INHERITANCE OF GROWTH AND LACTATION PARAMETERS IN YANKASA SHEEP

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ABSTRACT

Estimates of genetic and phenotypic parameters for lactation records of 143 ewes and growth performance of 134 lambs were examined using the paternal half-sib mixed model analysis. Heritability (h^2) estimates for the curve parameters were 1.4, 0.3, 0.2 and 0.5 for a (level of general production), b (pre-peak curvature), c (post-peak curva-ture) and total lactation (T). The estimates of phenotypic and genetic correlations between the various curve parameters were mostly positive and moderate in magnitude. For the growth parameters, h^2 estimates of 0.3 and 0.7 were obtained for birth weight (BWT) and 90-day weaning weight (WWT) respectively. The genetic and phenotypic correlations between these traits were 0.7 and 0.3 respectively. In conclusion the moderate estimates of h^2 obtained for curve parameters in this study indicate that improvement of milk production performance of the Yankasa sheep through selection is possible. Similarly, the magnitude of the estimate of correlations between BWT and WWT probably indicates that selection based on BWT will improve WWT. Furthermore, preliminary culling based on BWT is also possible.

Keywords: Inheritance, growth and lactation parameters, Yankasa sheep.

INTRODUCTION

The widespread of Yankasa breed of sheep throughout most ecological zones of Nigeria called for in-depth studies into its genetic merits. Its distribution extends from the sub-humid through the semi-arid zones (FDLPCS, 1991). It has an estimated population size of 22.1 million which constituted about 60 per cent of the national sheep flock (Osinowo, 1992).

Traits of economic importance in sheep production enterprise which influence productivity include that of reproduction, milk production and growth performance most especially at the early age when the dependency for growth is highly critical. Milk from ewes accounted for 40-50 per cent variation in weaning weight and pre-weaning average daily gain of lamb (Ehoche *et al.*, 1990). Moreover, the pre-weaning traits of sheep that influence flock productivity include birth weight, weaning weight and average daily gain to weaning. These traits invariably determine the period of slaughter weight attainment in sheep.

Genetic improvement in both milk and growth rate in sheep can be realized through selection for lactation and growth parameters. For the pre-weaning weight gain, a high estimate of 0.45 and 0.73 have been obtained for both phenotypic and genotypic correlations respectively between weaning weight and yearling weight averaged from several reports (Hassan, 1987). However, to access genetic merits of these traits, both lactation and growth parameters need to be adjusted for environmental effects such as dam's parity, lamb's sex, and type of birth (Lewis *et al.*, 1989). In addition adjustment may be required in the tropics for the season of birth since lambing frequently occurred throughout the year.

This study was therefore conducted to estimate the genetic parameters for lactation curve and body weight in order to evaluate the genetic improvement that could be achieved through selection.

MATERIALS AND METHODS

The data used for this study comprised complete 84 days lactation records of 143 ewes sired by 15 rams and 134 lamb weight records sired by 9 rams respectively. The data were generated from a single trial over two seasons (early wet; April – June and late wet; July – September) within a year. These sheep were part of the random bred experimental flock kept for the Nucleus Breeding Project at the National Animal Production Research Institute (NAPRI), Shika. The sheep were under semi-intensive system of management involving grazing on improved *Digitaria smutsii* pasture for 6-8 hours daily plus 0.3 - 0.5 kg per day of a 15 – 20 per cent crude protein supplement. The concentrate supplement comprised cotton seed cake, maize grain (ground) or offals, bone meal and salt and was given throughout the year depending on season (feed availability) and the physiological status (whether pregnant, nursing or dry). Animals were housed in well-ventilated pens and had access to water and mineral salt licks. The ewes were routinely bred to rams through controlled natural mating following heat detection using apron fitted rams in a twice-yearly accelerated lambing programme. The mating ratio is about one ram to 10 ewes while the lambs were usually weaned at about 90 days of age.

