CHARACTERIZING LITTER LOSSES IN PUREBRED 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 lower body weight (bwt) than their surviving littermates. M0-21 was higher in litters of low mean kit birth weight (≤ 60 vs > 60 g). 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 tended to increase (P = 0.06) with longer gestation periods. M0-21 was higher in large litters (alive kits ≥ 9 vs < 9 kits). Summer and spring born litters experienced significantly higher M0-21 than autumn and winter born ones. Stillbirth increased with parity (P< 0.05). Repeatability was 0.31 for M0-21 and low (0.00 to 0.07) for other traits. Conclusion: 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 reduce kit survival, particularly at birth and during the first three weeks of age.

Key words: Rabbits, litter mortality, environmental factors, repeatability

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 [9]. Therefore, maintaining high economic efficiency in commercial rabbit production necessitates high kit survival.

Stillbirth is common and its rate is high in rabbits [13], [15], and the early postnatal days are critical to survival of kits [3], [24]. 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 [1], [2], [6]. 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 [13], [24], [26], [28]. Also, seasonal differences in kit losses have been recorded [3], [19].

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 i^{th} mean kit birth weight of the litter (2 levels: Low, litters with mean kit birth weight ≤ 60 g; High, litters with mean kit birth weight ≥ 61)

D_j fixed effect of j^{th} doe body weight difference between birth and day 21 post-kindling (3 levels: Losing weight; gaining < 250 g; gaining ≥ 250 g)

LSB_k fixed effect of k^{th} litter size born alive (2 levels: Small, < 9; large, ≥ 9 kits)

S_l fixed effect of l^{th} kindling season (4 levels: autumn, September to November; winter, December to February; spring, March to May; summer, June to August)

K_m fixed effect of m^{th} kindling order (3 levels: 1st, 2nd; ≥ 3rd)

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 [25]. Means were separated with 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 [16].

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.* [24] 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). A total preweaning mortality of 21%, largely due to stillbirth followed by M0-20 and M21-30, was reported earlier [10]. Also, higher rates (15.9 and 13.9%) of stillbirth were previously recorded [15], [18].

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 (P< 0.01) higher 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.

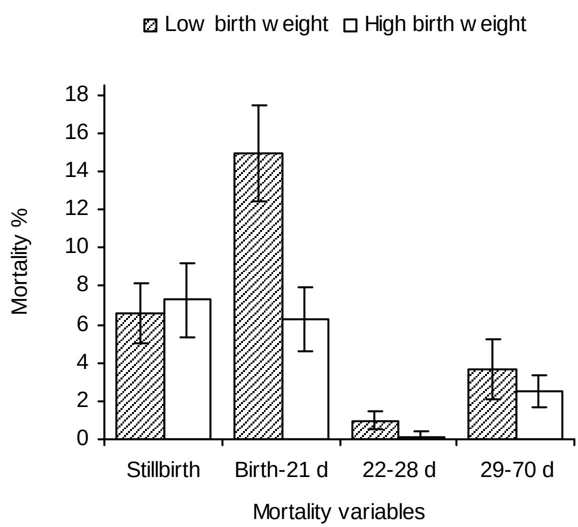

Figure 1 Effect of mean kit birth weight on within litter mortality
Low (litters with mean kit birth weight ≤ 60 g, n = 54 litters), High (litters with mean kit birth weight ≥ 61, n = 50 litters).
Values are least squares means and their standard errors.
Differences of within litter mortality from Birth–21 d, were significant (P< 0.01), other variables did not differ (P> 0.05).

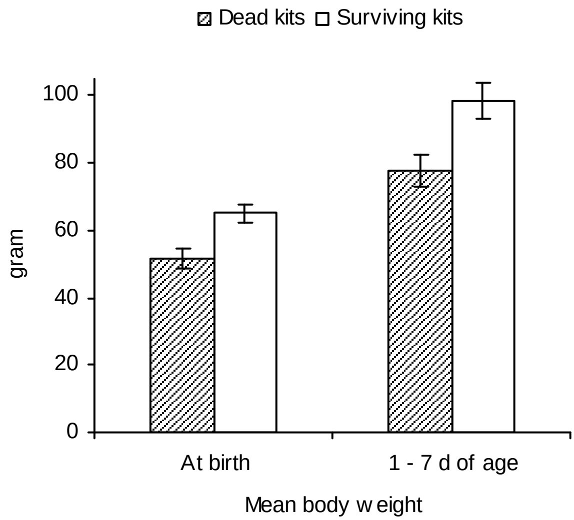

Figure 2 Body weight of dead and surviving kits of the same litter at birth and within the first week post–kindling
Values are least squares means and their standard errors.
Differences were significant (P< 0.01 at birth, n = 32; P< 0.05 during the first week post–kindling, n = 31.)

