

MORTALITY IN YOUNG RABBITS : A REVIEW

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ABSTRACT : Mortality rate of young rabbits is of vital importance in commercial rabbit farming, since it determines the net income of the rabbitries. However, there is no definite proportion for mortality in young rabbits, since it may be less than 10% in one situation in a given breed and reaches 100% in other situations, in the same breed. This may be due to susceptibility of the genotype to diseases and to the numerous uncontrollable external environmental factors. The significant differences between breeds confirm that mortality can be genetically improved. Within the same breed, kit mortality during the suckling period decreases during the period between 4 and 12 months of doe production, then increases thereafter as age advances up to certain parity. The increase of pre-weaning mortality associates the increase in litter size at birth and reduction of remating interval period, although doe

milk yield appeared to be the most important factor, in this respect. Thus, all factors which may decrease doe rabbit milk yield (nutrition, management of the rabbitry, climatic conditions and doe diseases), increase pre-weaning mortality. Improvement of nutrition (by using feed additives, antibiotics, probiotics, green fodder or natural sources) increases rabbit doe milk. Heat stress and diseases are the most important factors that affect post-weaning mortality. It is worthy to note that young rabbits loss may be avoided to a large extent and health and vigour in the stock can be maintained by applying simple methods for cleanliness and in management. Prevention of diseases is also very important, because curative treatment is less successful in rabbits than in many other livestock classes.

RÉSUMÉ : Mortalité chez les lapereaux : une revue

Le taux de mortalité des lapereaux revêt une importance vitale pour les élevages commerciaux, puisqu'il détermine le bénéfice net de ceux-ci. En outre, ce taux de mortalité n'est jamais définitif à l'intérieur d'un même élevage, pouvant varier de moins de 10 % dans un cas particulier avec une race donnée, à 100 % dans des circonstances différentes avec la même race. Ceci peut être dû à la fragilité de ce génotype vis à vis des maladies et de nombreux et incontrôlables facteurs extérieurs. Les différences significatives entre les races confirment que le taux de mortalité peut être génétiquement amélioré. Au sein d'une même race, la mortalité des lapereaux pendant l'allaitement diminue pendant la période de production de la mère comprise entre 4 et 12 mois, puis augmente au fur et à mesure du vieillissement de celle-ci jusqu'à certaine parité. L'accroissement de la taille de la portée à la naissance

et à la réduction du temps entre deux accouplements contribuent à l'augmentation de la mortalité avant sevrage, bien que la quantité de lait produite semble être le facteur le plus important. Donc tous les facteurs susceptibles de diminuer la production laitière (nutrition, conduite de l'élevage, conditions climatiques et maladies de la mère) augmentent la mortalité avant sevrage. L'amélioration de l'alimentation (par l'utilisation d'additif alimentaire, d'antibiotiques et de probiotiques, de fourrage vert) augmente la production laitière. Le stress dû à la chaleur et les maladies sont les causes principales de la mortalité avant sevrage. Il convient de noter que la perte des lapereaux peut être évitée et que la santé et la vigueur du troupeau seront maintenues en appliquant des règles simples de propreté et de conduite d'élevage. La prévention des maladies est aussi très importante car les traitements curatifs ont moins de succès chez le lapin que chez d'autres espèces.

INTRODUCTION

Rabbits can play a significant role in solving the problem of meat shortage in many parts of the world, due to their high potential for reproduction, rapid growth rate, short generation interval, ample nutritional spectrum, limited vital space and ease of rearing. However, pre- and post-weaning mortality until marketing limits the crop of rabbits in kilograms and a lower income would be obtained.

Pre-weaning mortality was estimated to be 5-7% of the young as stillborn and another 16-20% die before weaning (LEBAS *et al.*, 1988) in modern French rabbitries with highly prolific does, under intensive reproduction system and adequate environmental conditions. Although the mortality rate may be between 12 and 20%, it may reach up to 50% mainly in rabbits at 4 to 8 weeks of age, while mortality in rabbits older than 3 months is rare (UROSEVIC *et al.*, 1986 ; PEETERS, 1988).

Pre-weaning loss was estimated to be 70 to 78% in the first week and 16.63% in the second week with nearly a total of 93.9% of losses occurring in the first two weeks of life. The causes of pre-weaning mortality are the abandonment of the litter by the doe (31-31.3%),

cannibalism (17.6-18.0 %), insufficient milk or starvation (11.7-12.0%), crushing (6.8-8.0%), disease (3-4%), runtling (4%) and death of dam (3%), besides unknown causes (21-25%). In addition, trachoma resulting from physical injury to the young rabbits (15%) and chilling + starvation (82%), were reported, in the same respect (DELAVEAU, 1979 ; PARTRIDGE *et al.*, 1981 ; FRANCESCHI, 1983). COUDERT (1982) confirmed that the young rabbit losses are not uniformly distributed from the day of birth to weaning time.

The purpose of the present article is to throw some light on the factors which affect mortality rate or, in other words, the survival rate of the rabbit's offspring.

FACTORS AFFECTING MORTALITY OF YOUNG RABBITS

Pre-weaning mortality may depend on genotype of the animal, pathological causes, doe traits such as birth weight, litter size, order and frequency of parturitions, season of birth, quality and management of the nest in addition to the climate conditions (HARRIS, 1982; HARRIS *et al.*, 1982 ; SZENDRÖ and BARNÁ, 1984). Meanwhile, post-weaning mortality of young

rabbits may be mainly affected by genotype, kit age and weight at weaning and the external environmental factors.

