EFFECT OF LITTER SIZE AND BIRTH WEIGHT ON THE MORTALITY AND WEIGHT GAIN OF SUCKLING AND GROWING RABBITS

SZENDRÔ ZS., PÁLOS J., RADNAI I., BIRÓ-NEMETH E., ROMVÁRI R.

PANNON Agricultural University, Faculty of Animal Science, H-7400 KAPOSVÁR, P.O.Box 16, Hungary

Abstract - 360 Pannon White new-born rabbits were grouped according to their birth weight. The litter size was 6, 8 and 10, the birth weight of the rabbits was between 35 and 70 g in each group. The mortality of rabbits in litter size 6, 8 and 10 between birth and 3 weeks of age was 6.8, 10.2 and 22.2 % respectively, and in the group of rabbits weighing 40-49 g, 50-59 and 60-69 g at birth mortality was 20, 12.7 and 7.4 %, respectively. The difference in weight gain at 0-3 and 3-6 weeks between groups of litter size 6 and 10 was 46 and 20 %, respectively. The same figures for groups of rabbits between 40-49 g and 60-69 g were 21 and 23 %, respectively. The correlations between litter size and weight gain were significant up to the age of 6 weeks, and between birth weight and weight up to the age of 12 weeks. The difference in weight at 3, 6 and 12 weeks between litter size 6 and 10 were 129, 272 and 298 g, respectively, and the same values between groups of rabbits of 40-49 g and 60-69 g were 80, 253 and 451 g, respectively.

INTRODUCTION

In the polytocous species the maternal effect plays an important role in the survival and body weight of the suckling and growing animals through litter size and birth weight. The rabbit is one of the most suitable model animals for investigating the effect of these two factors. The embryos and the suckling animals spend a long time in close attachment to their mothers; 3.5-4 months pass from the ova shed to the slaughtering of the animal - the gestation period is about 1 month and the suckling rabbits are weaned from their mothers at the age of 1-1.5 months. This way, the lifetime of the growing rabbits consists of about 25 % gestation life and 25-35 % suckling period.

The body weight of the 28-day old foetuses depends on their number and position in the uterine horn (LEBAS, 1982). The phenotypic correlation between litter size and individual birth weight falls between r = -0.33 and -0.46 (KROGMEIER and DZAPO, 1991; 1975, MOURA *et al.*, 1991; POLASTRE *et al.*, 1992). The relationship between litter size and the amount of milk produced by the mother for one suckling rabbit is r =0.35 (LEBAS, 1975). It is especially during the third week of nursing that the negative effect of a large litter can be detected clearly regarding the weight gain of the rabbits (SZENDRÔ, 1986). Through the genetic analysis of the body weight at weaning several authors have emphasized the marked effect of the mother. This effect can be perceived until the end of the fattening period (BRUN, 1993; BRUN *et al.*, 1992; POLASTRE *et al.*, 1992). As far as gain in weight is concerned, however, the maternal effect can be said to be remarkable only up to the age of 6 weeks, and it becomes negligible during the fattening period (RANDI and SCOSSIROLI, 1980; BLASCO *et al.*, 1983; SZENDRÔ, 1984).

The relevant literature suggests that the relationship between litter size and the mortality of suckling rabbits is weak (RAO *et al.*, 1977; KROGMEIER and DZAPO, 1991). Nevertheless, the correlation coefficient does not express the closeness of the relationship accurately because mortality becomes more elevated both in small and in large litters (SZENDRÔ and BARNA, 1984). New-born rabbits are smaller in larger litters. We have found that all rabbits weighing 25-35 g and half of rabbits weighing 35-45 g at birth die during the first week of life (SZENDRÔ, 1978).

In the experiments carried out so far the effects of litter size and birth weight have not been separated (the larger litters included smaller new-born rabbits, the smaller litters larger ones). The objective of our research programme was to evaluate the combined and separate effects of these two traits (litter size and birth weight) as two important factors from the point of view of the maternal effect.

