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EFFECT OF BIRTH WEIGHT AND LITTER SIZE AT SUCKLING AGE ON REPRODUCTIVE PERFORMANCE IN DOES AS ADULTS

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ABSTRACT : A total of 121 Pannon White female rabbits born with low (39-43 g) or high (63-70 g) weight were raised in litters of 6 or 10 kits. Their reproductive performance (AI practiced 9-11 days after kindling) was controlled for 6 consecutive litters for a total of 300 kindlings. The does' birth weight had a significant effect on the number of inseminations necessary for the first kindling: the higher the birth weight of does, the lower their kindling rate. Later on, however, birth weight no longer affected the conception rate. With higher birth weight, significantly improved doe performance could be expected. Litter size at birth was 12.4% higher (9.52 *vs* 8.34; P≤0.01), litter size at 21 days was 9.4% higher (7.64 *vs* 6.92; P≤0.01) and litter weight at 21 days was 5.9 % greater (2.73 *vs* 2.57 kg; P≤0.05) when the doe was born with greater weight. Total litter loss was 21.0% and 8.2% (P≤0.01) for the high and low birth weight does, respectively. The size of the litters in which the does had been reared (6 or 10) did not influence their performance.

RÉSUMÉ : Effets de leur poids à la naissance et de la taille de la portée pendant leur allaitement sur les performances de reproduction des lapines à l'âge adulte.
Un total de 121 lapines Pannon White, de faible (39-43 g) ou fort (63-70 g) poids à la naissance ont été élevés dans des portées de 6 ou 10 lapereaux. Leurs performances ont été suivies (IA pratiquée 9-11 jours après chaque mise bas) pendant 6 portées consécutives, soit 300 mises bas au total. Le poids à la naissance des lapines a un effet significatif sur le nombre d'inséminations nécessaires pour obtenir la première mise bas : plus il est élevé plus le taux de mise bas est faible. Par la suite, le poids à la naissance n'affecte plus le taux de fécondité. Quand le poids à la naissance est élevé des performances dec reproduction plus élevées sont observées. Ainsi, la taille des portées à la naissance a été supérieure de 12,4% (9,52 *vs* 8,34 ; P≤0,01), la tailles des portées à 21 jours a été supérieure de 9,4% (7.64 *vs* 6.92; P≤0.01) et le poids de la portée à 21 jours a été de 5,9% supérieur (2.73 *vs* 2.57 kg; P≤0.05) lorsque les lapines avaient un poids élevé à la naissance. Les pertes totales de portées ont été de 21,0% et 8,2% pour les deux groupes, respectivement. La taille de la portée dans laquelle la mère est élevée (6 ou 10) n'influence pas ses performances.

INTRODUCTION

In multiparous species, individual birth weight decreases with increase in litter size. During the suckling period the young of larger litters have to share the milk of the mother with a larger number of siblings, which has a disadvantageous effect on their weight gains (KROGMEIER and DZAPO, 1991; MOURA *et al.*, 1991; POLASTRE *et al.*, 1992).

FALCONER (1960) observed that female mice that had been reared in large litters produced smaller litters than those which had been reared in small litters. A substantial difference has also been observed in pigs between the prolificacy of the female offspring of sows showing the strongest and the weakest prolificacy. The progeny of those producing fewer offspring have the advantage (VAN DER STEEN, 1985; HORN *et al.*, 1987). In rabbits, BABILE and MATHERON (1980), SZENDRÖ *et al.* (1989) and BIRÓ-NÉMETH and SZENDRÖ (1990) found that increasing the size of the litter in which does were reared had a negative effect on their reproductive performance; i.e. the larger the litter in which were does reared, the lower their subsequent prolificacy. However, in some cases birth and rearing in an extremely large litter has proven not to be disadvantageous (SZENDRÖ *et al.*, 1989; BIRÓ-NÉMETH and SZENDRÖ, 1990).

In larger litters, weight at birth and at weaning is generally lower than the corresponding weights for the young of smaller litters. Thus, experiments previously performed have failed to show clearly whether the effect of different litter size is a prenatal or postnatal maternal effect, or both. It was for this reason that in the present study pre-natal effects and effects present during the suckling period were evaluated separately. This involved investigations to determine to what extent the birth weight of does and the size of the litter in which they were reared influenced their subsequent reproductive performance.