1. Genotype :

1.1. Pre-weaning :

The breed differences in pre-weaning mortality percentage as reported in the literature, are presented in Table 1. It is clear that pre-weaning mortality rate percentages differ between and within the different

breeds (Table 1) and between purebred and crossbred rabbits (LUKEFAHR *et al.*, 1983b ; EL-MAGHAWRY *et al.*, 1988 ; KHALIL *et al.*, 1988 ; RASHWAN *et al.*, 1997). From another point of view, the genetic variability of rabbit pre-weaning mortality rates was found to be 12% mainly from enteritis and pneumonia. The heritable paternal component (h^2) of mortality was 0.12 ± 0.02 , while the heritable maternal component (h^2) was 0.45 ± 0.05 for the mortality from enteritis and 0.58 ± 0.05 for the mortality from pneumonia. This indicates a significant additive genetic variability in

Table 1 : Pre-weaning mortality percentages in some breeds of rabbits.

Authors and years	Weaning age (weeks)	NZW	Cal	GW	BR	BB	Bw	GB	Bu	Ch
RAGAB <i>et al.</i> (1956)	4			17.5	16.2					
RAGAB and WANIS (1960B)	4			31.9						
GHANY <i>et al.</i> (1963)	4			27.8						
SHAWER (1963)	4				39.3				33.8	
NOSSIER (1970)	5				13.1				17.9	
AFIFI (1971)	7			35.3					12.3	52.0
ZICARELLI and LELLA (1974)	6	14.4								
MOWLEM (1977)	4	34.8								
CHEN <i>et al.</i> (1978)	4	17.8								
TORRES <i>et al.</i> (1979)	35d	23.0								
KHALIL (1980)	5			45.7	60.2				43.8	
PARTRIDGE <i>et al.</i> (1981)	4	27.0	26.1							
AFIFI <i>et al.</i> (1982)	5			47.6					48.5	
EMARA (1982)	5			51.4	50.6					
ISMAIL (1983)	30d				11.4				15.1	
AFIFI and EMARA (1984)	5			51.9						
AFIFI and KHALIL (1986)	5			51.4						
KHALIL (1986)	5			27.6					29.9	
SZENDRÓ and VARGA (1986)	4	16.9	27.4							
EL-MAGHAWRY <i>et al.</i> (1988)	5	28.0	51.9							
GUALTERIO <i>et al.</i> (1988)	5	32.3								
KHALIL <i>et al.</i> (1988)	5			41.0						
ASKAR (1989)	5	19.2								
OUDAH (1990)	5	9.9	8.9		8.0					
RASHWAN (1990)	4	21.4	22.6							
SEDKI (1991)	4	31.8	28.7							
YAMANI <i>et al.</i> (1991)	4	31.8	28.7							
EL-BOGDADY <i>et al.</i> (1992)	4	24.2	21.8							
SALLAM <i>et al.</i> (1992)	36d	8.9	20.3							19.1
YASSEN (1992)	30d	13.7	12.6							
EL-SAYIAD <i>et al.</i> (1993A)	4	13.7	12.6							
EL-SAYIAD <i>et al.</i> (1993B)	4	48.7	48.2							
KHALIL (1993)	5			38.7						
GALAL and KHALIL (1994)	5	25.0	34.0	37.0	35.0	14.0	13.0	16.0		
YAMANI <i>et al.</i> (1994)	30d	19.1	15.8						20.0	
RASHWAN <i>et al.</i> (1995)	4	16.4	17.9			26.8				
TAWFEEK (1995)	4	11.7								
DORRA <i>et al.</i> (1997)	4	10.2	7.3							
EL-KELAWY (1997)	4	13.5	9.3							
SOLIMAN <i>et al.</i> (1997)	4		16.9		20.7				11.5	
AHMED and MARAI (1998)	4	22.0	23.0			24.4				

NZW = New Zealand White; Cal.= Californian; GW= Giza White; BR= Baladi Red; BB= Baladi Black; BW= Baladi White; GB= Gabali; Bu= Bauscat; Ch= Chinchila.

mortality or viability of young rabbits for the two main causes of death detected, i.e. enteritis and pneumonia. The superiority of the maternal component of heritability to the paternal reflects the mother's high impact on viability of the young (ROLLINS and CASADY, 1967b). Such results confirm that genetic improvement can reduce pre-weaning mortality, although fixing undesirable and lethal traits may accompany fixing desirable types or desirable genes without discrimination (ROLLINS and CASADAY, 1967a). However, other authors found no significant genetic differences in mortality rate (RASHWAN *et al.*, 1995 ; DORRA *et al.*, 1997 ; AHMED and MARAL, 1998).