MATERIAL AND METHODS

The experiment was carried out at the rabbit research farm of the university, using Pannon White rabbits. The animals were housed in a closed rabbit house with windows on flat deck cages. A minimum temperature of 14 °C was maintained during winter. The commercial diet (CP: 16.5 %, CF:15.5 %) was available ad libitum.

On the 31st day of pregnancy the does were injected with oxytocin to induce parturition. The new-born rabbits were taken away from their mothers immediately after delivery (before they started suckling). Their weight was measured individually and they were branded with a colour yarn. The new-born rabbits were divided into litters of 6, 8 or 10 according to their birth weight classes 40-49 g, 50-59 g, 60-69 g. Altogether, 50 litters were formed (numbers of litters of size 6, 8 and 10 : 22, 16 and 12, respectively) including 380 new-born rabbits. (Rabbits weighing 35-39 g were left out of the evaluation because of the high rate of mortality in this category.)

Suckling rabbits which died before weaning were replaced with pups taken from other litters (out of the experiment) in order to keep litter size unchanged during the suckling period. The rabbits were measured once a week up to the age of 6 weeks and once a fortnight between 6 and 12 weeks of age. Weaning was carried out when the rabbits were 4 weeks old by leaving the young in the maternal cage and transferring the doe into a new one.
Data were statistically analysed using one-way analysis of variance, regression analysis and chi-square test by Statgraphics vers. 5.0.

RESULTS AND DISCUSSION

Mortality

Taking the whole experimental period into consideration, 26.3 % of the rabbits died during the first 12 weeks. Mortality became more elevated with increasing size of litter and with decreasing weight at birth. The effect of litter size and birth weight proved to be significant only during the suckling period, particularly during the first week of life (Table 1). The mortality was low during the first week (3.9-5.3 %) in the litters of 6 and in the weight category of 60-69 g. Even in the lowest weight category (i.e. 40-49 g) the rate of mortality exceeded 10 % only in the litters of 8 (13.8 %) and 10 (24.2 %).During the first 3 weeks the mortality rates were 6.8, 10.2 and 22.2 % in the litters of 6, 8 and 10 rabbits, respectively, and 20, 12.7 and 7.4 % in the new-born weight categories of 40-49 g, 50-59 g and 60-69 g, respectively.

From these results it can be established that both litter size and birth weight have an influence on the mortality of suckling rabbits. However, the situation is particularly unfavourable only in the case when the rabbits born with a small weight are reared in a large litter. Under natural circumstances this is the usual situation. On commercial farms, where knowledge of parentage is not important, the smallest new-born rabbits should be fostered by a doe nursing a small litter.

Weight gain

The relationship between litter size and weight gain is detectable only up to the age of 6 weeks - there is no significant correlation between these later on (Table 2). The rabbits nursed in litters of 6 gained 59 and 20 % more weight between weeks 0-3 and 3-6 than those nursed in litters of 10, respectively. A similar conclusion can be reached by taking the regression curve for these two traits (Table 2). Whereas the correlation coefficients are 0.65 and 0.31 for the periods of 0-3 and 3-6 weeks, respectively, these traits become independent from each other after the sixth week.

As shown by the data, the influence of birth weight can also be detected during the fattening period, i.e. up to the age of 12 weeks (Table 1). As compared to the smallest rabbits (40-49 g), the largest ones (60-69 g) gained 20, 23, 9 and 16 % more weight between the ages of 0-3, 3-6 6-10 and 10-12 weeks, respectively. At the same ages the correlation coefficients were between 0.20 and 0.37 and the regression coefficient was significant in every case (Table 2).