MATERIAL AND METHODS

These experiments, involving Pannon White rabbits, were performed at the experimental rabbit breeding site of the Pannon Agricultural university from January 1996 to November 1998. The rabbits were kept in a heated, closed building, in flat-deck spot-welded wire-net cages. During winter the minimum indoor temperature was 14-15 °C. Lighting was provided partly by natural light through the windows, and partly by fluorescent lighting. The minimum daily light period was 16 hours. Ventilation in the form of warm air being blown in was applied in winter. In the other seasons natural ventilation was allowed through the

windows. The rabbits were fed *ad libitum* with commercially available pellets (digestible energy 10,3 MJ/kg, crude protein 16%, crude fibre 15,5%, crude fat 2,5%), and water was available to the animals from weight-valve self-drinkers.

Rabbit does with one to six pregnancies were used. Parturition was induced with 1 IU/kg body weight oxcytocin in the early morning on day 31 of pregnancy. The new-born rabbits were removed from the mothers before the first suckling, for individual weighing and marking. Litters with 6 and 10 rabbits were formed, each litter contained rabbits only with low (39-43 g) or only with high (63-70 g) birth weight. The rearing of rabbits in litters standardised for birth weight was necessary to eliminate the effect of unbalanced suckling by rabbits with different weights.

The does used for nursing had two to five previous pregnancies. To keep the effect of litter size constant, any young that died were replaced with suckling rabbits from extra litters kept alongside the experimental ones. After weaning at five weeks, the young rabbits were kept in mixed sex groups with six rabbits per cage. At 12 weeks the females were housed individually.

The does were first inseminated artificially after the age of 16 weeks, at a minimum weight of 3.8 kg, and again 9-11 days after parturition. Ovulation was induced with 1.5 μg GnRH analogue (D-Phe 6-GnRH; Ovurelin injectable., Reanal). Fresh, diluted semen from individual bucks was used for insemination.

When a doe produced more than 10 offspring in a litter, some kits were allocated on the day after kindling to does in the same group to ensure that each doe suckled no more than ten progeny.

The study continued up to the sixth parturition. In total 300 parturitions by 90 does were evaluated. The number of inseminations per litter, the weight of the does at parturition, litter size (total, live, stillborn, number at 21 days), litter weight at 21 days, and total litter loss and mortality among the suckling rabbits from birth to 21 days were recorded. Two replicates were used in the experiment. The first parturition in the first replicate occurred in autumn, in the second replicate, in Spring.

The effect of birth weight and litter size was analysed by means of multifactorial variance analysis (incorporating weight and parity of the does, litter size and litter weight). The fixed model for variance analysis was:

$$Y_{ijklm} = \mu + Bw_i + Ls_j + (Bw * Ls)_{ij} + P_k + I_l + e_{ijklm}$$

where:

Y_{ijklm} = observed individual
μ = overall mean
Bw_i = effect of birth weight (small, large)
Ls_j = effect of litter size (6, 10)
$(Bw * Ls)_{ij}$ = interaction of birth weight and litter size
P_k = effect of parity (1st, and subsequently, 2nd-6th)
I_l = effect of replication (1st, 2nd)
e_{ijklm} = random error

Table 1 : The proportion of does producing litters from the age of 16 weeks to the sixth parturition, according to their birth weight and the size of the litter in which they were reared

Age/parturition	Birth weight (g)		Litter size		Total
	low	High	6	10	
16 weeks (100%)*	50	71	60	61	121
1st insemination	82.0	88.7	83.3	88.5	86.6
1st parturition	78.0	71.8	70.0	78.7	74.3
2nd parturition	58.0	57.7	56.7	59.0	57.9
3rd parturition	44.0	39.4	41.7	41.0	41.3
4th parturition	38.0	31.0	31.7	36.1	33.9
5th parturition	30.0	19.7	20.0	27.9	24.0
6th parturition	22.0	15.5	13.3	23.0	18.2

* 100 % = total number of rabbits at the age of 16 weeks

Conception rate and mortality in the suckling rabbits were compared among the experimental groups with χ^2 analysis. Statistical analysis of the experimental data was performed by least square means using the STATGRAPHICS programme, version 5.0.

