BIRTH WEIGHT AND LITTER BIRTH WEIGHT IN YANKASA SHEEP: ENVIRONMENTAL FACTORS AND HERITABILITY ESTIMATES

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ABSTRACT

A study was conducted to examine the influence of five environmental factors on birth weight (BWT) and litter birth weight (LBWT) and to obtain heritability estimates for both traits in Yankasa sheep. Records of 2490 lambs sired by 133 rams and 1225 lambs sired by 120 rams from 1983-1993 at Shika were analysed for BWT and LBWT, respectively. The Yankasa flock was semi-intensively managed in an accelerated lambing programme. Least-squares means were 2.48 ± 0.03 kg and 3.57 ± 0.03 kg for BWT and LBWT, respectively. All five environmental factors considered (parity, sex, type of birth, season and year of birth) were highly significant ($P < 0.001$) for both traits. Lambs from multiparous ewes had higher body weights than lambs from primiparous ewes. Likewise, rainy-season-born lambs were heavier than dry-season-born lambs. Ram lambs were consistently heavier than ewe lambs for both traits, their superiority also being reflected in higher LBWT for mixed sexes. Single born lambs were superior in BWT to twin born lambs, with a difference of 0.39 kg in favour of single lambs. Twins were however, superior to single lambs for LBWT. