CHARACTERIZATION OF LITTER MORTALITY IN STRAIGHTBRED NEW ZEALAND WHITE RABBITS

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ABSTRACT

Eight hundred sixty six kits of 104 New Zealand White litters were studied for the rate of stillbirth, within litter mortality (M) between birth and day 21 of age (M0-21) where kits rely solely on milk, day 22 to weaning (M22-28) and postweaning to marketing (M29–70). Overall least squares means were 6.96% (stillbirth), 10.62% (M0-21), 0.55% (M22-28) and 3.08% (M29-70). In 30.77% of litters, all kits survived to marketing. Dead kits at birth and those died within the first week of age had significantly (P<0.01 and P<0.05, respectively) lower body weight (bwt) than their surviving littermates. M0-21 was higher (14.97 vs 6.27%, P<0.01) in litters of low mean kit birth weight (≤ 60 vs > 60g). Kit survival pre- (M0-21) and postweaning (M29-70) was better when their does gained > 250 g bwt during the first three weeks post-kindling compared to dams losing bwt or gaining < 250 g. The rate of stillbirth increased (P = 0.06) with longer gestation periods. M0-21 was higher (14.39 vs 6.86%, P< 0.05) in large litters (≥ 9 alive kits vs < 9 kits). Summer and spring born litters experienced higher (P<0.05) M0-21 (14.98 and 14.27%) than autumn (7.42%) and winter (5.81%) born ones. Parity affected only stillbirth (P<0.05) with litters of the 1st, 2nd and ≥ 3rd orders lost 5.83, 4.98 and 10.07% of

their kits at birth, respectively. Repeatability estimates were generally low (0.00 to 0.07) except for a moderate value of 0.31 for M0-21. It could be concluded that stillbirth and M0-21 are the major components of kit losses. Small kit size, dam bwt loss or low bwt gain during the first three weeks postnatal, large litters, summer and spring kindlings, and 3rd or higher kindling orders reduced kit survival, particularly at birth and during the first three weeks of age.

Keywords: Rabbits, mortality, kit weight, doe body weight, litter size, season, parity, gestation length

INTRODUCTION

The productivity of rabbits depends principally on the number of young reaching the market and their growth rate. Chiefly because of its high prolificacy (large litter size), a rabbit doe can produce up to 80 kg of meat per year, which is equivalent to 2900 to 3000% of its body weight per year *(FAO, 2001)*. Therefore, maintaining high economic efficiency in commercial rabbit production necessitates high kit survival.

Stillbirth is common and its rate is high in rabbits *(Garreau et al., 2008; Guillĕn et al., 2008)*, and the early postnatal days are critical to survival of kits *(Belhadi, 2004; Rödel et al., 2008b)*. Within large rabbit litters, there is an intensive competition among littermates for dam's milk and thermally favorable positions in the litter huddle, and weak kits of low birth weight are more likely to die because of starvation *(Drummond et al., 2000; Bautista et al., 2005; Bautista et al., 2008)*. In addition to the size of the nursing litter, kit body mass, litter homogeneity, and doe body mass and its physiological condition could affect its caring ability and subsequently kit survival *(Seitz et al., 1998;*

Elmaghraby et al., 2004; Zerrouki et al., 2005; Bonanno et al., 2008; Garreau et al., 2008; Rödel et al., 2008b). Also, seasonal differences in kit losses have been recorded *(Bhatt et al., 2002; Marai et al., 2002; Belhadi, 2004).*

The objective of the present study was to describe the pattern of within litter rabbit mortality at birth, preweaning and postweaning in a population of purebred New Zealand White rabbits in relation to some potential influential factors.

*Abbreviations***:** *M0-21, mortality between birth and day 21 of age; **M22-28**, mortality between days 22 and 28 of age; **M29-70**; mortality postweaning to marketing; **bwt**, body weight.*

MATERIALS AND METHODS

Rabbits of the present study were purebreds of the New Zealand White breed. They were raised in El–Tamboli rabbit farm, a large producer of meat rabbits. The farm is located in El–Obour city, Cairo–Ismailia road. Females were mated for the first time at 4 − 6 months of age. After kindling, remating occurred after 10 days, and pregnancy was diagnosed via abdominal palpation 12 − 14 days post-mating. After three weeks of nursing, kits were allowed a complete pelleted ration composed of (in kg) hay 320, wheat bran 200, soybean meal 120, corn 120, barely 200, molasses 20, sodium chloride 5, limestone 8, sodium bicarbonate 5 and mineral mixture 2. Breeding bucks and non–lactating does were given about 150 g of the same ration daily, whereas weaned kits and lactating does were fed *ad libitum*. After 28 days, kits were weaned, sexed, ear-tagged, and weighed individually.

Traits and statistical analyses:

866 kits of 104 litters of purebred New Zealand White rabbits were investigated for within litter mortality (M). Mortality was recorded at birth (stillborn), within the first three weeks (M0-21), 22nd day to weaning (M22-28), and postweaning to marketing (M29-70). The least squares statistical model for M0-21, M22-28 and M29-70 included the fixed effects of mean kit birth weight of the litter, litter size born alive, kindling season, kindling order, and doe body weight difference between birth and day 21 of kindling.

$$Y_{ijklm} = \mu + KBW_i + D_j + LSB_k + S_l + K_m + e_{ijkl}, \text{ where}$$

Y_{ijklm} observed value of a given dependent variable

μ overall mean

KBW_i fixed effect of ith mean kit birth weight of the litter (Low, litters with mean kit birth weight ≤ 60 g; High, litters with mean kit birth weight ≥ 61)

D_j fixed effect of jth doe body weight difference between birth and day 21 post-kindling (Losing weight, gaining < 250 g, and gaining ≥ 250 g)

LSB_k fixed effect of kth litter size born alive (Small, < 9; large, ≥ 9 kits)

S_l fixed effect of lth kindling season (autumn, September to November; winter, December to February; spring, March to May; summer, June to August)

K_m fixed effect of mth kindling order (1st, 2nd and $\geq 3^{rd}$)

e_{ijklm} the random error.

For stillbirth, the same previous model was used except for the following modifications: total litter size at birth (alive and dead) was used and classified as small (< 10 kits) and large (≥ 10 kits), and doe body weight at kindling (Light does < 4.5 kg, and Heavy does ≥ 4.5 kg) in addition to gestation length in days as a covariate. In both models most two-way interactions were non-significant, and therefore removed from the final analyses. Separate simple linear regression of stillbirth on gestation length was performed.

Within the same litter, body weight of dead and survivor kits at birth and within the first week were compared using the t-test. All analyses were performed using the Statistical Analysis System *(SAS, 2002)*. Means were separated using the least squares means of the same program. Results from arcsine transformed and non-transformed data did not differ, therefore the normal scale was used.

Repeatability was estimated as $(\sigma^2_S + \sigma^2_D)/(\sigma^2_S + \sigma^2_D + \sigma^2_E)$ where σ^2_S, σ^2_D, and σ^2_E are sire, doe within sire and remainder variance components, respectively. Approximate standard errors were computed using the LSMLMW software of *Harvey (1990)*.

RESULTS AND DISCUSSION

Table (1) provides statistical description of the rabbit litters under investigation. Overall, kit mortality occurred in 72 (69.23%) of litters up to marketing. *Rödel et al. (2008b)* recorded deaths in 42.7% of litters during the nest period of European rabbits living in a field enclosure. Birth through the first three weeks post-kindling, where the kits relay solely on their mother's milk, is a critical period to litter survival (6.96% stillbirth; 10.62% M0-21). *Farghaly (1996)* reported a total preweaning mortality of 21% largely due to stillbirth followed by M0-20 and M21-30. Higher rates (13.9 and 15.9%) of stillbirth were previously recorded by *Leone-Singer* and *Hoop(2003)*and *Guillén et al.(2008)*,respectively.

Table (1): Descriptive statistics of New Zealand White litters under investigation.

Variable	Minimum	Maximum	Arithmetic Mean	STD
Litter size (number)				
Total born	1	13	8.33	2.50
Born alive	1	13	7.84	2.70
Born dead	0	6	0.49	0.99
Day 21 post–kindling	1	11	6.81	2.31
Day 28 (weaning)	1	11	6.76	2.30
Day 70 (marketing)	0	11	6.53	2.38
Within litter mortality (%)				
Stillbirth	0	66.67	6.68 (6.96)*	12.66
Preweaning				
Birth to day 21	0	69.23	11.20 (10.62)*	16.67
Days 22 to 28	0	25.00	0.58 (0.55)*	3.17
Postweaning (Days 29–70)	0	80.00	3.14 (3.08)*	9.32
Litters with all kits surviving to marketing	Number = 32 (30.77% of 104 litters)			

Number of litters = 104.

