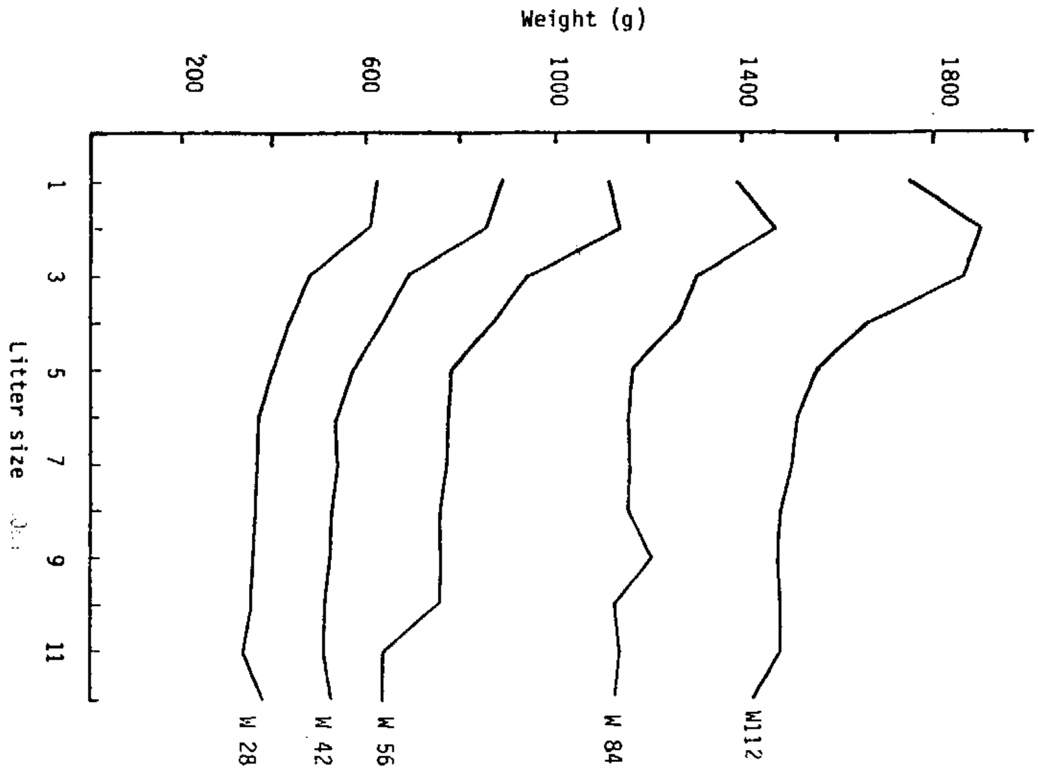

Figure 1:
Mean weight at different litter sizes

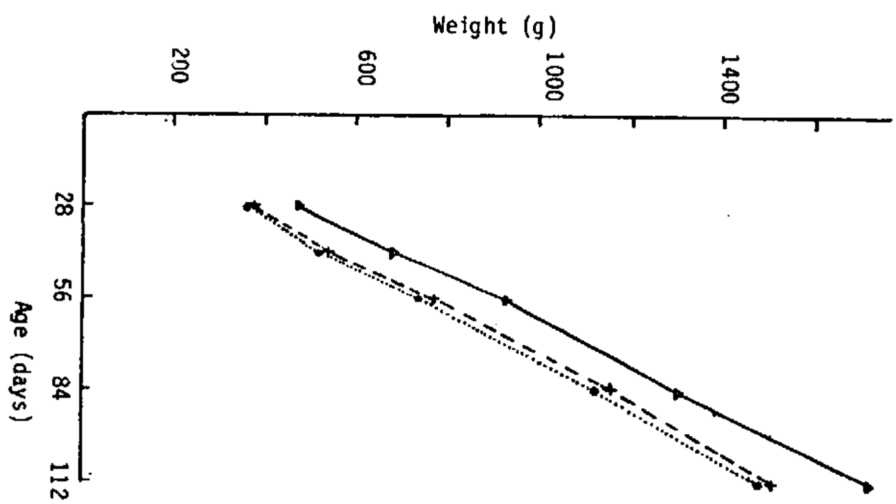

Figure 2:
Mean weight of rabbits born in litters of the size 1-4—Δ—, 5-8 - + - and 9-12 ....●....

