

Impact of genetic and environmental factors on birth weight of Fulbe sheep in Cameroon

A.L. Ebangi¹ D.A. Mbah² A.C. Ngo Tama¹

Key words

Fulbe Sheep - Birth weight - Heritability - Analytical method - Statistical analysis - Parturition interval - Cameroon.

Summary

From 1984 to 1990, data were collected on birth weights of 607 progeny from 266 dams, originating from a random bred non-selected foundation population of Fulbe sheep kept at the Animal and veterinary Research Station, Garoua (IRZV). The results from the analyses showed that the average age at first lambing was 15 months and the majority of the ewes (57.69 %, n = 225) lambled once. Conceptions peaked at the beginning and at the end of the rainy season. The mean lambing interval decreased with increase in parity and ranged from 10.8 to 13.3 months. Sex of the animals and sex by type of birth interaction did not affect birth weights ($p > 0.01$). On the other hand, the random effect of dam and the fixed effects of year of birth, month by year interaction, type of birth and parity ($p < 0.001$) were higher than the effect of month of birth ($p < 0.01$). Heritability estimates from lambing interval regression of the offspring on that of the dam, the birth weight of the lamb on that of the ewe and from dam variance component were 0.07, 0.35 and 0.45, respectively.

INTRODUCTION

Sheep production plays an important role in the economy and socio-cultural activities of the people of the North and Far North provinces of Cameroon. The sheep population in this part of the country is about 57.8 % of the national sheep population (15). The Fulbe breed found there is dominantly white in coat colour, has long legs, large and long ears that droop on the sides of the head. The females are hornless and the males have long, spiral and horizontal horns. Husbandry practices are mostly in small flocks located in rural areas, in a subsistence manner, with minimal management and capital investment. Consequently, sheep production is in the hands of the rural farmers whose methods of production may not be appropriate in improving flock size and scale of operation. This, as well as the limited information available on the role of existing environmental factors in determining productivity, seriously affect the farmers' earnings in this sector of the economy.

The role of environmental factors in determining sheep productivity in this area is very important because of the

variability, severity and length of the dry season which directly affect forage production. Knowledge of the role of these factors will permit carrying out modifications towards improvement strategies aimed at increasing productivity and/or adjusting the records of reliable genetic parameter estimates.

Therefore, the objectives of this study include identification of environmental factors that influence birth weight of Fulbe sheep reared under relatively rural conditions, determination of the maximum lambing period, oestrous and ovulation activities, determination of productivity parameters under such environment and genetic evaluation of ewe performance through statistical adjustment of productivity for significant management and environmental influences.

MATERIALS AND METHODS

Data on birth weights were collected from 1984 to 1990 from a random bred non-selected foundation population of Fulbe (Peulh) sheep maintained at the Animal and veterinary Research Station, Garoua, Cameroon. All the animals were identified with ear tags. Each progeny was pedigreed only by dam. Individual sire identification of lambs was not possible because the ewes were exposed to several rams simultaneously. Management practices were relatively rural. The animals were allowed to graze on

1. Institute of animal and veterinary research (IRZV), PO Box 1073, Garoua, Cameroon

2. Ministry of scientific and technical research, PO Box 1457, Yaoundé, Cameroon

unimproved pastures during the rainy and dry seasons and were given varying quantities of feed supplementation (cotton seed cake and brewer's dry grain) in the dry season.

This region is located within the Sudano-Guinean zone of Cameroon. The rain pattern divides the year into two distinct seasons: a rainy period that usually begins in April and ends in October, with no consistent pattern of rainfall, and a very severe dry season from November to April. There is such an irregular variation in precipitation that the quality and quantity of forage available for grazing change according to the seasonality and distribution of rain.

Ewes and lambs were identified and the lamb birth weights (kg), sex, parity, type of birth, month and year of birth were recorded within 24 h of lambing.

Statistical model and analytical technique

The linear model (dam model) used to obtain the least squares means (LSM) estimates for lamb birth weights was as follows:

$$Y_{ijklmno} = \mu + D_i + M_j + Y_k + S_l + T_m + U_n + (MY)_{ij} + e_{ijklmno}$$

where,

$Y_{ijklmno}$ = birth weight of the 0th lamb, from the nth parity, of the mth type of birth, of lth sex, born in the jth month of the Kth year by the ith ewe randomly mated,

μ = overall mean,

D_i = random effect of the ith ewe ($i = 1, 2, \dots, D = 266$),

M_j = fixed effect of the jth month of birth ($j = 1, 2, \dots, M = 12$),

Y_k = fixed effect of the kth year of birth ($k = 1, 2, \dots, Y = 7$),

S_l = fixed effect of the lth sex ($l = 1, 2$),

T_m = fixed effect of the mth type of birth ($m = 1, 2$),

U_n = fixed effect of the nth parity ($n = 1, 2, \dots, U = 5$) and

$(MY)_{ij}$ = effect of the interaction of the ith month of birth with the jth year of birth, and

$e_{ijklmno}$ = random error, iid ($0, \sigma^2_e$).