RESULTS AND DISCUSSION

Based on weight, physical condition and state of health, 86.6% of the 16-week-old rabbits were assessed as suitable for inclusion in the breeding trials (Table 1). Neither birth weight nor litter size during the suckling period exerted any influence on the proportion of young rabbits meeting the requirements for breeding. Lifetime performance was not influenced negatively by lower birth weight or by rearing in a larger litter, as the highest proportion of does producing at least six litters (22 and 23 %) was recorded among those of lower birth weight or originating from litters of 10 (Table 1).

Body weight and age of does at first parturition

Body weight of the does at 16 weeks of age was influenced significantly by birth weight and litter size. Rabbits reared in litters of 6 were 0.24 kg heavier than those from litters of 10, and the difference between rabbits of lower and higher birth weight was 0.28 kg ($P<.01$) (Table 2). Rabbits born with high body weight and reared in small litters (6 littermates) were the heaviest at 16 weeks of age (Figure 1). After the first

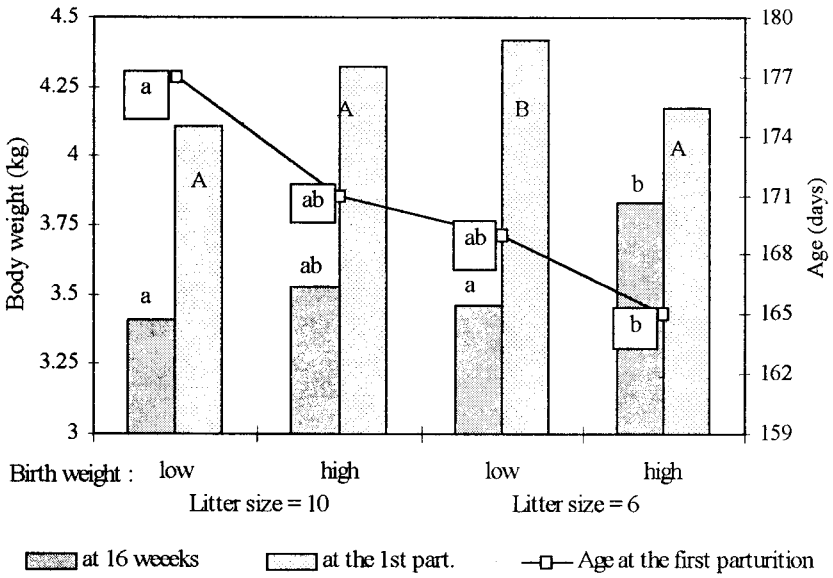

Figure 1 : The effect of birth weight and the size of the litter in which the does were reared on their body weight at 16 weeks and first parturition,

parturition the body weights of does were not influenced by birth weight and litter size.

BABILÉ and MATHERON (1980) and TUDELA *et al.* (1998) observed that the size of the litter in which the does were born and suckled had an influence on their weight at maturity (particularly at the first parturition). The difference between those studies and the present one might be because those authors introduced the does into the breeding programme at a certain age, while in this study does were not inseminated until they also reached a certain weight. Does weighing less than 3.8 kg at the time of the first insemination were only later incorporated into the experiment, on condition that they then met the requirements for breeding. These results and other data in the literature draw attention to the fact that in some cases different conclusions may be reached depending on whether it is the age of does or their weight which determines at what point they will be bred for the first time.

The age of the does at first parturition, which ranged from of 143 to 253 days, was not influenced by birth weight and litter size. Does of higher birth weight reared in litters of 6 produced their first litter on average 12 days earlier than does of lower birth weight and from larger litters (P<0.05) (Figure 1).

Number of inseminations required per parturition

The overall mean number of inseminations required per parturition was 1.50 (Table 3). It was found that 1.32 inseminations were required for the first parturition; for the 2nd to the 6th parturitions an average of 1.59 inseminations was required.

The *birth weight* of the does exerted significant influence on kindling rate at the first insemination (Table 3.) With higher birth weight, the number of inseminations required per parturition was higher. Does of lower birth weight needed 1.15 inseminations for the first parturition; those of higher birth weight, 1.45 inseminations . The size of the litter in which the does were reared did not influence kindling rate.

Considering the combined effect of birth weight and suckling litter size (Figure 2) it is evident that at the first parturition does of higher birth weight derived from smaller litters had the lowest kindling rate (65.8%), while does of lower birth weight from larger litters had the highest kindling rate (92.6%).