Crossbreeding between different breeds of rabbits (either local and/or exotic) either in Egypt or in other countries was generally associated with improvement in most economic traits in rabbits of which mortality is the most important (AFIFI and KHALIL, 1991). Particularly, LUKEFAHR *et al.* (1983c) and LEBAS *et al.* (1986) recorded a lower pre-weaning mortality rate and EL-QEN (1988) noticed that efficiency in either producing more young per litter or in rearing them more efficiently were better in crossbred than in purebred animals. Particularly, RASHWAN *et al.* (1995) reported that pre-weaning mortality in kits produced from New Zealand White (NZW) x Californian (Cal) cross was lower (12.9 %) than in NZW, Cal and BB (Baladi Black) purebreds and their reciprocal crosses, which ranged between 13.83 - 26.79 %. The same authors added that the hybrid vigour was found in mortality rate during 0-28 days of suckling period in reciprocal crosses among each two breeds of NZW, Cal and BB. Heterosis was also obtained in crossbreeding between each of NZW, CAL and BB does and Papillon bucks (RASHWAN *et al.*, 1995). Similar superiority in viability rate was obtained by RASHWAN *et al.* (1997) with reciprocal crossing between NZW and each of BB and BR (Baladi Red) reflecting the existence of non-additive genetic effects to maintain more young than in purebreds. This superiority may be a result of heterotic effect of crossbreeding on milking ability and mothering or rearing ability of the dam, i.e. maternal ability determined by nourishment of the young during the suckling period (RANDI and SCORSICOLI, 1980). LEBAS *et al.* (1986) confirmed that the main advantages of crossbreeding are heterosis and interbreed nicking ability. The same authors added that heterosis may improve the young rabbits' viability. On the other side, EMARA (1982), AFIFI and EMARA (1989), recorded absence of heterotic effects on pre-weaning mortality. LEBAS *et al.* (1986) confirmed that breed differences in General Combining Ability (GCA) for pre-weaning mortality were limited and non-significant.

1.2. Post weaning :

Comparison within the same environment showed differences between the different breeds in post-weaning mortality rate. HABEEB *et al.* (1997) found that the survival rate from 5 to 14 weeks of age was higher in NZW than in Cal rabbits (88 vs 81 %). However, another study indicated that mortality rate was not affected by breed (EL-HINDAWY *et al.*, 1992).

From another point of view, crossbreds showed less post weaning mortality percentage than in purebreds (RASHWAN *et al.*, 1995). Particularly, TAG EL-DIN (1979) found that Balladi White-Buscat (BW-Bu) crossbred rabbits recorded lower mortality than in either of the parental breeds, from weaning to 90 days. In addition, AFIFI (1971) noted that heterosis percentages of individual viability of crossbred rabbits were slightly higher than those of the purebred groups from 4 to 12 and from 4 to 24 weeks of age. Particularly, AFIFI and EMARA (1988) observed negative heterotic effects on post-weaning viability in most of the single crossbred groups from 5 (weaning) to 6, 8 and 12 weeks of age. However, OUDAH (1990) did not find evidence for the presence of heterotic effect for the same trait, from 4 (weaning) to 10 weeks of age.

2. Maternal traits :

Suckling spends a long time (about 25% of the life time of the growing rabbits) in close contact with their mothers (SZENDRÖ *et al.*, 1996).

2.1. Doe age and weight at kindling :

Pre-weaning mortality seemed to be greater in does of younger and older ages than in those of medium age (IBRAHIM, 1985 ; ASKAR, 1989). LEBAS and COUDERT (1986) reported that pre-weaning mortality was either slight or nearly absent when does were first mated at ages 15, 16, 17, 18, 19 or 20 weeks. SZENDRÖ and VARGA (1986) showed that NZW and Cal does had their best production during the period between 4-12 months of production, while mortality rate in the suckling period started to increase from month 15 of production. The increase of weight of doe at conception or kindling was accompanied by insignificant increase in pre-weaning mortality (EL-MAGHAWRY *et al.*, 1988 ; SZENDRÖ *et al.*, 1989, 1994). Particularly, the does weighing <4.0 kg showed insignificant increase in pre-weaning mortality (24.5%) than in those weighing >4.0 kg (17.9%) (ASKAR, 1989).

2.2. Parity consecution :

From the biological point of view, pre-weaning mortality rate decreases as parity advanced up to certain parity, then increases thereafter, i.e. a curvilinear relationship between pre-weaning mortality and parity could be plotted (HILMY, 1991 ; SEDKI 1991 and

Table 2 : Pre-weaning mortality percentages as affected by parity consecution.

Authors and years	Breed	Weaning age (weeks)	Parity consecution							
			1 st	2 nd	3 rd	4 th	5 th	6 th	7 th	> 8 th
EL-MAGHAWRY <i>et al.</i> (1988)	NZW	5	23.5	35.5	27.2					
	Cal	5	76.5	37.3	36.8					
GUALTERIO <i>et al.</i> (1988)	NZW + Dutch	5	36.3			30.1				31.8
ASKAR (1989)	NZW	5	31.5	45.4	24.4	13.9	11.0	16.1		
OUDAH (1990)	Cal + NZW + Baladi	5	11.0		7.0-9.0		0.3			
KHALIL and AFIFI (1991)	Bu		19.1	19.3	31.6	32.4	27.5	31.1		
	GW		23.5	24.5	27.6	15.5	27.3	16.5		
YAMANI <i>et al.</i> (1991)	NZW	4	33.8	26.6	32.3	38.3	38.6	18.6		
	Cal	4	37.1	25.0	26.7	25.6	29.3	28.5		
SALLAM <i>et al.</i> (1992)	NZW + Cal + Ch	36d	17.8	15.0	18.3	19.3	25.6			
YASSEN (1992)	NZW + Cal	30d	15.2	10.3	16.1	14.3				
EL-SAYIAD <i>et al.</i> (1993B)	NZW	4	20.0	32.5	39.7	36.8	38.5	51.7	54.6	30.7-41.3
HASSAN <i>et al.</i> (1994)	NZW		41.8	43.5	40.2	16.9	9.2	—	—	—
NASR (1994)	NZW	4	40.0	51.0	40.0	26.2	21.0	14.0	18.0	13.0
EL-KELAWY (1997)	NZW + Cal	4	12.6	9.0	14.7					
SOLIMAN <i>et al.</i> (1997)	Cal + BR + Bu	4	21.3	21.4	15.1					
AHMED and MARAI (1998)	NZW + Cal + BB	4	20.5	20.4	19.9					