Following parturition, ewes with their lambs were separated into nursing pens and lamb birth weights recorded appropriately. Daily milk yields of ewes were determined at weekly interval from about one week after lambing till the 14th week of lactation. The collection procedure has been reported (Afolayan *et al.*, 1992). The lambs were weighed on weekly basis on days corresponding to the milking dates. All lambs were allowed free access to both grazing and concentrate supplement feeds given to their dams except on milking days.

Least squares procedures (SYSTAT, 1989) were used in determining the environmental effects on both lactation curve and weight records. Base class adjustments of milk yield data for type of birth, parity and season were made using least squares constants. The curve parameters (a, b and c) were estimated through multiple regression for each ewe's milk production throughout the lactation period. The constant a, b and c are parameters which determine the shape of the curve. While a is the level of general' production, b is the parameter of pre-peak curvature and c is the parameter of post peak curvature (Wood, 1969). The genetic parameters for growth and lactation curves were estimated by paternal half-sib analysis using the mixed model least squares and maximum likelihood computer programme (Harvey, 1990). Heritability estimates of the traits under consideration were estimated by one-way variance component analysis; while the correlations were obtained from the covariances. The covariance between traits i and j were estimated from the variances (var) through the relationship:

$$Covij = ½ (car (i + j) – var [i] – vari [j]$$

RESULTS AND DISCUSSION

Heritability Estimates for Growth Parameters

The paternal half-sib heritability estimates (h^2) for birth weight (BWT) and body weights of lamb of 30, 60 and 90 days are presented in Table 1. The BWT and 30-day weight had a similar h^2 of 0.3, which however, was lower than those obtained for either 60 or 90-day weight. The h^2 estimate obtained for birth weight in this study is intermediate between those reported for Sudan desert sheep (0.12) by El-Karim and Owen (1988) and for D'man sheep (0.34) by Boujename and Kerfal (1990). The high value of 0.7 obtained for the 90-day weaning weight closely agreed with that obtained for the same breed (Osinowo *et al.*, 1993). The moderate to high estimates observed for the growth traits clearly showed that variation due to the additive genetic effect is probably large. However, the high standard errors obtained for these traits may be attributed to the small sample size.

TABLE 1: ESTIMATES OF HERITABILITY, GENETIC, PHENOTYPIC AND ENVIRONMENTAL CORRELATIONS BETWEEN BIRTH WEIGHT (BWT) 30, 60 AND 90-DAY WEIGHTS OF YANKASA LAMBS.

Traits	Variance or covariance components					
	Among	Within	$h^2 \pm$ S.E	$r_g \pm$ S.E	r_p	r_e
BWT	0.0103	0.1267	0.30±0.35			
30 Days	0.0497	0.6054	0.30±0.35			
60 Days	0.1175	1.0829	0.40±0.37			
90 Days	0.2826	1.2687	0.73±0.43			
BWT and:						
30-day weight	0.0324	0.0847		1.43±0.68	0.39	-0.06
60-day weight	0.0419	0.0776		1.20±0.59	0.30	-0.18
90-day weight	0.0390	0.0972		0.72±0.50	0.30	-0.10
30 and 60 days weight	0.0958	0.6125		1.25±0.30	0.80	0.56
30 and 90 days weight	0.1348	0.5063		1.14±0.30	0.64	0.23
60 and 90 days weight	0.1500	0.9963		0.82±0.19	0.84	0.99

Correlations for Growth Parameters

Estimated genetic (r_g) and phenotypic (r_p) correlations between growth traits under consideration are given in Table 1. High and positive r_g estimates were obtained for all the traits. Positive and high genetic correlations were obtained between BWT and 30, 60- and 90-day weight while very high r_g estimates were obtained for all other combinations for the productive traits. Likewise, the r_p were positive and ranged from moderate to high in magnitude. Moderate estimates were obtained for r_p between BWT and 30-day weight, BWT and 60-day weight and BWT and 90-day weight. However, high and positive estimates were recorded for other combinations.