STD = Standard deviation.

* Values between parentheses are overall least squares means.

Kit body weight:

Effect of mean kit birth weight on within litter mortality is illustrated in Figure (1). Litters with high mean kit birth weight (> 60 g) had significantly higher (P< 0.01) preweaning survival (M0-21 = 6.27%) compared to litters with low mean kit birth weight (14.97%). Moreover, bwt of dead and surviving kits of the same litter differed significantly at birth (51.7 vs 65.0 g, P< 0.01; Figure 2) and within the first week post-kindling (77.8 vs 98.5 g, P< 0.05; Figure 2), which implies that death within a litter was confined mostly to smaller, and eventually weaker, kits.

The importance of bwt during the early postnatal period for kit survival has been previously reported. ***Seitz et al. (1998)*** found kit losses to decrease with the increase of birth weight (77% for kit birth weight < 30 g to only 9.9% for birth weight > 71 g). Also, ***Bautista et al. (2008)*** reported that dead kits averaged 10 g less at birth, weighed 29.2% less within the first 5 days postnatal, and had no milk in their stomachs compared to the survivors. Heavier kits compete more effectively for mother's milk and favorable thermal positions in the litter huddle, grow faster and are better able to maintain body equilibrium than lighter kits ***(Drummond et al., 2000; Bautista et al., 2008; Muciño et al., 2008; Rödel et al., 2008a,b)***. Therefore, they are more likely to survive.
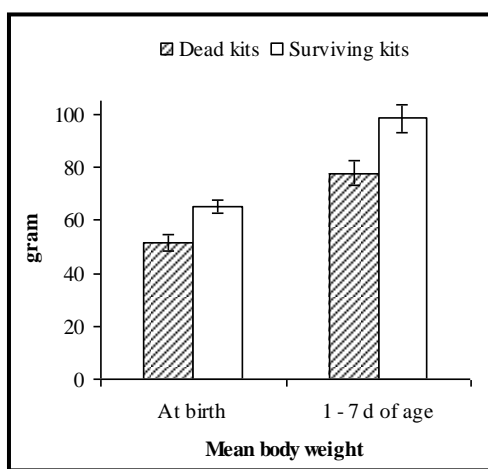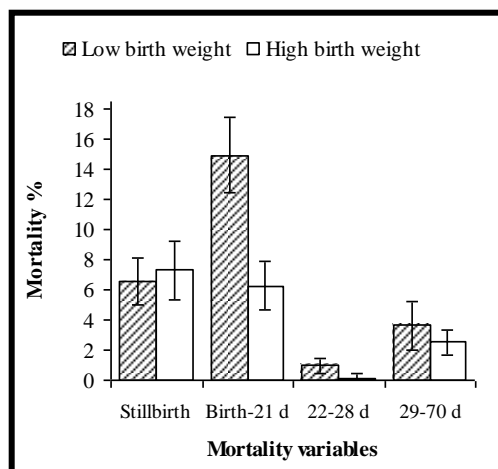

Fig.(1): Effect of mean kit birth weight on within litter mortality

Low (litters with mean kit birth weight ≤ 60 g, n = 54 litters), High (litters with mean kit birth weight ≥ 61, n = 50 litters).

Values are least squares means and their standard errors.

Differences in within litter mortality from Birth–21 d, were significant (P< 0.01), other variables did not differ (P> 0.05).

Fig.(2): Body weight of dead and surviving kits of the same litter at birth and within the first week post–kindling

Values are least squares means and their standard errors.

Differences were significant (P< 0.01 at birth, n = 32; P< 0.05 during the first week post–kindling, n = 31.)

Doe body weight:

Doe bwt at kindling had no effect on stillbirth (Table 2). Gaining more than 250 g in doe bwt during the first three weeks post-kindling was beneficial to the survival of their litters pre- and postweaning (P< 0.05, Table 2). Their M0-21 (6.12%) and M29-70 (0.74%) were 7.81 and 1.7% less than the respective mortalities of litters from does gaining less than 250 g bwt, as well, 5.69 and 5.32% less than the corresponding mortalities of litters produced by does losing bwt post-kindling. ***Bonanno et al. (2008)*** found that poor body condition of does was linked to higher mortality of nursed kits during 1-11 days postpartum (10.3, 2.2 and 4.5% for body condition scores 0, 1 and 2, respectively; P<0.001).

Table (2): Effect of doe body weight on stillbirth (%) and change in doe body weight between birth and day 21 post-kindling on within litter mortality variables (%).

	Light does (< 4.5 kg)	Heavy does (≥ 4.5 kg)	
Number of litters	49	55	
Stillbirth	7.56 ± 1.81	6.36 ± 1.80	NS

	Doe body weight difference between birth and day 21			
	Losing weight	Gaining < 250 g	Gaining ≥ 250 g	
Number of litters	31	47	26	
Preweaning mortality				
Birth to day 21	11.81 ± 2.14 ab	13.93 ± 2.98 a	6.12 ± 2.50 b	
Days 22 to 28	0.12 ± 0.02	0.77 ± 0.58	0.70 ± 0.64	NS
Postweaning mortality (Days 29–70)	6.06 ± 2.66 a	2.44 ± 0.78 ab	0.74 ± 0.66 b	

Values are least squares means ± standard errors.

Different letters in a row indicate significant difference (P< 0.05); NS = not significant (P> 0.05).

Effect of litter size at birth and gestation length:

Figure (3) demonstrates that large litters at birth ($\geq$ 9 alive kits) had significantly (P< 0.05) higher mortality than small litters (< 9 kits) between birth and day 21 (14.39 vs 6.86%). Stillbirth (8.54 vs 5.38%), M22-28 (0.91 vs 0.15%) and M29-70 (4.01 vs 2.15) were numerically, but not statistically (P> 0.05), higher in small litters.

The effect of gestation length (GL) on stillbirth approached significance in the analysis of covariance (P = 0.09) and simple linear regression (P = 0.06) indicating that longer gestation periods are associated with higher stillbirth. [Equation: Stillbirth (%) = $-$ 66.159 + 2.294 (GL in days)]. However, the small coefficient of determination (R^2 = 0.03) makes the predictability of the equation questionable.

In agreement with the current findings, *Depres et al. (1997)* and *Kpodekon et al. (2006)* recorded an increase in preweaning mortality with the increase in litter size. *Elmaghraby et al. (2004)* reported a positive correlation (r = 0.64, P< 0.01) between litter size and preweaning mortality in large litters (10-14 kits) compared to a correlation of only 0.20 (P> 0.05) in small litters (1-9 kits). For large litters, 9–13 kits in the current study, limited number of teats (8-10) in rabbit females *(Szendrö et al., 1992)*, and once-a-day nursing *(Gonzalez-Marsical, 2007)*, there would be an exhaustive competition among littermates for milk and well-insulated (thermally advantageous) positions in the litter cluster *(Bautista et al., 2005; Bautista et al., 2008)*. According to previous findings, milk available to individual kits decreases with the increase of litter size *(Ayyat and Marai, 1998; Zerrouki et al., 2005)*. Weak competitors might, therefore, suffer starvation and are more likely to die *(Farougou et al., 2006)*. Practically, reducing the size of the nursing litter through crossfostering to a maximum of nine kits per litter could reduce preweaning mortality from 20.24 to 8% *(Elmaghraby and Mahrous, 2007)*.

Fig. (3): Effect of litter size at birth on within litter mortality.

For stillbirth, total litter size at birth (alive and dead) was used and classified as small (< 10 kits, n = 51 litters) and large (≥ 10 kits, n = 53 litters). For other mortality traits, litter size born alive was used and classified as small (< 9, n = 53 litters) and large (≥ 9 kits, n = 51).

Values are least squares means and their standard errors.

Differences in within litter mortality from Birth–21 d mortality were significant (P< 0.05), other variables did not differ (P> 0.05).
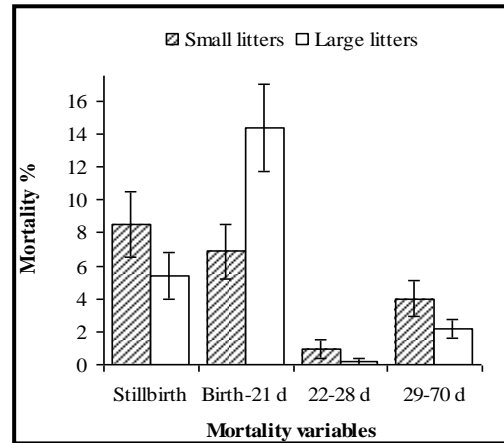
Effect of kindling season:

Kindling season influenced significantly M0-21 (Table 3). Litters born during summer and spring months suffered approximately twice M0-21 recorded for autumn born ones, and twofold and half of winter born litters (P< 0.05). Stillbirth rate was numerically (P> 0.05) the least during winter, which agrees with the finding of ***Belhadi (2004)*** on local Algerian rabbits. Previous studies also demonstrated seasonal variation in mortality parameters ***(Farghaly, 1996; Bhatt et al., 2002). Marai et al. (2002, 2004)*** mentioned that long daylight and summer heat stress of Egypt adversely affect performance of rabbits including kit survival pre- and post-weaning. High ambient temperature (above 26 C) reduces feed intake of lactating does by 25 to 50% leading to energy deficit and deterioration of doe body condition and productivity (a review by ***Fortun-Lamothe, 2006***).

Table (3): Effect of kindling season on within litter mortality variables (%).

	Kindling season				
	Autumn	**Winter**	**Spring**	**Summer**	
Number of litters	32	30	22	20	
Stillbirth	9.78 ± 2.87	4.78 ± 2.01	6.06 ± 2.50	7.20 ± 2.37	NS
Preweaning mortality					
Birth to day 21	7.42 ± 2.03 b	5.81 ± 1.73 b	14.27 ± 3.32 a	14.98 ± 3.19 a	
Days 22 to 28	0.45 ± 0.60	0.40 ± 0.71	0.82 ± 0.53	0.54 ± 0.65	NS
Postweaning mortality (Days 29–70)	4.47 ± 2.54	4.13 ± 1.32	1.16 ± 0.75	2.56 ± 1.03	NS

Values are least squares means ± standard errors.

Different letters in a row indicate significant difference (P< 0.05); NS = not significant (P> 0.05).

Kindling order:

Litters of the third and higher kindlings showed the highest stillbirth (10.07%, P< 0.05) compared to those of the first (5.83%) and second (4.98%) parities (Table 4). Other pre- and postweaning mortality variables did not vary (P> 0.05) with the parity order. ***Guillén et al. (2008)*** reported a similar trend for stillbirth, but they found significantly increasing M0-21 with the advance of parity. Does in the current study were remated 10 days after kindling. Except during the first pregnancy, most does were lactating and pregnant concurrently, and might therefore suffer energy deficit. Fetal growth and viability are affected by the energy status of the doe ***(Fortun-Lamothe et al., 1999; Fortun-Lamothe, 2006)***. ***Oguike and Okocha (2008)*** could reduce stillbirth from 3.67 to 0.00 and 0.33% by increasing the remating interval from 3 to 4 and 5 weeks, respectively.

Table (4): Effect of kindling order on within litter mortality variables (%)

	Kindling order			
	1st	**2nd**	**3rd or more**	
Number of litters	30	25	49	
Stillbirth	5.83 ± 1.65 b	3.98 ± 1.62 b	10.07 ± 2.90 a	
Preweaning mortality				
Birth to day 21	8.81 ± 2.69	12.32 ± 4.19	10.72 ± 2.21	NS
Days 22 to 28	0.53 ± 0.62	0.91 ± 0.73	0.21 ± 0.55	NS
Postweaning mortality (Days 29–70)	5.38 ± 2.77	2.12 ± 1.05	1.74 ± 0.78	NS

Values are least squares means ± standard errors.

Different letters in a row indicate significant difference (P< 0.05); NS = not significant (P> 0.05).

Repeatability estimates:

Estimates of repeatability of mortality variables are presented in Table (5). Stillbirth and postweaning mortality were lowly repeatable. But, M0-21 had moderate repeatability indicating that culling does with high first litter preweaning mortality would be effective in raising litter survival. ***Farghaly (1996)*** reported low repeatability estimates for stillbirth and preweaning mortality.

Table (5): Repeatability estimates of within litter mortality variables.

	Repeatability
Stillbirth	0.04 ± 0.07
Preweaning	
Birth to day 21	0.31 ± 0.19
Days 22 to 28	0.00*
Postweaning (Days 29–70)	0.07 ± 0.09

* Negative sire and dam variance components were set to zero

Conclusion and Applications:

It could be concluded that (1) Stillbirth and kit mortality during the first three weeks postnatal account for most (17.58 of 21.21%) of kit losses until marketing. (2) Small kit size, dam bwt loss or low weight gain during the first three weeks postnatal, large litters, summer and spring kindlings, and 3rd or higher kindling orders adversely affect kit survival, particularly at birth and during the first three weeks of age. Management adjustment e.g. crossfostering to reduce litter size and increase litter homogeneity, improving post-kindling doe energy balance via increasing remating interval to avoid concurrent lactation and pregnancy particularly during higher parities, reducing heat stress, and culling does with high first litter preweaning mortality would improve overall kit survival.