Table 2 : The effect of birth weight and the size of the litter in which the does were reared on their body weight and on age at first parturition (Least squares means)

Trait	Birth weight (g)			Litter size			Bw × Ls	Overall mean	SE
	low	high	P	6	10	P	P		
No. of does	39	51		42	48			90	
No. of litters	139	161		133	167			300	
Body weight (kg)									
at 16 weeks	3.42a	3.70b	**	3.70a	3.46b	*	*	3.572	0.048
at 1st parturition	4.21	4.24	NS	4.25	4.21	NS	*	4.227	0.043
at 2nd -6th parturition	4.65	4.65	NS	4.67	4.64	NS	NS	4.652	0.029
at 1st -6th parturition	4.53	4.53	NS	4.56	4.52	NS	NS	4.533	0.027
Age at the first parturition (days)	174	168	NS	166	174	NS	*	170.4	1.96

* P≤0,05; ** P≤0,01 (Bw x Ls: combined effect of birth weight and litter size)

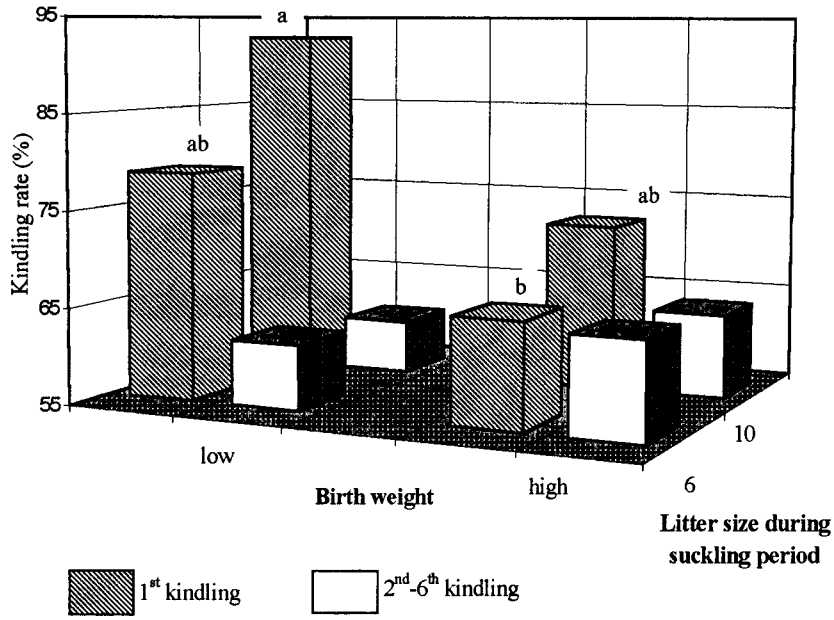

Figure 2 : The effect of birth weight and the size of the litter in which the does were reared on the kindling rate (a, b: P<0.05)

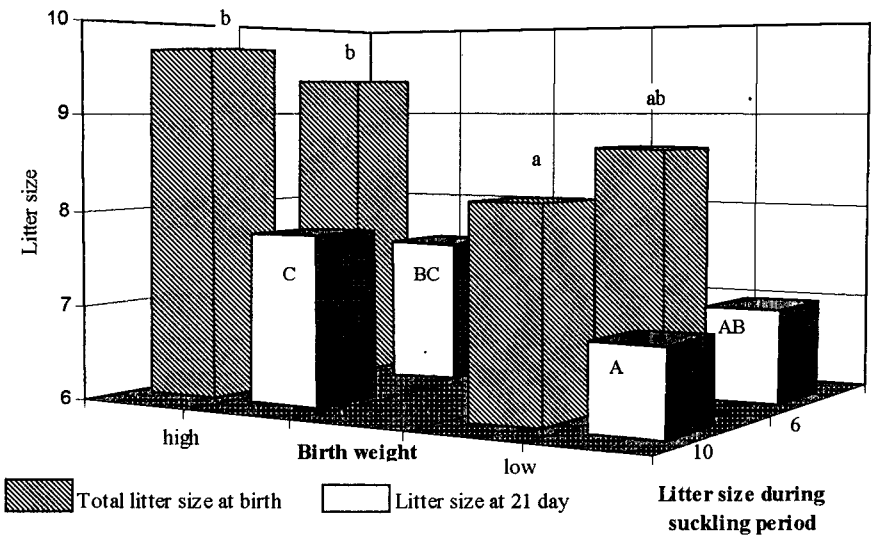

Figure 3. The effect of birth weight and the size of the litter in which the does were reared on the size of the litters produced (at a given age, columns bearing differing letters differ at P<0.05)

Does born with lower weight and reared in large litters produced their first litter on average 12 days earlier than does of lower birth weight and from larger litters (P<0.05) (Figure 1). This may lead to a more favourable attainment of breeding maturity as suggested by EIBEN *et al.* (1998).