The high and positive genetic correlation observed between BWT and other weight in this study shows that only one single gene (pleiotrophy) influences these traits. This thus supports the earlier assertions that the genetic causes of correlation are chiefly pleiotrophy and linkage. Invariably, selection for higher BWT will ensure selection for higher subsequent weight given a favourable environment (adequate feeding and good health management). The observed high phenotypic correlation estimate in later weight pointed to the fact that the genetic effect on weight in lamb decreases with age.

Heritability Estimates for Lactation Parameters

The heritability estimates using the paternal half-sib relationships for the lactation parameters (a, b, c and T) are shown in Table 2. There were generally positive and highly significant (P<0.01) estimates obtained for all the traits. Very high estimates were obtained for the general level of production (a) while others were within the range of 0.3 – 0.5.

The range of 0.3 – 0.5 h^2 estimates obtained for both b, c, and T closely agrees with Cianci *et al.*, (1989) estimate for milk yield in Massere sheep through daughter-dam regression. The high estimate obtained for (a) was rather unusual as it exceeded most values reported from literature (0.2 – 0.4) for all the milk yield traits (Daltons, 1982). Also, heritability estimates from variance component may be subjected to large sampling errors and can be over-estimated due to inclusions of non-additive genetic effects (Warwick and Legates, 1970).

Correlations for Lactation Parameters

The genetic (r_g) and phenotypic (r_p) correlations between the lactation parameters are represented in Table 2. Both positive and negative estimates were obtained. For the r_g, positive and high estimates were recorded between a and T and b and c. However, negative but moderate correlations were between a and b while negative and low estimates were observed for other combinations for r_p. Thus while correlation between a and b was low and positive that between a and c, a and T and b and c respectively were moderate and positive. A negative but weak r_p was recorded between **b** and T, while between c and T it was still negative and low.

The genetic correlations (r_g) between the lactation parameters do not follow a particular pattern. These conflicting results especially in sign however pointed out that the additive action of the gene responsible for these parameters (lactation traits) has a greater influence at the early lactation. Invariably, the potential of ewes in late lactation is more prone to the environment compared to the early lactation. This is clearly evidenced from the result of the phenotypic correlations between these traits. It should be noted that since the genetic correlation is also a function of the covariance and respective variances of two traits, it is subjected to the same sources of bias with regard to variance component estimates.

TABLE 2: ESTIMATES OF HERITABILITY, GENETIC, PHENOTYPIC AND ENVIRONMENTAL CORRELATIONS BETWEEN LACTATION PARAMETERS AND 84 DAYS LACTATION IN YANKASA EWES

Traits	Variance or covariance components					
	Among	Within	h^2±S.E.	r_g±S.E.	r_p	r_e
A	0.0537	0.0980	1.42±0.43			
B	0.0038	0.0473	0.30±0.27			
C	0.0003	0.0043	0.28±0.27			
T*	1.1898	8.3989	0.50±0.32			
a and b:	-0.0324	-0.0116		-0.43±0.48	0.20	-0.14
a and c:	-0.0016	0.0051		0.39±0.42	0.26	-0.02
a and T:	0.2042	0.3447		0.81±0.21	0.46	0.49
B and c:	0.0080	0.0087		0.72±0.37	0.62	0.58
B and T:	0.0325	-0.1051		-0.29±0.38	-0.10	-0.49
c and T:	0.0273	-0.0399		-0.11±0.47	-0.06	-0.96

T* = Total Lactation yield at 84 days.

CONCLUSION

In conclusion, the moderate estimates of h^2 obtained for curve parameters in this study indicates that improvement of milk production performance of the Yankasa through selection is possible. Similarly, the magnitude of the estimates of correlations between BWT and WWT probably indicates that selection based on BWT will improve WWT.