The data were analysed using the Mixed model least-squares and Maximum likelihood computer program (9) which adjusted for fixed effects. This method uses Henderson's method 3 (10) to estimate the dam variance component (σ^2_d) and the error variance component (σ^2_e) from which heritability (h^2_d) and its error were computed. The least squares means estimates (LSM) and their appropriate standard errors were also computed using LSMLMW Computer Program (9).

Estimates of the regression coefficients and standard errors of offspring lambing interval and birth weight on the ewe lambing interval and birth weight (b_{op}) were carried out according to the method reported by Mead and Curnow (14). Heritabilities and their standard errors were estimated as described by Falconer (6). Ewes which lambed more than once were considered as separate entries due to the fact that the age of the ewe has been shown to significantly affect her performance (1, 17).

RESULTS AND DISCUSSION

Although, the ewes lambed all around the year, there was a variation in the number lambed per month. The highest number of births was registered for the month of October followed by that of February (table I). This could be an indication that a high rate of conception took place around the months of May and September, respectively. Consequently, the period of maximum oestrous and ovulation activities could be at the beginning and at the end of the rainy season. Ngo-Tama *et al.* (unpublished results), however, indicated the months of September and November as months of high rate of conception for the same breed. The difference may be due to sample size and seasonal variations. The period of maximum oestrous and ovulation activities may also differ within regions and breeds. The Moroccan Sardi, Beni-Guil and Timahdite breeds show maximum oestrous and ovulation activities during the months of June to January (8). Bearing this in mind, it can be possible to influence the optimum weight for early sexual maturity by giving appropriate feed to the dams during pregnancy and to the lambs up to puberty.

Statistically, there was a significant month effect ($p < 0.01$) on birth weights. A comparative month effect ($p < 0.005$) was reported by Ngo-Tama *et al.* (unpublished results) for the same breed. Fall *et al.* (7) also reported a month effect ($p < 0.001$) for tropical sheep. Bathaei and Leroy (1), however, reported a non-significant month effect ($p > 0.001$) for the Iranian fat-tailed Mehraban sheep.

The year effect on birth weight was highly significant ($p < 0.001$). Similar results have been obtained by various researchers on various breeds (1, 4, 7, 16). The interaction effect of month by year of birth was quite significant ($p < 0.001$). Bathaei and Leroy (1) reported similar results. The significant effects of month, year and month by year of birth interaction could be due to seasonal variations, associated with nutritional problems, climatic stress, incidence of diseases, herdsman skill or probable changes in the genetic make-up of the flock during the long period of breeding. These variations caused changes in the quantity and quality of forage, and in the weight and body condition of gravid ewes. These effects subsequently influenced the lamb birth weights.

The random effect of dam on lamb birth weight was highly significant ($p < 0.001$). Foetuses of gravid dams tend to receive nutrients in priority and, therefore, are to a degree protected from environmental fluctuations (4), but differences in the genes transmitted from the dam to the offspring, variations in pre-natal environment and changes in the dam nutrition and body condition could seriously affect the birth weights.

Birth types are presented in table II. Though single births were predominant, twinning was also significant. Triplets and quadruplets, however, were not common. Ngo-Tama *et al.* (unpublished results) obtained comparable results for the same breed. Shelton and Menzies (17) reported a range of 7.7 to 28.9 % and 19.7 to 44.3 % of multiple births for fine-wool sheep maintained in two different stations. The type of birth effect was quite significant ($p < 0.001$). Single lambs were heavier at birth than twins. Similar results have also been reported by various researchers (13, 16). This could result from the limited capacity of the ewe to provide pre-natal nourishment for the development of the foetus. Therefore, where twins are concerned, feed supplementation may be necessary to compensate for the deficiencies they might have acquired in their pre-natal environment and while competing for maternal milk (4, 16).

TABLE I

Least squares means (LSM) and standard error (s.e.) of birth weight (kg) according to significant environmental fixed effects (n = 607)

Main effect	Nbr. obs.	LSM of birth weight	s.e.
Month of birth**			
January	45	1.77	0.13
February	73	1.84	0.11
March	48	1.89	0.12
April	50	2.11	0.14
May	48	2.14	0.13
June	43	2.29	0.13
July	44	2.42	0.14
August	48	2.11	0.13
September	56	2.19	0.13
October	82	2.19	0.10
November	39	2.15	0.13
December	31	2.54	0.15
Year of birth***			
1984	20	2.45	0.53
1985	78	1.84	0.15
1986	89	1.55	0.13
1987	64	1.72	0.14
1988	89	2.12	0.12
1989	123	2.55	0.11
1990	144	2.71	0.11
Sex (ns)			
Male	322	2.19	0.05
Female	285	2.07	0.09
Type of birth***			
Single	397	2.32	0.05
Double	210	1.95	0.06
Interactions			
Month by year***	607	2.14	0.37
Single x male (ns)	227	2.41	0.06
Double x male (ns)	95	1.98	0.08
Single x female (ns)	170	2.22	0.07
Double x female (ns)	115	1.92	0.08
Parity***			
1	350	2.15	0.06
2	134	2.29	0.08
3	100	2.44	0.13
4	20	2.15	0.12
5	3	3.53	0.39