Does inseminated at similar body weights but with more advanced ages had a better kindling rate, than the does, which reached the certain weight earlier. The intensive rabbit meat breeds are in this age susceptible to fat, which may negatively influence conception rate (EIBEN *et al.*, 1998).

After the first parturition neither birth weight nor litter size during suckling exerted an influence on the number of inseminations required per parturition (Table 3, Figure 2).

Litter size

With increase in does birth weight, litter size at birth and at 21 days increased significantly (Table 4 and Figure 3). Litter size at parturition (total) was 8.34 for the does of lower birth weight, whereas does with higher birth weights had 9.52 kits (P<0.01). The difference between the two groups with respect to the number of young born alive was 9% (7.38 and 8.07; NS). The difference in litter size at 21 days was 9.4% (6.92 and 7.64 respectively; P<0.001). The litter size at 21 days from does born with high weight, larger than that from those born with a low weight, was – beside the effect of milk production of does – a consequence of a greater litter size at birth and of a lower mortality between birth and 21 days.

HÖRÜGEL *et al.* (1991) with pigs reported that sows of higher birth weight produced larger litters at the first parturition than sows with lower birth weight.

In case of rearing in large litters, birth weight had a very important effect : does of high birth weight produced 1.51 (+16%) more offspring at kindling; and +0.88 kits (+11%) at 21 days than the does of low birth weight reared also in large litters. The

Table 3. The effect of birth weight and the size of the litter in which the does were reared on the number of inseminations per parturition (Least squares means)

Inseminations per parturition	Birth weight (g)			Litter size			Bw × Ls	Overall mean	SE
	39-43	63-70	P	6	10	P	P		
1st parurition	1.15 a	1.45 b	*	1.43	1.37	NS	*	1.32	0.070
2nd-6th parurition	1.64	1..56	NS	1.57	1.48	NS	NS	1.59	0.067
1st -6th parurition	1.45	1.5.3	NS	1.53	1.42	NS	NS	1.50	0.054

* P≤0.05 (Bw × Ls: combined effect of birth weight and litter size)

corresponding figures were +0.73 and +0.54 kits per litter when the does were reared in small litters (Figure 3).

The lower birth weight is a result, in part, of the large number of foetuses in the uterus (LEBAS, 1982; SZENDRŐ, 1986; HALEY and LEE, 1992; PÁLOS *et al.*, 1996), in part of unfavourable sites within the uterine horn (LEBAS, 1982; PÁLOS *et al.*, 1996); and in part of the effect of parity (BASELGA *et al.*, 1992; ARGENTE *et al.*, 1996; HAMILTON *et al.*, 1997). In the present experiment, does born with lower body weights were also born in significantly larger litters (11.2 kits) than does born with higher body weight (8.8 kits) (P<0.05).

On the contrary, does reared in small and large litters were born in litters with similar number of kits (10.2 *vs* 10.1). This was a consequence of the random grouping. The direct genetic effect compared with the effect of birth weight on the litter size showed in this experiment, that the rabbits born with higher weight – in spite of the fact, that they originated from smaller litters – produced larger litters, and nursed more kits at 21 days than does from larger litters and born with lower weights.

The size of the litter in which the does were reared had no average effect either on the number of progeny produced per litter (total or live) or on 21-day litter size (Table 4).