NZW= New Zealand White; Cal.= Californian; GW= Giza White; BR= Baladi Red; BB= Baladi Black; Bu= Bauscat; Ch= Chinchila

SALLAM *et al.*, 1992). Particularly, many studies showed that pre-weaning mortality decreases either significantly ($P < 0.05$) (LUKEFAHR *et al.*, 1983a ; GUALATERIO *et al.*, 1988 ; OUDA, 1990) or insignificantly (AFIFI and KHALIL 1986, 1990 ; AFIFI *et al.*, 1992 ; AHMED and MARAI 1998) with parity advancement. KHALIL (1980) revealed that this trend is thought to be due to improvement in care and ability of the mother to suckle her young with advancement of parity sequence. However, some studies showed that the same trait increased either significantly ($P < 0.01$) (AFIFI *et al.*, 1982) or insignificantly (KHALIL and AFIFI 1991 ; EL-SAYIAD *et al.*, 1993b) with advancement of parity. NASR (1994) noticed that mortality rate during the suckling period increased up to the third parity, then decreased gradually from the fourth till the eighth parity and the differences were significant ($P < 0.05$).

Pre-weaning mortality percentages as affected by parity consecution reported in the literature are presented in Table 2.

2.3. Litter size at birth :

Mortality percentages during the suckling period was found to increase significantly ($P < 0.01$ or 0.05) with the increase in litter size at birth (RAGAB and WANIS, 1960b ; CARO *et al.*, 1984 ; TAWFEEK 1995). SZENDRÖ and BARNA (1984) clarified that mortality

rate was 10-15% for litters of less than 8 individuals, 20% for those of 10 individuals and more than 30% for litters of 12 individuals, during the suckling period. However, BROECK and LAMPO (1975), Mach and TROJAN (1978) and PARTRIDGE *et al.* (1981) mentioned that mortality became more elevated both in small and in large litters. Similarly, ASKER (1989) confirmed that pre-weaning mortality in NZW rabbits was lower in litters comprised of 5 or 7 young. However, some studies showed that the relationship between litter size at birth and mortality was not significant (ROLLINS and CASADAY 1967a ; RAO *et al.*, 1977 ; AFIFI and KHALIL 1986 ; HASSAN *et al.*, 1994).

The increase of pre-weaning mortality with the increase of litter size at birth seems to be due to the decrease in the average individual weight per litter at birth (AFIFI *et al.*, 1973), in addition with increased litter size, the competition for teats is greater and consequently, the smaller rabbits obtain less milk.

2.4. Remating intervals :

Productivity of early or late remating has attracted the attention of many investigators. However, no unanimous conclusion could be reported, since the high annual litter number of the early remating does not always give a high annual total number of live young per doe.

PERRY (1983) in his study on NZW rabbits found that pre-weaning mortality values were significantly lower (17.3 and 16.2%) with does mated at 3 and 4 weeks after kindling, respectively, than those mated immediately (24.2%), 2 weeks (21.2%) and 5 weeks (21.6%) after kindling. MENDEZ *et al.* (1986) also found significantly lower mortality during lactation in the group remated on day 4 (11%) than in those remated days 1 and 24 post-kindling (20.9 and 17.2% respectively). Recently, TOSON *et al.* (1995) indicated that mortality rate was significantly ($P < 0.05$) higher in young borne by does remated one day after parturition than in those born by does remated 14 or 28 days after parturition, probably due to the lower milk production of the pregnant does during lactation period (does remated one day after parturition). In addition, during the short interval between litters, the hair used for nest building from the female's underside normally becomes insufficient to provide heat insulation, thus increasing mortality owing to chilling (SCHLOLAUT, 1980). However, some researchworkers found no significant effect of remating interval on mortality from birth to weaning (SZENDRŐ *et al.*, 1983 ; PARTRIDGE *et al.*, 1984 ; YAMANI *et al.*, 1990 ; AYYAT and MARAI, 1998).

2.5. Doe milk yield :

Milk production is one of the major post-natal maternal traits, since early litter growth and survival of young are dependent on the intrinsic ability of the dam to provide adequate maternal environment (LEBAS, 1969). LEBAS (1975) and MAERTENS and OKERMAN (1988) confirmed that the rabbit kits depend completely in their feeding on does milk during the first 20 days of lactation period.

The increase in total milk yield during lactation period leads to the increase in viability of the young (YAMANI *et al.*, 1991). Refusal of the doe to suckle her young probably because of her nipples tenderness and sometimes because of her failure to produce milk will cause death of young rabbits during the suckling period. SCHLOLAUT (1980) confirmed that the main cause of pre-weaning losses was insufficient milk supply and RAJADEVAN *et al.* (1986) revealed that the ability of the young animals to successfully find a teat during the once-a-day suckling period for two to three minutes influences the mortality rate. KHALIL (1993) added that mortality was a result of the low post-natal maternal ability due to low milking and suckling abilities.

Particularly, PAPP *et al.* (1983) indicated that daily milk yield in rabbits fell by 7.7 g for every 1°C increase in temperature above 20°C and GHALY (1988) reported that exposure of rabbits to constant 30°C air temperature, lowered milk yield with about 40% of that

under natural air temperature (20°C). However, generally, all factors that may affect milk yield of the rabbit doe such as genotype, parity consecution, remating interval, nutrition, season and disease affect the pre-weaning mortality percentage.