The combined effect of litter size and birth weight is difficult to follow through the data shown on Table 1, although it can be seen clearly that there is a 2.3-fold difference between the smallest (litter of 10, 40-49 g) and biggest (litter of 6, 60-69 g) values at the ages of 2-3 weeks. The two-variable functions (Table 2) provide more

Table 1 : Effect of litter size and birth weight on mortality, live weight and daily weight gain of suckling and growing rabbits (Mean ± SD)

Age (weeks)	Litter size								
	6			8			10		
	Birth weight, g								
	40-49	50-59	60-69	40-49	50-59	60-69	40-49	50-59	60-69
n	*33*	*41*	*29*	*29*	*45*	*34*	*33*	*48*	*31*
	Mortality, %								
0-1	6.1^{ab}	2.4^{a}	3.4^{a}	13.8^{ab}	11.1^{ab}	2.9^{a}	24.2^{b}	8.3^{ab}	9.7^{ab}
0-3	9.1^{a}	4.9^{a}	6.9^{a}	13.8^{ab}	13.3^{a}	2.9^{a}	36.4^{b}	18.8^{ab}	12.9^{ab}
3-6	9.1	7.3	3.4	6.9	4.4	-	-	8.3	-
6-10	9.1	4.9	6.9	-	6.7	-	9.1	10.4	6.5
10-12	3.0	4.9	-	3.4	2.2	2.9	-	-	3.2
0-12	30.3^{b}	22.0^{ab}	17.2^{a}	24.1^{ab}	26.7^{b}	5.9^{a}	45.5^{b}	37.5^{b}	22.6^{ab}
	Daily weight gain, g								
0-3	15.4±2.4	16.3±2.7	18.8±2.5	12.8±4.6	14.6±2.1	15.4±3.9	9.4±2.2	10.4±2.8	11.5±2.7
3-6	38.8±7.9	39.5±9.3	46.2±10.6	34.2±7.5	39.5±6.4	44.7±7.5	30.0±7.6	35.3±6.9	35.9±7.8
6-10	36.5±6.5	37.8±6.6	40.3±7.9	35.6±6.8	38.6±6.4	38.9±8.5	36.5±4.9	39.9±5.6	39.9±8.6
10-12	30.9±9.8	30.3±9.8	32.8±9.9	28.6±11.4	31.8±10.2	33.8±12.3	28.0±12.1	31.6±9.2	35.3±10.1
	Live weight, g								
at birth	45.5±3.0	54.4±2.8	63.6±2.6	44.6±2.8	53.8±4.1	64.2±3.1	45.4±2.4	54.1±2.8	63.5±2.9
3	369±59	396±56	458±53	291±65	352±66	401±47	243±46	273±58	306±55
6	1175±209	1224±218	1424±235	976±269	1164±237	1330±160	873±194	1020±177	1060±192
10	2198±347	2305±320	2560±372	1933±504	2225±450	2420±325	1911±221	2135±268	2197±312
12	2670±356	2760±317	3019±418	2302±629	2595±693	2934±387	2302±214	2497±541	2693±371

Age (weeks)	Birth weight, g			Litter size			Total
	40-49	50-59	60-69	6	8	10	
n	*95*	*134*	*94*	*103*	*108*	*112*	*323*
	Mortality, %						
0-1	14.7	7.5	5.3	3.9^{a}	9.3^{ab}	13.4^{b}	9.0
0-3	20.0^{a}	12.7^{ab}	7.4^{b}	6.8^{a}	10.2^{a}	22.2^{b}	13.3
3-6	5.3	6.7	1.1	6.8	3.7	3.6	4.6
6-10	6.3	7.5	4.3	6.8	2.8	8.9	6.2
10-12	2.1	2.2	2.1	2.9	2.8	0.9	2.2
0-12	33.7^{a}	29.1^{ab}	14.9^{b}	23.3^{a}	19.5^{a}	35.6^{b}	26.3
	Daily weight gain, g						
0-3	12.7±3.4	13.7±3.5	15.2±4.2	16.7±3.0	14.2±3.0	10.5±2.7	13.9±3.9
3-6	34.6±8.4	38.1±7.8	42.4±9.6	41.2±9.8	40.0±8.1	34.2±7.6	38.6±9.1
6-10	36.3±6.2	38.7±6.3	39.6±8.3	38.2±7.1	38.0±7.4	39.1±6.7	38.4±7.1
10-12	29.3±11.0	31.2±9.7	34.0±10.9	31.2±9.7	31.7±11.3	31.9±10.3	31.6±10.6
	Live weight, g						
at birth	45.2±2.8	54.1±2.8	63.8±2.8	54.1±7.6	54.5±8.3	54.1±7.2	54.2±7.7
3	309±72	340±73	389±79	405±66	353±73	276±58	347±81
6	1021±231	1137±202	1274±244	1268±241	1176±259	996±194	1151±242
10	2025±324	2225±286	2393±361	2348±369	2222±462	2101±287	2228±347
12	2436±377	2620±482	2887±409	2812±384	2642±629	2514±442	2660±460