In experiments with multiparous species (mouse: FALCONER (1955, 1960), NELSON and ROBINSON (1976); pig: VAN DER STEEN (1985), HORN *et al.* (1987); rabbit: BABILÉ and MATHERON (1980), SZENDRŐ *et al.* (1989), BIRÓ-NÉMETH and SZENDRŐ, (1990)) it was demonstrated that females that were suckled in smaller litters showed better reproductive performance than females suckled in larger litters. However, in these experiments the young reared in the large litters have most probably also a smaller birth weight, so they were at a disadvantage from pregnancy until weaning. The difference in production between the experimental groups was the combined effect of the two factors. Thus, the results obtained indicate that even at the foetal stage females are subject to certain effects which bear influence on their reproductive performance as adults. The effects of the birth weight of the does and the size of the litter in which they were reared on the first and on subsequent parturitions (2-6) were compared. At the first parturition litter size was 18 % smaller than for later litters, but at both age groups the same trends could be observed. Does of higher birth weight produced and suckled larger litters and in no case did the size of the litter in which does were reared

Table 4. The effect of birth weight and the size of the litter in which the does were reared on the size of the litters produced (Least squares means)

Litter size	Birth weight (g)			Litter size			Bw × Ls	Overall mean	SE
	Low	high	P	6	10	P	P		
Total	8.34a	9.52b	**	9.12	8.90	NS	*	9.03	0.181
Alive	7.38	8.07	NS	7.75	7.79	NS	NS	7.83	0.210
Stillborn	0.96	1.45	NS	1.37	1.11	NS	NS	1.20	0.139
At 21 days	6.92a	7.64b	***	7.34	7.29	NS	**	7.32	0.112

* P≤0.05; ** P≤0.01***; P≤0.001 (Bw × Ls : combined effect of birth weight and litter size)

Table 5 : The effect of birth weight and the size of the litter in which the does were reared on mortality and total litter loss of suckling rabbits (1-21 days)

(%)	Birth weight (g)			Litter size			Bw × Ls	Overall mean
	Low	high	P	6	10	P	P	
Mortality during suckling	14,0	11,5	NS	13,9	11,5	NS	*	12,3
Total litter loss	8,2 a	21,0 b	***	15,8	8,7	NS	*	11,7

* P≤0,05; *** P≤0,001 (Bw × Ls: combined effect of birth weight and litter size)

Table 6. The effect of birth weight and the size of the litter in which the does were reared on litter weight and individual weight at 21 days of age (Least squares means)

Weight at 21 days of age	Birth weight (g)			Litter size			Bw × Ls	Overall mean	SE
	low	high	*P*	6	10	*P*	*P*		
Litter (kg)	2.57a	2.73b	*	2.68	2.64	*NS*	*NS*	2.65	0.045
Individual (g)	383a	361b	*	371	371	*NS*	*	371	5.350

* P≤0.05; (Bw × Ls: combined effect of birth weight and litter size)

Mortality among suckling progeny

Overall, 12.3% of the young rabbits died between birth and 21 days (Table 5). Neither birth weight nor litter size alone had an influence on mortality rate.

Does of low birth weight that were suckled in smaller litters had the highest mortality rate in this period (16.5%). The lowest mortality (10.3%) was seen with the does of high birth weight that were suckled in larger litters (P<0.05).

Mean frequency of total litter death in this study (i.e., entire litter stillborn, or no progeny reaching the age of 21 days) was 11.7%. Birth weight of the doe had an important effect (P<0.01) on total litter death (Table 5). The does with higher birth weight had a total litter death rate nearly three times (21%) that of does with lower birth weight (8.4%) (P<0.01). The same tendency was observed for does reared in both large and small litters. The overwhelming majority of totally stillborn litters occurred at the first parturition. The size of the litter in which does were reared had no significant effect on total litter death (Table 5).

Litter weight and individual weight at 21 days of age

Birth weight of the does had a significant effect on litter weight and individual weight of their progeny at 21 days (Table 6). The weights of litters issued of does born with higher weight were 6% (0.16 kg) higher than those issued of does born with lower weight (P<0.05).

The does birth weight influenced the individual weight of suckling rabbits (P<0.05): in the larger litters (7.64) of the does born with higher weight the individual weight of the suckling rabbits was with 5.7% lower than in the smaller litters (6.92) of the does born with lower weight. However, this did not constitute a direct relation, but indirect connection via birth weight and litter size. This verifies that, whatever the ratio by which litter size increased with respect to the difference between the does of low birth weight and those of high birth weight, individual weight decreased to a similar degree.

The size of the litter in which the does were reared did not influence litter weight and individual weight at 21 days of age (Table 6).

CONCLUSIONS

On the basis of these results, it can be established that among the pre- and postnatal effects, generally dealt with collectively in the literature, the influence of birth weight bears far greater significance than litter size with respect to the reproductive performance of does.

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