2.6. Kit age and weight at weaning :

Earlier weaning than the standard age and weight belonging to each breed, due to culling or death of a doe, increases post-weaning mortality rate. In this respect, CHIMTELIN (1992) showed that groups in which the weaning weight was less than 600 g displayed a significantly higher mortality (due to enteritis) than in those with 600g weaning weight or higher. The above results confirm those obtained by MORISSE *et al.* (1985). Post-weaning mortality is also affected indirectly with doe remating system and litter size at birth, since the doe which remates immediately after parturition and that one which kindle high litter size produce kits with lower weaning weights (AFIFI *et al.*, 1973 ; RASHWAN, 1990 ; EL-MAGHAWRY, 1993).

3. Management of the rabbitry :

3.1. Pre-weaning :

Disturbance of the doe at or shortly after kindling usually causes complete loss of young rabbits of the litter. At kindling, the disturbed doe drops her young on the floor of the nest and leaves them without care to die, but when disturbance occurs shortly after kindling, the doe crushes her young in her attempt to protect them (AFIFI and EMARA, 1984).

The construction of the nest and type of bedding in the nest should not hinder the distribution of the young during suckling (SCHLOLAUT, 1980). Scattering of the young and increase in the level of cannibalism and, consequently, increase in kit mortality occur with the absence of a suitable location or of nesting materials (DENENBERG *et al.*, 1959). However, PARTRIDGE *et al.* (1981) stated that poor nesting quality was not closely associated with subsequent mortality. The microclimate inside rabbitries has a great influence on health and morbidity, as well as, the incidence of pasteurellosis in rabbits (MOUSA, 1996). Lighting system showed insignificant effect on mortality percentages during the suckling period (EL-BOGDADY *et al.*, 1992 ; TAWFEEK *et al.*, 1993).

3.2. Post-weaning :

New Zealand White growing rabbits recorded 15 and 5% mortality in groups raised on floor or cages, respectively, from 5 to 12 weeks of age (RASHWAN and AHMED, 1996).

Table 3 : Pre-weaning mortality percentages as affected by month and season of kindling

Authors and years	Breeds	a. Month of kindling												Sig
		Jan.	Feb.	March	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	
EL-MAGAWRY <i>et al.</i> (1988)	NZW Cal	19.4 57.5	36.2 43.5	36.0 56.8	33.9 29.2	30.5 22.1	6.2 20.9							*
ASKAR (1989)	NZW	12.9	9.7	22.9	29.3	51.6	39.1	14.1	25.4	11.6	10.2	12.8	7.3	*
KHALIL and AFIFI (1991)	Bu	19.2	20.0	21.6	46.7						36.5		18.8	**
	GW	13.8	13.2	12.0	56.4						34.0		13.2	**
YAMANI <i>et al.</i> (1991)	NZW				35.9	35.6	20.9	36.4	20.8	40.0	28.5	25.5		NS
	Cal				37.4	20.8	27.9	24.7	23.0	24.9	31.6	32.7		NS
SALLAM <i>et al.</i> (1992)	NZW + Cal + Ch		19.4			22.5						15.4		NS
HASSAN <i>et al.</i> (1994)	30.2	26.9	31.4	18.4	41.0	54.0	36.0				0.9	31.3	58.0	**
Authors and years	Breed	b. Season of kindling				Significance								
		Spring	Summer	Autumn	Winter									
TROJAN <i>et al.</i> (1977)	Cal + DWL				28.6		12.5	**						
GUALTERIO <i>et al.</i> (1988)	NZW		30.7		29.1	32.1	38.0	*						
YAMANI <i>et al.</i> (1991)	NZW		36.2		22.4	11.3	12.9	**						
NASR (1994)	NZW		45.0		20.0	14.0	22.3	NS						

NZW= New Zealand White; Cal.= Californian; GW= Giza White; Bu= Bauscat; Ch= Chinchila and DWL= Danish White Land.
Sig. = Significance; NS = Not significant; **P<0.01; * P<0.05

4. Climatic conditions (month and season of kindling and heat stress) :

4.1. Pre-weaning :

Data of pre-weaning mortality percentages as affected by month and season of kindling reported in the literature, are presented in Table 3.

Month of kindling showed significant ($P<0.01$ or 0.05) effects on pre-weaning mortality rate in the different breeds of rabbits (LUKEFAHR *et al.*, 1983c ; AFIFI and EMARA, 1988 ; EL-MAGHAWRY, 1993 ; HASSAN *et al.*, 1994). The lowest pre-weaning mortality rate was recorded in rabbits born either during January and February (RAGAB and WANIS, 1960a ; NOSSIER, 1970), during November and December (KHALIL, 1980) or during March and April (CSONKA and SZENDRÖ, 1984). Differences in pre-weaning mortality due to month of kindling may be attributed to differences in nutrition (SCHLOLAUT, 1984), atmospheric temperature (AFIFI *et al.*, 1982) and disease (LUKEFAHR *et al.*, 1984). In Egypt, NOSSIER (1970) and EMARA (1982) attributed the lowest percentages of litter losses during the period of January up to April to the availability of the nutritive green fodder, in addition to the mild weather prevailing during

the mentioned months. On the other side, other studies showed that month of kindling did not show any significant effect on pre-weaning mortality (EL-KELAWY, 1993 ; EL-SAYIAD *et al.*, 1993b ; TAWFEEK, 1995).