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INFLUENCE OF BREED AND ENVIRONMENTAL FACTORS ON LITTER PARAMETERS OF RABBITS RAISED IN A SEMI-HUMID ENVIRONMENT

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ABSTRACT

The influence of breed and environmental factors such as season, temperature, relative humidity, sunshine hours and wind speed on litter parameters of rabbits raised in a semi-humid environment was investigated using two hundred and twenty four (224) litter records collected between 1991 and 1997. New Zealand White does kindled significantly (P<0.05) larger and heavier litter at birth than the other breeds. Crossbred does produced kits with significantly higher preweaning daily gain and lower neonatal mortality compared with the purebred does. Chinchilla and Crossbred does raised kits with significantly (P<0.05) heavier weaning weights than New Zealand White and Californian does. There was a non-significant effect of season on litter size at birth, kits alive at birth and neonatal mortality. Does that kindled in the cool-wet season had significantly (P<0.05) higher litter birth weight and average kit birth weight compared with does that kindled in the cold-dry and hot-dry seasons. Kits kindled in the hot-dry season had significantly higher preweaning litter daily gain and lower preweaning mortality than those kindled in the other seasons. Does that kindled in the hot-dry and cool-wet seasons weaned more kits than those that kindled in the cold-dry season. There was a significant (P<0.05) negative correlation between maximum temperature and litter size alive at birth, litter birth weight, litter weaning weight, average weaning weight and litter size at weaning. Rainfall and relative humidity had significant positive correlation with average birth weight, while, wind speed was positively correlated with average weaning weight. This study indicates that the best season for rabbit breeding in the semi-humid environment is the hot-dry (February-May) season. Maximum temperature was also observed to be more critical to rabbit reproduction as it influenced negatively more litter parameters than other environmental factors studied.

Keywords: Environment, Season, Litter parameters, Rabbits

INTRODUCTION

There exists breed and seasonal variations in reproductive performance of rabbits. Work done in temperate regions show marked variation in breed (Lukefahr *et al.*, 1983) and environment (Lebas *et al.*, 1986) on performance of rabbits. Prolificacy depends on the season and the reproductive rate imposed on the doe. In healthy does receiving normal feed and 12-14 hours light, prolificacy seems to be linked to adult size (Lebas *et al.*, 1986).

Effects of environmental factors such as season (Iyeghe *et al.*, 1993; Abdulmalik *et al.* 1993; Yahaya, 1993), temperature, humidity, air flow and day length (Lebas *et al.*, 1986) on reproductive performance of rabbits have been reported. High temperatures exceeding 30-33°C were reported to cause an increase in embryonic mortality (Lebas *et al.*, 1986). Yahaya (1993) reported higher preweaning mortality for kits born between February and May than between June and September. Not much work has however been done on the effect of the individual components of the environment on performance of rabbits in the tropics. This study was undertaken to investigate the influence of breed and environmental factors such as season, rainfall, temperature, relative humidity, sunshine hours and wind speed on litter parameters of rabbits raised in a semi-humid environment.

MATERIALS AND METHODS

Two hundred and twenty four (224) litter records collected between 1991 to 1997 were used to investigate the effect of breed and environmental factors on litter parameters of rabbits kept under semi humid conditions. The data were obtained at the National Animal Production Research Institute, Shika, located between latitude 11° 11" and longitude 7° 38" in the Northern Guinea Savanna. The rabbits were raised individually in cages in a completely walled house with open windows. They were fed concentrate mash in the morning and forages in the evening. Water was provided *ad libitum* daily. Litter parameters measured were: date of kindling, total litter size at birth (LSB), litter size born alive (LSA), litter birth weight (LBWT), average kit birth weight (ABWT), litter size at weaning (LSW), litter weaning weight (LWT), average kit weaning weight (AWT), preweaning litter daily gain and kit mortality to weaning. Kits were weaned six weeks after birth. Breeds of doe used were New Zealand White, California, Chinchilla and Crossbred does. Data for rainfall, relative humidity, temperature, sunshine hours and wind speed were obtained from the Institute for Agricultural Research, Ahmadu Bello University, Zaria. Table 1 shows a summary of the climatic data obtained between 1989 and 1995 for the study area. For the purpose of this study, season of birth of kits was divided into three namely; cold-dry (October-January), hot-dry (February-May) and cool-wet (June-September). The climatic data were correlated with the litter parameters using Pearson correlations matrix, while season and breed effects were subjected to analysis of variance test and significant differences obtained by pair-wise difference comparison (SAS, 1987).