Table 3:

Duncan's multiple range test showing the differences in mean weights of different litter sizes at 42 days

Total number born	Number of individuals	Mean weight (g) [1]
1	5	890 [a]
2	10	852 [a]
3	27	698 [b]
4	56	634 [c]
5	69	571 [d]
7	125	546 [d,e]
6	131	536 [e]
12	39	527 [e]
8	193	526 [e]
9	89	523 [e]
10	84	520 [e]
11	46	513 [e]

[1] a,b,c,d,e represent significantly different means ($P < 0.05$)

Table 4:

Duncan's multiple range test showing differences between mean weights of different litter sizes at 112 days

Total number born	Number of individuals	Mean weight (g) [1]
2	10	1906 [a]
3	27	1775 [a]
1	5	1752 [a,b,c]
4	56	1667 [c,b]
5	68	1566 [c,b]
6	131	1524 [c,b,d]
7	125	1512 [c,d]
11	46	1495 [c,d]
8	193	1491 [c,d]
10	84	1490 [c,d]
9	89	1483 [c,d]
12	39	1434 [d]

[1] a,b,c,d represent significantly different means ($P < 0.05$)

Table 5:

Duncan's multiple range test showing differences between litter size groups of 1-4, 5-8 and 9-12 at 28, 42, 56, 84 and 112 days

Weight Age (days)	Litter size range	Number of individuals	Mean[1] weight (g)
	1 - 4	98	477[a]
W28	5 - 6	518	375[b]
	9 - 12	258	364[b]
	1 - 4	98	687[a]
W42	5 - 8	518	539[b]
	9 - 12	258	521[c]
	1 - 4	98	931[a]
W56	5 - 8	518	772[b]
	9 - 12	258	754[b]
	1 - 4	98	1305[a]
W84	5 - 8	516	1164[b]
	8 - 12	258	1137[b]
	1 - 4	98	1726[a]
W112	5 - 8	516	1514[b]
	8 - 12	258	1480[b]

[1] a,b,c represent significantly different means ($P < 0.05$)

In all groups it appeared that there were no differences between litter sizes above 7. To illustrate this point, the data was divided into groups of litter sizes 1-4, 5-8 and 9-12. Table 5 gives the means and tests obtained from such groups. This is illustrated in Figure 2. Statistically significant differences were observed only between litter sizes of less than 4 and more than 4, at all ages except 42 days.

Discussion

The results obtained in this study are consistent with previous reports by Kopec 1926; Venge 1953, 1963 and El Amin 1974. In this study the percentage variance component for litter size was 21.7, 15.7 and 5.4

at the age of 28, 56 and 112 days. This can be compared with Kopec's (1926) observations of 14 and 9% for males and females, respectively, at 60 days of age and the residual variance of 8% for Polish breeds of rabbits at 117 days (Venge 1953). In the present paper male and female performances are not reported separately due to lack of sexual dimorphism on weight up to the age of 112 days. There were still significant differences ($P < 0.05$) in body weight between litter sizes even at the age of 112 days. The variance component between litters contain both genetic variation and variation due to maternal effect. One might expect a decrease until an age of 84 days. The increase in variation between litters from 84 to 112 days cannot be explained at the present time.

The results presented in Table 5 show that differences exist between litter sizes of 1 - 4 and those above 4. A closer examination of Figure 1 reveals that kids born in litter sizes of 1 tend to exhibit reduced weight gains as they grow, and particularly after weaning they tend to exhibit lower weights than individuals from litter sizes of 2 or 3.Since kids were mixed into groups of up to 3 after weaning, it appeared that individuals born in litter sizes of 1 interacted with the new environment worse than individuals from litter sizes of 2 or more. A more detailed, controlled study needs to be done to confirm this.

Venge (1963) reported findings similar to his ealier observations (Venge 1953) and to those of Kopec (1926), which observed that there was a negative correlation between litter size and weight at 2 - 4 months of age but after that time no significant correlation was found, and concluded that litter size at birth had no permanent influence on growth and adult size. This implies that individuals selected from bigger litters, and hence having smaller individual birth weights, do not necessarily have smaller mature size which could make them produce smaller litters and thereby reduce progress.

Simila:ly Eisen & Durrant (1980) reported that valid inferences concerning genetic differences among lines in litter size may be made at any post-natal litter size between eight and sixteen. If both these statements are true, then one may imagine that selection for body weight at a later age would give better response if mass selection was adopted as opposed to within family selection. On the other hand, since a small amount of litter influence is still detectable at the age of 112 days then adjustment of the litter with mass selection at the age of 112 days would improve the response. Selection for litter size might not need any litter standardisation at birth depending on the age at which the animals are mated. It is, therefore, important to specify the age at which animals are mated, since, as mentioned by Eisen (1974) , although the maternal effects decrease in relative importance after weaning, they are still present at sexual maturity and these could bring complications in drawing conclusions, particularly in selection experiments for pre-weaning growth. To this one may add selection for litter size.

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Received 12 May 1982