Season of kindling was found to show significant ($P<0.01$ or 0.05) effects on pre-weaning mortality percentages (ROLLINS and CASADY, 1967a ; TROJAN *et al.*, 1977 ; ABDEL-SAMEE, 1995). MARAI *et al.* (1996), AYYAT and MARAI (1998) indicated that pre-weaning mortality was higher in summer than in winter season, due to the direct effect of heat stress on the sensitive young offspring, in addition to reduction of dams' milk production (AYYAT *et al.*, 1995) as a result of the general depression of metabolic activity in such conditions (SHAFIE *et al.*, 1984). The duration of the breeding season in hot-climate countries (such as Egypt) is limited to 6-7 months each year, due to the unfavorable conditions of the hot climate season for rabbit production. The pre-weaning mortality increases as ambient temperature increases. At temperatures 20, 25, 30 and 35°C, 1, 3, 8 and 23 baby rabbits died, respectively, and at temperatures of 30 and 35°C, the values were significantly higher than at lower temperatures (as reported by RAFAI and PAPP, 1984).

ABDEL-MOTY *et al.* (1991) showed significant ($P<0.05$) increase in mortality rate till weaning on 33.5-34.5°C than in the control group (about 16.4°C). HASSANEIN (1980) found that the highest value (31.8%) of mortality rate was recorded on 35°C. However, NASR (1994) found that mortality rate was not significantly affected by season of kindling in NZW does.

4.2. Post-weaning :

Summer season was found to be the most important factor that influenced the post-weaning mortality. HABEEB *et al.* (1997) showed that mortality rate was found to be 18 % in summer, while no mortality was recorded during winter. Similarly, SHEHATA *et al.* (1998) recorded 18.52 % mortality rate during summer compared to 3.70, 7.41 and 7.41% during spring, autumn and winter seasons, respectively.

Some studies showed that the feeding system might increase the survival rate of growing rabbits from weaning up to marketing age. RASHWAN *et al.* (1996) showed that in summer mortality rate values recorded 40, 15 and 10 % for rabbits fed diurnal, nocturnal and all day, respectively.

Supplementation of the heat-stressed growing rabbits with Avopercin (A), Flavomycin or Zinc Bacitracin reduced mortality rate from 33% to 16% during 60 days after weaning (ABDEL-SAMEE, 1995).

5. Nutrition and drinking water :

5.1. Pre-weaning :

A balanced, clean and sanitary diet offered to doe rabbits during the suckling period decreases the pre-weaning mortality.

The viability percentage during the suckling period tended to be rather high as the protein level in dams diet is high (KWONG and BARNES, 1977 ; REDDY *et al.*, 1979 ; CERVERA *et al.*, 1988 ; RASHWAN, 1990). SANCHEZ *et al.* (1985) found that kits mortality averaged 9.85, 6.91 and 10.03 % during 1-21 days and 1.88, 1.04 and 1.63 during 22-28 days for NZW doe rabbits fed 17.5, 19.0 and 20.5 % CP, respectively. However, OMAR *et al.* (1997) found that mortality rate was the highest (19.7%) with 17% CP diet compared to 15 and 19 % CP (14.3 and 10.5%, respectively), at birth-28 days.

Mortality rate during the period from birth to weaning was found to decrease significantly ($P<0.05$) (CHEEKE, 1988, 1989 ; HOLLISTER *et al.*, 1990 ; TAWFEEK and EL-HINDAWY, 1991) and insignificantly (EL-GAAFARY *et al.*, 1992 ; RASHWAN, 1993) by feeding doe rabbits on diets supplemented with probiotics such as Lacto-Sacc or Bospro. The increase in appetite and the lower incidence of enteritis problems

during the suckling period in young rabbits as a result of production of lactic acid by *lactobacillus acidophilus* and *streptococcus faecium* in the digestive tract of the rabbit and inhibition of growth of undesirable bacteria (Alltech Biotechnology Center, 1989) may be the reasons for such desirable results. Recently, ABDEL-SAMEE (1995) found that probiotics increased pre-weaning viability (77.0%) compared to the control group during summer (69.5%).

The use of some dietary supplements seemed to affect positively pre-weaning mortality. Supplementation of the pelleted doe diet with green Egyptian clover (*Trifolium alexandrinum*) during the suckling period showed lower mortality rate (13.3%) as compared to the control group (21.1%) (RASHWAN *et al.*, 1993). Similarly, viability percentage was improved significantly ($P<0.05$) from birth up to both 21 and 28 days of age when 10% of doe rabbits alfalfa ration was replaced with 10% tomato pomace (TAWFEEK *et al.*, 1995). The use of natural sources such as anise, fenugreek and caraway seeds as dietary supplementation to does decreased pre-weaning mortality significantly ($P<0.05$) from birth to 21 days of age (the values were 15.85, 8.10, 6.49, 9.29% for the control, control plus anise, control plus fenugreek and control plus caraway groups, respectively) (RASHWAN, 1998). Such improvement in pre-weaning mortality was attributed to the higher milk produced by the treated does. Using different feed additives such as methionine, choline and sulphate (EL-SAYIAD *et al.*, 1993a), mineral mixture biomix-223 (TAWFEEK, 1993), folic acid + iron (EL-MASRY and NASR, 1996) and zinc (ABD EL-RAHIM *et al.*, 1995), were also found to improve significantly ($P<0.01$ or 0.05) pre-weaning mortality percentages.