Values of mortality on the same line with different letters are significantly different ($P<0.05$).
The significant effects of birth weight and litter size on daily weight gain and live weight are shown in Table 2.

information for the breeders. Our results indicate that litter size and birth weight have similar effects on weight gain up to the age of 6 weeks. After 6 weeks, however, only birth weight remains effective.

It is normal that the rabbits show better growth in smaller litters by getting more milk during the suckling period. This advantage seems to come out during the transition from the milk to the solid diet and also around weaning (between 3-6 weeks). Similarly, it is normal that - assuming equal litter size - the stronger and larger rabbits are in a better position during the short (2.5-3 min.) time of suckling, and this effect is still detectable between the third and sixth weeks. It is surprising, however, that the effect of birth weight emerges right until the end of fattening. Our hypothesis suspects an additive genetic effect in the background, i.e. those individuals which show better growth during their total life may also become over average during the period of fattening.

Body weight

A negative relationship was found between litter size and body weight in every age category. Supposing that the rabbits are of the same weight at birth but they are reared in litters of 6 or 10, the gap will be 129, 272 and 298 g between them at 3, 6 and 12 weeks of age, respectively. These data highlight the fact that the difference does not actually increase after 6 weeks, but neither is there compensation (Table 1). The correlation and regression coefficients show similar relationships (Table 2). As time (age) passes, the correlation coefficient indicates an ever-weakening relationship.

Table 2 : Equations for prediction of daily weight gain and live weight of rabbits at different ages according to litter size and birth weight

Y	Equation b+aX	R^2	r
Daily weight gain between			
weeks 0 and 3	26.2-1.54 LS	0.42	-0.65
weeks 3 and 6	52.4-1.74 LS	0.10	-0.31
weeks 6 and 10	36.6+0.21 LS^{NS}	0.00	-0.05
weeks 10 and 12	30.3+0.16 LS^{NS}	0.00	-0.02
weeks 0 and 3	6.4+0.14 BW	0.07	0.28
weeks 3 and 6	14.4+0.44 BW	0.14	0.37
weeks 6 and 10	28.4+0.18 BW	0.04	0.20
weeks 10 and 12	13.8+0.32 BW	0.06	0.24
Weight at			
3 weeks	604-32.1 LS	0.41	-0.64
6 weeks	1695-67.5 LS	0.20	-0.45
10 weeks	2731-61.3 LS	0.08	-0.28
12 weeks	3271-74.4 LS	0.07	-0.26
3 weeks	120+4.2 BW	0.16	0.4-0
6 weeks	436+13.1 BW	0.17	0.42
10 weeks	1215+18.7 BW	0.17	0.42
12 weeks	1340+24.3 BW	0.17	0.41
	$c + ax_1 + bx_2$		
Daily weight gain (g) between			
weeks 0 and 3	18.0+0.15 BW-1.58 LS	0.51	
weeks 3 and 6	28.1+0.45 BW-1.82 LS	0.24	
weeks 6 and 10	27.0+0.18 BW-0.18 LS^{NS}	0.04	
weeks 10 and 12	12.8+0.32 BW-0.12 LS^{NS}	0.06	
Weight at			
3 weeks	365+4.5 BW-33.1 LS	0.60	
6 weeks	962+13.7 BW-69.9 LS	0.39	
10 weeks	1701+19.2 BW-64.9 LS	0.26	
12 weeks	1933+24.6 BW-77.3 LS	0.24	

Marks: BW= birth weight; LS= litter size; NS= non significant

The rabbits were born with different weights ranging from 40 to 69 g (Table 1). The gap between the groups of lowest (40-49 g) and highest (60-69 g) birth weight tends to increase: it is 80, 253 and 451 at the ages of 3, 6 and 12 weeks, respectively. The regression curves are in agreement with the previous statement (Table 2): the value of the regression coefficient is 4.2, 13.1, 18.7 and 24.3 at 3, 6, 10 and 12 weeks of age, respectively. These two data sets show well the relationship described in the case of weight gain.