** = $p < 0.01$; *** = $p < 0.001$

nbr. obs. = number of observations

n.s. = non-significant

TABLE II

Type of birth (n = 593)

Traits	Nbr. births	% birth	% progeny
Single	465	78.4	63.8
Twin	125	21.1	34.3
Triplet	2	0.3	0.8
Quadruplet	1	0.2	0.6

TABLE III

Lambing percentage of ewes (n = 390)

Traits	Nbr. ewes	%
Lambled once	225	57.69
Lambled twice	76	19.49
Lambled thrice	42	10.77
Lambled four times	29	7.44
Lambled five times	13	3.34
Lambled six times	5	1.26

The percentage of ewes that lambled decreased with increase in parity (table III). This could be an indication of a negative correlation between age of the ewes and lambing percentage.

The age of the ewe has been shown to significantly affect her performance (1, 17). Consequently, under random mating conditions it may be economical to carry out a selection based on breeding to increase ewe fertility (twinning) under improved management as multiple births could result in maximum meat output per unit of input. Selection in this direction, however, will depend on the economic advantages of feed supplementation (3, 4) and its availability during the stressful period to compensate for slow growth of lambs born and raised as twins (16).

Parity was equally a very significant source of variation for the lamb birth weight ($p < 0.001$). Comparative results have been reported on various breeds by Bologum *et al.* (5), Fall *et al.* (7) and Inyangala *et al.* (11). This is because first parity dams are still growing and therefore must provide for their nourishment and that of the foetus.

The mean, s.e. and range of age at first lambing were 15, 5.8 and 8-28 months, respectively (n = 112). Similar results were obtained by Ngo-Tama *et al.* (unpublished results) for the same breed. The mean lambing interval decreased with increase in parity (table IV). Rajab *et al.* (16) explained this occurrence by the fact that ewes at

TABLE IV

Mean lambing interval (months) (n = 160)

Traits	Interval	SD
1st and 2nd parity (n = 76)	13.29	1.03
2nd and 3rd parity (n = 42)	12.26	1.89
3rd and 4th parity (n = 29)	10.92	5.29
4th and 5th parity (n = 13)	10.79	3.13

SD = Standard deviation

first parity just reached sexual maturity and, as a result, their ovulation rate and their efficiency in providing nourishment and ultra-uterine environment during pre-natal development was at its lowest. In this study involving a random mating system, most of the dams might have entered into reproductive life much earlier than it would have been with planned breeding practices.

The LSM and s.e. of the environmental effects studied are presented in table I. Although the LSM of male birth weights were higher than those of females for all the fixed effects and lambs from single births were generally heavier than those from double births, there was no significant sex effect ($p > 0.01$). The results compare favourably with those obtained by Rajab *et al.* (16) on the performance of three tropical hair sheep. Bathaei and Leroy (1) and Fall *et al.* (7), however, reported significant sex effects ($p < 0.001$) on birth weights for the Iranian fat-tailed Mehraban and tropical sheep breeds, respectively. The differences observed in the weights of male and female lambs could be due to hormonal differences in their endocrinological and physiological functions.

The heritability estimates and s.e. from the dam variance component and from the regression of offspring lambing interval (n = 44) and birth weight (n = 120) on the ewe are presented in table V. The estimate from the dam component is much larger than the estimate from the b_{op} indicating a substantial bias which could be due to common environment, maternal and/or dominance effects. On the other hand, this high estimate (0.45) from the dam component seemed to suggest a high variance of milking and maternal ability in this breed (to be proven). The estimate from the regression of offspring birth weight on the birth weight of the dam appeared to be free from unwanted variations due to environmental differences between sire groups, though the approach did not adjust for environmental factors. Although this estimate compares favourably with that of 0.33 reported by Bathaei and Leroy (2) on the Iranian fat-tailed Mehraban sheep breed, Fall *et al.* (7) on the Djallonke sheep breed, Strickberger (18) on the Shropshire sheep, it was higher than that reported by Inyangala *et al.* (12) on the Dorper sheep. This difference could be due to sample size, method of estimation, genotype-environmental interaction and breed type. This moderately high estimate seems to suggest that an intrapopulation selection carried out on birth weight of the Fulbe sheep breed could be genetically profitable. The heritability estimate of lambing interval from the regression of offspring lambing interval on dam is quite low, indicating the

TABLE V

Estimates of heritability, standard error and confident interval of lambing interval and lamb birth weight from dam component and from regression

Trait	Component	h^2	s.e.	CI (95 %)
Birth weight	Dam variance	0.45	0.23	0.01-0.9
	Regression	0.35	0.12	0.1-0.6
Lambing interval	Regression	0.07	0.05	0.04-0.2

 h^2 = heritability

s.e. = standard error

CI = confident interval

important role of environmental factors in the determination of this trait.