RESULTS AND DISCUSSION

Breed and seasonal influence on litter size at birth, alive at birth and weaning is shown in Table 2. New Zealand White does had significantly ($P<0.05$) larger litter size at birth than California, Chinchilla and Crossbred does. Litter size alive at birth and at weaning was similar for all the breeds. Season had no effect on litter size at birth and litter size born alive. This result is in agreement with that obtained by Abdulmalik *et al.* (1993) and Yahaya (1993). There was a significant ($P<0.05$) effect of season on litter size at weaning. Does that kindled in the cool-dry season weaned significantly fewer kits than in the hot-dry and cool-wet seasons. This does not agree with the report of Yahaya (1993) and Abdulmalik *et al.* (1993) who reported no seasonal influence on litter size at weaning New Zealand White and California does had significantly ($P<0.05$) heavier kits at birth than Chinchilla and Crossbred does (Table 3). The reverse was the case for litter weaning weight. Yahaya (1993) reported higher litter birth weight for New Zealand White does than California and Chinchilla does. Litter weaning weight was higher for kits kindled in the cool-wet and hot-dry seasons. Litter birth weight and average kit birth weight were higher for kits kindled in the cool-wet season than other seasons. This could be attributed to higher feed intake as a result of the lower daily temperatures, which is in turn translated into tissue in the growing rabbit. In late pregnancy, this is laid down in the foetus.

TABLE 1: SUMMARY OF THE MEAN MONTHLY RAINFALL (MM), RELATIVE HUMIDITY (%), TEMPERATURE (°C), SUNSHINE HOURS AND WIND SPEED (MLS/SEC) FOR ZARIA BETWEEN 1989 AND 1995

Month	Rainfall	Relative humidity	Minimum temperature	Maximum Temperature	Sunshine hours	Wind speed
January	0.00	20.48	12.17	28.10	7.05	141.38
February	0.00	16.09	15.00	31.06	7.26	117.10
March	6.39	20.99	18.94	35.07	7.28	144.00
April	27.7	37.06	21.93	36.19	7.87	189.76
May	118.8	58.05	20.93	33.59	7.37	191.80
June	141.8	61.71	1960	30.80	6.45.	194.16
July	205.7	72.76	20.19	28.97	6.30	162.20
August	259.6	77.16	19.76	28.40	5.22	130.36
September	136.3	71.52	19.74	30.03	6.45	92.92
October	36.41	56.40	18.24	31.94	8.28	76.12
November	0.37	25.42	14.13	31.17	8.72	92.16
December	0.07	20.41	12.97	28.20	7.53	133.40

TABLE 2: INFLUENCE OF BREED AND SEASON ON LITTER SIZE OF RABBITS

Criterion	Litter size at birth	Litter size alive at birth	Litter size at weaning
Breed:			
NZW	5.14 ± 0.3^{a}	4.30 ± 0.3^{a}	1.24 ± 03^{a}
CC	4.26 ± 0.3^{b}	3.96 ± 0.3^{b}	1.37 ± 0.4^{ac}
CH	4.42 ± 0.4^{b}	4.13 ± 0.3^{a}	2.29 ± 0.5^{bc}
Cross	4.86 ± 0.2^{b}	4.72 ± 0.2^{a}	2.58 ± 0.2^{b}
Season:			
Cold-dry	4.38 ± 0.4	4.15 ± 0.4	1.11 ± 0.4^{a}
Hot-dry	4.74 ± 0.2	4.22 ± 0.2	2.39 ± 0.2^{b}
Cool-wet	4.89 ± 0.2	4.46 ± 0.3	2.11 ± 0.3^{b}

Means with different superscript within columns are significantly different (P<0.05).
NZW (New Zealand White), CC (California), CH (Chinchilla).