The combined effect of litter size and birth weight is demonstrated through the data shown on Table 1, by the functions listed in Table 2.

As a rule of thumb, it can be considered that a smaller litter size or a higher birth weight implies a larger body weight (Table 1). The two-variable functions (Table 2) underline the fact that the influence of both factors tends to become stronger up to the age of 6 weeks, but then, it is only the birth weight which has a further increasing effect.

CONCLUSIONS

The experimental design (i.e. mixed litters of different size with rabbits born with low, medium and high weight in each) made it possible to evaluate the combined and separate effects of litter size and birth weight. Based on the results the following can be concluded:

1. Litter size and birth weight affect mortality only during the suckling period. Rearing the small rabbits (40-49 g) in litters of 8 or 10 and medium-sized rabbits (50-59 g) in litters of 10 is particularly unfavourable.
2. The (negative) relationship between litter size and weight gain can be verified up to the age of 6 weeks. Consequently, litter size affects - through the milk supply for one suckling rabbit - the weight gain not only during the suckling period (0-3 weeks) but also when the animals begin eating a solid diet (3-6 weeks of age).
3. The effect of birth weight continues after weaning, up to the age of 12 weeks. Although the larger animals have a better chance to get to the teat (and milk) during the nursing period, according to our hypothesis it is because of the additive genetic effect that the rabbits born with a higher weight show better growth after weaning.
4. The results of our experiment shed light on the fact that these two factors (i.e. litter size and birth weight) have separate effects on mortality, weight gain and also body weight.
5. By evaluating the combined effect of litter size and birth weight it can established that mortality during the first week can be reduced considerably if the new-born rabbits weighing below 40 g (very poor vitality) are discarded and the small ones (40-50 g) are reared in smaller litters.

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Einfluß von wurfzahl und geburtsgewicht auf die mortalität und das wachstum von saug- und jungkaninchen - 360 neugeborene Weiße Pannon Kaninchen wurden ihrem Geburtsgewicht entsprechend gruppiert. Mit den Neugeborenen zwischen 35 und 70 g wurden 6-er, 8-er und 10-er Würfe gebildet. In den ersten drei Lebenswochen betrug die Mortalität der Saugkaninchen - unabhängig vom Gewicht - in den 6-er, 8-er u nd 10-er Würfen 6.8, 10.2, 22.2 %. Und die der Neugeborenen mit einem Geburtsgewicht von 40-49 g, 50-59 g und 60-69 g - aslo unabhängig von der Wurfgröße - 20.0, 12.7, 7.4 %. Der Unterschied der Gewichtszunahme in den Lebenswochen 0-3 und 3-6 lag bei den 6-er und 10-er Würfen zwischen 16 und 20 %, bei den Neugeborenen der Gewichtsklassen 40-49 g und 60-69 g zwischen 21 und 23 %. Eine Signifikanz ergab sich bei der Korrelation zwischen Wurfzahl und Gewichtszunahme bis zur 6. Lebenswoche sowie zwischen Geburtsgewicht und Gewichtszunahme bis zur 12. Lebenswoche. Der Gewichtsunterschied im Lebensalter von 3, 6 und 12 Wochen bei den Kaninchen der 6-er und 10-er Würfe lag in der angegebenen Reihenfolge bei 129, 272 und 298 g, bei den Kaninchen der Geburtsgewichtsklassen 40-49 g und 60-69 g in der gleichen Reihenfolge bei 80, 253 und 451 g.