Aflatoxins which are extremely toxic chemical compounds produced by the molds during crop growth, harvest or storage of different foods and feeds (CHEEKE and SHULL, 1985 and WOOD, 1989) cause death of the animals when consumed in high quantity (HARVEY *et al.*, 1989 and ABDEL-HAMID *et al.*, 1992). NOWAR *et al.* (1994) found that mortality rate was 100% after feeding the pelleted diet contaminated with aflatoxins. Similarly, Vitamin A is toxic when given in high doses to animals (CHEEKE, 1987). ISMAIL *et al.* (1992 a, b) confirmed that the percentage of mortality during suckling was higher (28.48%) than normal when doe rabbits were given high alfalfa (44.24%) in addition to supplemental vitamin A (about 13.200 IU/ kg diet) in the diet.

Among the serious problems that face rabbit production in the desert areas is the low quality of the underground water (saline) used as drinking water (RAY, 1989 and HABEEB *et al.*, 1997). The use of desalinated well water was found to improve ($P<0.05$)

Table 4 : Pre-weaning dispositions expressed as percentages of number born alive according to ROLLINS and CASADAY (1967a).

Periods	Case and age of death (Days)							
	Enteritis		Pneumonia		Pneumonia and enteritis jointly		Other causes ⁺⁺	
	0 - 14	15 - 56 ⁺	0 - 14 ^{**}	15 - 56	0 - 14	15 - 56	0 - 14	15 - 56
1. Jan-Aug	0.1	6.9	1.1 ^b	1.1	0.0	1.9	3.4	1.0
2. Sept-Dec	0.1	7.9	5.3 ^a	1.5	0.0	3.1	2.3	1.0

Means in the same column having different letters, differ significantly ($P < 0.01$).

^{**} $P < 0.01$ ⁺ Weaning age was usually 56 days. ⁺⁺ Other causes included starvation, injury or bruising, impaction of caecum, abscesses, heat prostration, toxemia, wool block, toxic liver, wet nest, hunger wry neck, paralysis, internal hemorrhage, kidney infection, umbilical hernia, nest box scours and telescoped intestines.

viability percentage from birth up to weaning compared to those treated with saline well water, in Cal rabbits (ABD EL-SAMEE and EL-MASRY, 1992). The increase in the level of salt in drinking water increases sensitivity of rabbits to stressful conditions (HABEEB *et al.*, 1997) or to kidney failure (AYYAT *et al.*, 1991).

5.2. Post-weaning :

Increasing dietary protein level in the growing rabbit diet showed a decrease in mortality rate (SONBOL *et al.*, 1992 ; EL-HINDAWY *et al.*, 1993).

Feeding growing rabbits Af-diet (naturally contaminated with 860 ppb aflatoxin) resulted in 100% mortality (NOWAR *et al.*, 1996).

The rate of post-weaning mortality increases directly with the increase in concentration of salinity over 2000 ppm in drinking water, especially under hot summer conditions (HABEEB *et al.*, 1997).

6. Disease :

6.1. Pre-weaning :

Disease is mostly the result of poor surroundings and environment coupled with the onslaught of a pathogenic agent-microbe, virus or parasite.

Currently, susceptibility of rabbits to several diseases that reduce viability, especially during the suckling period, leads to an unprofitable level in many rabbit farms. Pre-weaning dispositions expressed as percentages of number of born alive by ROLLINS and CASADAY (1967a), are presented in Table 4. There is a statistical significant increase ($P < 0.01$) in the death rate by pneumonia from Period 1 (January-August) to Period 2 (September-December), and this was largely due to an increase in the death rate prior to 15 days of age. ROLLINS and CASADAY (1967a) ; MAHAJAN *et al.* (1980) ; LUKEFAHR *et al.* (1984) reported that the non-genetic source of variation in pre-weaning death losses was due to enteritis and pneumonia. GERGIS *et al.* (1992) confirmed that pneumonia in domesticated

rabbits regularly caused clinical manifestations and death ranging between 51 and 59%.

Coccidiosis is an omnipresent parasitic disease and causes high more mortality rates in commercial farms (COUDERT, 1979 ; KHALIL, 1980 ; LANG, 1981 ; EMARA, 1982 ; HEGAZI, 1988). The parasite favours proliferation of *Escherichia coli* in the gut (LICOIS and GUILLOT, 1980). Attaching effacing enteropathogenic *Escherichia coli* (AEEC) are now considered to be an important cause of diarrhoea in suckling and weanling rabbits (CAMGUILHEM *et al.*, 1986 and OKERMAN, 1987). Mortality varies from very low to very high according to the strains involved. PATTON (1987) showed that young rabbits of 2-3 weeks of age are very susceptible to coccidia infections. CHEEMA *et al.* (1990) indicated that during an outbreak of hepatic coccidiosis, the main symptoms were anorexia, diarrhea, reluctance to move and death within 3-4 days.

Respiratory ailments (Pasteurellosis) are common among domestic rabbits, in Egypt. In rational production, such ailments strike mainly breeding adults, and the doe may die or be culled, which leads to high mortalities among the nursed young (WEISBROTH *et al.*, 1974 ; RONALD *et al.*, 1983 ; CHEEKE, 1987 ; GERGIS *et al.*, 1992).

Other disorders which cause an increase in morbidity and mortality in nursing does and consequently cause great loss in the suckling kits can be summarized as follows :

- a. Foot pad abscesses and mastitis (that are the main reasons for culling breeding does).
- b. Ear and skin mange, which may cause death within few weeks (KRAUSE and HOMOLA, 1974).
- c. Trichophagy (or fur-eating) : the animals eat each others hair cover and end up with bare backs and flanks.
- d. Does destroy and eat young : as a result of many causes (ASHBROOK, 1955).
- e. Genital infections.

f. Metabolic disorders (25-30% of does die in intensive production, usually with no definite symptoms). Mortality occurs in mid-lactation in first and second litter in young females and in the later stages of pregnancy in older does.

g. Parturition outside the nest box (first litter in young females are the usual offenders) disturbances and mice in the nesting box are possible causes.

h. Toxoplasmosis : the course of the disease does not usually produce symptoms.

i. Cannibalism : the female usually eats only those young which are already dead but still warm. Insufficient drinking water after parturition is considered a cause of cannibalism in rabbitries.

j. Abandonment of the litter : this is most often done by young females whose milk has not let down, or has let down too late. A doe that abandons 2 litters should be culled.

The toxicity of various antibiotics in rabbits had been reported for a long time (MILHAUD *et al.*, 1976 ; CAMGUILHEM, 1980). FACCHIN (1997) reported that the therapeutic treatment of the rabbits needs greater care because some antibiotics can be a risk or toxic, in addition to that the abuse or misuse of drugs can decrease the biosecurity of rabbit meat.

6.2. Post-weaning :

Mortality rate is between 12 and 20%, but may reach up to 50% mainly in rabbits weaned at 4 to 8 weeks of age. Mortality in rabbits older than 3 months is rare (UROSEVIC *et al.*, 1986 ; PETEERS, 1988).

Digestive disorders are the predominant cause of mortality in commercial rabbits. Feed composition may influence the course of the mentioned disorders and sometimes medication itself deteriorates the situation (UROSEVIC *et al.*, 1986 ; PETEERS, 1988). PEETERS *et al.* (1984) clarified that the losses resulting from diarrheal diseases were mostly concentrated in the time after weaning (4-6 weeks) in rabbitries and were generally assumed to be caused by lack of fibre, coccidia or by bacterial proliferation.

Enteropathogenic Escherichia coli (EPEC) is one of the most important causes of losses among broiler rabbits in large scale farms (OKERMAN and DEVERIESE 1988). The deep lack of balance of intestinal flora is often said to be the cause of rabbit enteritis, especially during post-weaning (PEETERS *et al.*, 1984). Hence, some studies advise the use of probiotics to decrease mortality rate post-weaning due to its support of intestinal microflora (GIPPERT *et al.*, 1992 ; AYYAT *et al.*, 1996).

Diarrhea is a serious economic threat in young weaned rabbits (4-10 weeks) and can in any case easily be prevented by elementary sanitary and feeding hygiene (LEBAS *et al.*, 1986). Supplementing the diet of growing

rabbits with clays decrease mortality rate, due to the protective effect of clays against rabbit diarrhea (GROBNER *et al.*, 1982 ; SARHAN *et al.*, 1997).

Pasteurellosis caused by *Pasteurella multocida* is one of the most important pathogens inducing respiratory problems and high losses in rabbitries (RONALD *et al.*, 1983 ; GERGIS *et al.*, 1992).

7. Nest and young rabbit mortality :

The doe pulls fur to make a nest and nurses her young once a day. Particularly, the relationship between the nest and the young rabbits mortality (or the survival of newborn rabbits) and hence the ultimate success of the rabbitry is closely related to the quality and hygiene of the litter's immediate environment, since if the amount and type of materials used in the nest (straw, wood shavings, ...etc) are inadequate during the first days, the newborn rabbits will get cold and deaths are then inevitable. From another point of view, if the nest box is poorly designed and the young are able to get out after the first few days after kindling, the does do not put them back. Cage and nest box hygiene should be checked, since if the nest hygiene is poor (because of dropping and dampness) or if the mother is sick (with mastitis or coryza), the young may develop a nostril-blocking rhinitis within a few hours. Such phenomena are dangerous, since the sense of smell is crucial as it guides the young to the mother's teats. Small staphylococci abscesses can quickly develop on the bodies of young rabbits (belly, groin and/or tarsus) in such conditions. Pre-weaning diarrhea (30-35 days) is a sign of inadequate hygiene. Coccidiosis indicates very poor hygiene (LEBAS *et al.*, 1986).

CONCLUSIONS

Differences in pre- and post-weaning mortality percentages at different locations might be due to type of genotype of the rabbits raised and to changes in the uncontrollable external environmental factors (management, nutrition, climatic conditions and disease). Within the same breed, diseases are the most important cause of pre-weaning mortality, but it was found that age, climatic conditions and the maternal ability of the doe may have their influence. In addition, year, parity consecution, month or season of kindling, litter size at birth, nutrition, drinking water and management of the rabbitry have their effects in this respect. The control of pre-weaning mortality increases the number and weight of rabbits weaned per doe per year. The level of mortality may be controlled by genetic and various non-genetic factors. Genetic improvement in pre- and post-weaning mortality of rabbits could be realized by crossing with high productive local or exotic rabbits. Group selection

(family, pedigree or progeny testing), besides improvement of the environmental conditions, could also be practiced, for the same purpose. Regarding the non-genetic factors, rabbit offspring loss may be avoided to a large extent if the breeder relies on simple methods of cleanliness and management to maintain health and vigour in his stock. Prevention of diseases in rabbits is of special importance not only because of the fact that many of the diseases are actually preventable, but because curative treatment is less successful with rabbits than with many other classes of livestock.

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