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توصيف النفوق فى خلفة أرانب النيوزيلاندى الأبيض النقية

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* **التربية و الإنتاج الحيوانى – كلية الطب البيطرى – إدفينا – جامعة الإسكندرية**

** **سلوكيات و رعاية الحيوان و الدوجن – كلية الطب البيطرى – البستان – جامعة الإسكندرية**

تم متابعة 866 من صغار أرانب النيوزيلاندى الأبيض النقية المولودة فى عدد 104 خلفة لدراسة معدلات النفوق داخل الخلفة عند الميلاد (المولود نافق)؛ بين الميلاد و عمر 21 يوم حيث تعتمد الصغار على لبن الأم كمصدر وحيد للتغذية؛ من عمر 22 إلى 28 يوم (الفطام) و بعد الفطام حتى التسويق (29 إلى 70 يوم). المتوسط العام لمعدل النفوق كان 6.96% (المولود نافق)؛ 10.62% (بين الميلاد و 21 يوم)؛ 0.55% (من 22 إلى 28 يوم) و 3.08% (من 29 إلى 70 يوم). لم يحدث أى نفوق فى 32 خلفة (30.77%) من الميلاد حتى التسويق.

الأرانب النافقة عن الميلاد و تلك التى نفقت فى الأسبوع الأول كان وزنها أقل معنوياً (إحتمال أقل من 0.01 و 0.05 على التوالى) عن قرينتها الأحياء داخل نفس الخلفة. معدل النفوق بين الميلاد و عمر 21 يوم كان أعلى (14.97% مقابل 6.27%؛ إحتمال أقل من 0.01) فى الخلفة ذات وزن ميلاد قليل (متوسط وزن ميلاد الأرنب 60 جرام أو أقل مقارنة بوزن أكبر من 60 جرام).

حيوية الصغار قبل الفطام (من الميلاد و 21 يوم) و بعده (29 إلى 70 يوم) كانت أفضل للخلفة التى ترعاها أمهات تكتسب أكثر من 250 جرام وزن فى الثلاثة أسابيع الأولى بعد الولادة مقارنة بالأمهات التى تفقد وزن أو التى تكتسب أقل من 250 جرام خلال نفس الفترة. معدل المولود نافق إزداد مع زيادة فترة الحمل.

النفوق بين الميلاد و 21 يوم من العمر كان أعلى معنوياً (14.39% مقابل 6.86%؛ إحتمال أقل من 0.05) فى الخلفة كبيرة العدد (9 أو أكثر من المواليد الأحياء مقارنة بأقل من 9). الخلفة المولودة فى فصول الصيف أو الربيع صاحبها معدلات نفوق أعلى (إحتمال أقل من 0.05) بين الميلاد و عمر 21 يوم (14.98% و 14.27% على التوالى) مقارنة بخلفة فصل الخريف (7.42%) و الشتاء (5.81%).

ترتيب الولادة أثر معنوياً (إحتمال أقل من 0.05) فقط على معدل المولود نافق و كانت معدلاته 5.83% فى الولادة الأولى و 4.98% فى الثانية و 10.07% فى الثالثة أو أكثر. كان المعامل التكرارى للنفوق ضعيفاً بشكل عام (صفر إلى 0.07) فيما عدا القيمة المتوسطة 0.31 للنفوق بين الولادة و عمر 21 يوم.

تبين من الدراسة أن المولود نافق و النفوق بين الميلاد و عمر 21 يوم تمثل المراحل الحرجة لنفوق الأرانب حتى عمر التسويق. أيضاً زادت معدلات النفوق (خاصة المولود نافق و بين الميلاد و عمر 21 يوم) فى الظروف الأتية: صغر حجم الأرنب المولود؛ الخلفة المصاحبة لأمهات تفقد وزن أو تكتسب وزن قليل فى الثلاثة اسابيع الأولى بعد الولادة؛ الخلفة ذات العدد الكبير؛ ولادات الصيف و الربيع و الولادة الثالثة أو أكثر.