The influence of breed and season on preweaning litter daily weight gain, neonatal and preweaning mortality is shown in Table 4. Crossbred does had significantly lower neonatal mortality and higher preweaning litter daily gain than the purebred does, indicating that Crossbred does likely produced more milk to cater for their kits than the purebred does. This agrees with Lebas *et al.* (1986) who reported that crossed does produce more milk than purebred does. New Zealand White does had higher stillbirths and preweaning mortality while Chinchilla does had the lowest preweaning mortality. This does not agree with Yahaya (1993) who reported a non-statistically higher preweaning mortality for California does and lowest mortality for New Zealand White does. Kits kindled in the hot-dry season grew faster than those kindled in the cool-wet and cold-dry seasons. Iyeghe *et al.* (1993) however, reported better performance by kits kindled in the late wet season (July-September) than those kindled in the early wet (April-June) and late dry (January-March) seasons. They attributed this

TABLE 3: INFLUENCE OF BREED AND SEASON ON LITTER WEIGHT (gms) OF RABBITS

Criterion	Litter birth Weight	Average kit birth weight	Litter weaning weight	Average kit weaning weight
Breed:				
NZW	254.17 ± 016.5^{a}	50.40 ± 2.8^{a}	1117.92 ± 243.7^{a}	835.06 ± 62.4
CC	190.05 ± 018.4^{b}	53.59 ± 3.3^{c}	1044.20 ± 266.6^{a}	769.30 ± 71.3
CH	165.95 ± 24.4^{b}	41.74 ± 4.3^{b}	1787.61 ± 324.0^{b}	789.30 ± 68.6
Cross	222.42 ± 8.6^{ab}	47.53 ± 1.5^{ab}	1660.24 ± 152.9^{b}	726.79 ± 37.3
Season:				
Cold-dry	202.34 ± 18.3^{a}	45.97 ± 3.2^{a}	976.03 ± 309.1^{a}	847.93 ± 76.8
Hot-dry	191.80 ± 9.8^{a}	45.85 ± 1.7^{a}	1583.53 ± 146.2^{b}	704.45 ± 35.6
Cool-wet	230.29 ± 14.3^{b}	53.13 ± 2.5^{b}	1647.93 ± 205.0^{b}	788.01 ± 48.4

Means with different superscript within columns are significantly different (P<0.05).
NZW (New Zealand White), CC (California), CH (Chinchilla).

to higher feed intake occasioned by cool environmental conditions resulting from constant rainfall and lower ambient temperature. Stillbirths was lower (P>0.05) in the cold-dry season than in the cool-wet and hot-dry seasons while preweaning mortality was highest in the cold-dry season and lowest in the hot-dry season. This result is at variance with that by Yahaya (1993) who reported higher mortality at weaning for kits born between February and May (hot-dry) than between June and September (cool-wet). The relationship between litter parameters and environmental factors is summarized in Table 5. Rainfall and relative humidity had significant positive correlation with average kit birth weight and litter weaning weight. This is in agreement with Lebas *et al.* (1986) who reported that rabbits are more sensitive to very low humidity than very high humidity. There was a significant negative correlation between maximum temperature and litter size alive at birth, litter birth weight, litter weaning weight, average kit weaning weight and litter size at weaning. This result indicates that the most

TABLE 4: BREED AND ENVIRONMENTAL INFLUENCE ON KIT PREWEANING DAILY GAIN AND MORTALITY OF RABBITS[1]