CONCLUSION

Climate related environmental factors such as month, year of birth and month by year of birth interaction severely affect the birth weight of the Fulbe sheep ($p < 0.001$). Maximum oestrous and ovulation activities appear to be important at the beginning and the end of the rainy season. The random effect of dam, and the fixed effects of type of birth and parity are equally very pronounced on the birth weight of the Fulbe lambs. Genetic factors also play a very important role in the determination of the birth weight of Fulbe sheep. This denotes a high estimate of heritability (h^2_d) from the dam variance component and a moderate estimate from regression (b_{op}). The moderately high estimate of 0.35 and the low s.e. of 0.12 could suggest that the birth weight of the lambs could be used for mass selection. On the other hand, environmental factors seem to influence lambing interval more than is expected of genetic factors as shown by the very low estimate of heritability from regression.

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Résumé

Ebangi A.L., Mbah D.A., Ngo Tama A.C. Effets génétiques et de l'environnement sur le poids à la naissance de moutons Foulbé (Peulh) au Cameroun

De 1984 à 1990, les poids à la naissance de 607 agneaux nés de 266 mères ont été enregistrés. La population initiale était composée de moutons Foulbé non-sélectionnés et les accouplements se faisaient au hasard. Les animaux étaient entretenus sur la Station de recherches zootechniques et vétérinaires de Garoua (IRZV). Les résultats de l'analyse des données ont montré que l'âge moyen au premier agnelage était de 15 mois et que la majorité des brebis (57,7 p. 100, n = 225) avait agnelé une fois seulement. Le maximum de fécondations a eu lieu au début et à la fin de la saison des pluies (mai et septembre). L'intervalle moyen entre mises bas compris entre 10,8 et 13,3 mois diminuait avec l'augmentation du rang de mise bas. Le sexe et l'interaction sexe x type de naissance n'ont pas d'effet sur le poids à la naissance ($p > 0,01$). D'autre part, l'effet aléatoire maternel et les effets fixes de l'année de naissance, de l'interaction d'année x mois de naissance, du type de naissance et de la parité étaient plus prononcés ($p < 0,001$) que l'effet mois de naissance ($p < 0,01$). Les estimations de l'héritabilité à partir de la régression de l'intervalle de mise bas de la descendance sur celui de la mère, du poids à la naissance de l'agneau sur celui de la brebis et à partir de la composante de la variance de la mère étaient 0,07, 0,35 et 0,45, respectivement.

Mots-clés : Ovin - Mouton Foulbé - Poids à la naissance - Héritabilité - Technique analytique - Analyse statistique - Intervalle entre parturitions - Cameroun.

Resumen

Ebangi A.L., Mbah D.A., Ngo Tama A.C. Importancia de los factores genéticos y ambientales sobre el peso al nacimiento de las ovejas Fulbe en Camerún

Entre 1984 y 1990 se recolectaron datos sobre el peso al nacimiento de 607 crías de 266 hembras, originarias de una población al azar de raza no seleccionada de ovejas Fulbe, en la Estación de investigación veterinaria y animal, Garoua (IRZV). Los resultados de los análisis muestran que la edad promedio al primer parto fue de 15 meses y que la mayoría de las ovejas (57,65 p. 100, n = 225) parió de una cría única. Los picos de concepción se observaron al inicio y al final de la estación lluviosa. El intervalo entre partos promedio disminuyó conforme aumentó la paridad, variando entre 10,8 y 13,3 meses. El sexo de los animales y la interacción entre el sexo y el tipo de parto, no afectó los pesos al nacimiento ($p > 0,01$). Por otro lado, el efecto al azar de la hembra y los efectos fijos del año de nacimiento, interacción mes-año, tipo de parto y paridad ($p < 0,001$) fueron más elevados que el efecto del mes de nacimiento ($p < 0,01$). La heredabilidad, estimada mediante la regresión de los intervalos entre partos de las crías sobre el de las madres, el peso al nacimiento del cordero sobre el de la madre y el componente de varianza de la madre fueron de 0,07, 0,35 y 0,45 respectivamente.

Palabras clave : Ovino Foulbe - Peso al nacimiento - Heredabilidad - Técnica analítica - Análisis estadístico - Intervalo entre partos - Camerún.