The importance of bwt during the early postnatal period for kit survival has been previously reported. Seitz *et al.* [26] 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.* [1] 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 [1], [6], [21], [23]. Therefore, they are more likely to survive.

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. Poor body condition of does is linked to higher mortality of nursed kits the first 11 days postpartum (10.3, 2.2 and 4.5% for body condition scores 0, 1 and 2, respectively) [5].

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^{a}	6.36 ± 1.80^{a}

	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^{a}	0.77 ± 0.58^{a}	0.70 ± 0.64^{a}
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.
[a,b,c] Within a row, least squares means without a common superscript letter differ, P< 0.05.

Effect of litter size at birth and gestation length

Figure (3) demonstrates that large litters at birth (≥ 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.

Similarly, high preweaning mortality in large litters has been recorded elsewhere [17]. Elmaghraby *et al.* [7] 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). In large litters, limited number of teats (8-10) in rabbit females [27], and once-a-day nursing [14] cause an exhaustive competition among littermates for milk and well-insulated (thermally advantageous) positions in the litter cluster [1], [2]. In addition, milk available to individual kits decreases with the increase of litter size [28]. Weak competitors might, therefore, suffer starvation and are more likely to die. 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% [8].

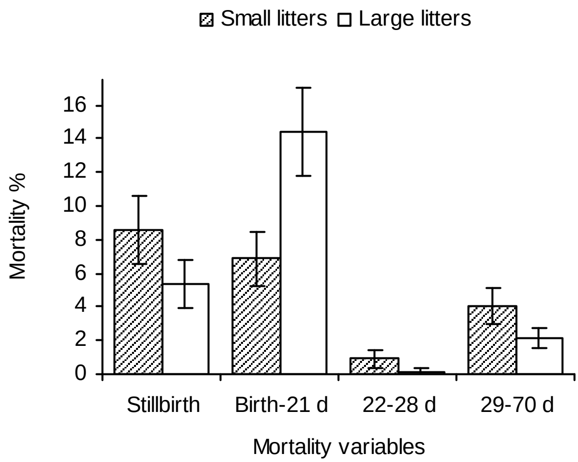

Fig. 3 Effect of litter size at birth on within litter mortality
For stillbirth, total litter size at birth (alive and dead) was used and classified as small (< 10 kits, n = 51 litters) and large (≥ 10 kits, n = 53 litters). For other mortality traits, litter size born alive was used and classified as 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 the 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 a finding on local Algerian rabbits [3]. Previous studies also demonstrated seasonal variation in mortality parameters [4], [10]. Long daylight and summer heat stress of Egypt adversely affect performance of rabbits including kit survival pre- and postweaning [19],[20]. 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 [11].

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[a]	4.78 ± 2.01[a]	6.06 ± 2.50[a]	7.20 ± 2.37[a]
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[a]	0.40 ± 0.71[a]	0.82 ± 0.53[a]	0.54 ± 0.65[a]
Postweaning mortality (Days 29–70)	4.47 ± 2.54[a]	4.13 ± 1.32[a]	1.16 ± 0.75[a]	2.56 ± 1.03[a]

Values are least squares means ± standard errors.
[a,b,c] Within a row, least squares means without a common superscript letter differ, P< 0.05.

Kindling order

Litters of the third and higher kindlings suffered the highest stillbirth (P< 0.05) compared to first and second parities (Table 4). Other pre- and postweaning mortality variables did not vary with the parity order. Guillén *et al.* [15] 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 for 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 [11], [12]. Stillbirth could be reduced from 3.67 to 0.00 and 0.33% by increasing the remating interval from 3 to 4 and 5 weeks, respectively [22].

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

	Kindling order		
	1[st]	2[nd]	3[rd] 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[a]	12.32 ± 4.19[a]	10.72 ± 2.21[a]
Days 22 to 28	0.53 ± 0.62[a]	0.91 ± 0.73[a]	0.21 ± 0.55[a]
Postweaning mortality (Days 29–70)	5.38 ± 2.77[a]	2.12 ± 1.05[a]	1.74 ± 0.78[a]

Values are least squares means ± standard errors.
[a,b,c] Within a row, least squares means without a common superscript letter differ, 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 dams with high first litter preweaning mortality would be effective in raising litter survival. Farghaly [10] 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

CONCLUSIONS

(1) Stillbirth and kit mortality during the first three weeks postnatal account for most 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 3[rd] 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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