Criterion	Preweaning daily gain (g)**	Stillbirths	Preweaning mortality**
Breed:			
NZW	25.11 ± 6.7^{a}	0.84 ± 0.2^{a}	3.06 ± 03^{ac}
CC	34.41 ± 7.6^{a}	0.30 ± 0.2^{bc}	2.60 ± 0.4^{ac}
CH	36.52 ± 8.4^{a}	0.29 ± 0.2^{bc}	1.84 ± 0.4^{b}
Cross	59.20 ± 2.9^{b}	0.15 ± 0.1^{c}	2.14 ± 0.2^{bc}
Season:			
Cold-dry	30.10 ± 6.8^{a}	0.24 ± 0.2	3.04 ± 0.4^{a}
Hot-dry	46.17 ± 3.8^{b}	0.52 ± 0.1	1.83 ± 0.2^{b}
Cool-wet	40.16 ± 4.8^{a}	0.43 ± 0.1	2.35 ± 0.3^{a}

[1]Means with different superscript within columns are significantly different (P<0.05, 0.001)
**P<0.001. NZW (New Zealand White), CC (California), CH (Chinchilla).

critical environmental factor affecting rabbit production in the semi-humid environment is the maximum temperature. This is in agreement with Lebas *et al.* (1986) who reported that high temperatures affect female rabbits negatively by lowering their prolificacy. High temperatures have been reported to decrease feed intake, litter size, growth rate and increase abortion and fetal resorption (Ingram and Mount, 1975; Lange, 1985). Sunshine hours were negatively correlated with average kit birth weight. This effect could be an indirect effect of sunshine on the does. Exposure of does to 14-16 hours of sunshine has been reported to favour sexual activity and fertilization (Lebas *et al.*, 1986) which could translate into higher litter size and lower average kit birth weight. Wind speed was positively correlated with average kit weaning weight. Leba *et al.* (1986) reported that the higher the temperature the higher the airflow needed for ventilation of the rabbitry for healthy growth of rabbits. They further observed that an imbalance in temperature and airflow causes respiratory disorders and intenstinal blockade in rabbits. Minimum effects were noted for the other factors probably because the rabbits were housed and therefore, protected to some extent from the full effect of these environmental

TABLE 5: RELATIONSHIP (CORRELATION COEFFICIENT) BETWEEN ENVIRONMENTAL FACTORS AND LITTER TRAITS OF RABBITS UNDER SEMI HUMID ENVIRONMENT

Trait	Rainfall	Relative humidity	Temp. min.	Temp. max.	Sunshine length	Wind speed
LSB	-0.004	-0.004	-0.013	-0.007	-0.016	-0.002
LSA	0.042	0.047	-0.083	-0.143*	-0.026	-0.005
LBWT	0.070	0.038	-0.088	-0.158*	-0.0142	-0.030
ABWT	0.221**	0.195**	0.067	-0.0122	-0.0218**	0.096
LWT	0.131*	0.132*	-0.0061	-0.0190**	-0.048	0.093
AWT	0.151	0.0126	-0.025	-0.0190*	-0.106	0.213**
LSW	0.050	0.064	-0.084	-0.0145*	0.020	-0.031
NM	-0.082	-0.105	0.126	0.243	0.019	0.006
PWM	-0.015	-0.030	0.015	0.025	-0.045	0.029

*p<0.05; ** p<0.01.
LSB: Litter size at birth
LSA: Litter size alive at birth
LBWT: Litter birth weight
ABWT: Average kit birth weight
NM: Stillbirth
Temp. Max: Maximum temperature
LWT: Litter weaning weight
AWT: Average kit weaning weight
LSW: Litter size at weaning
PWM: Preweaning mortality
Temp. Min.: Minimum temperature

factors. It could be concluded from this study that breed of doe had significant effect ($P<0.05$) on all parameters measured except average weaning weight. Crossbred and Chinchilla does have higher litter size and weight at weaning than New Zealand White and California does. Though rabbits can be bred all year round, the best season for rabbit breeding in the semi-humid environment is the hot-dry (February-May) season. Maximum temperature was observed to be more critical to rabbit reproduction as it influenced negatively more litter parameters than other environmental factors studied.

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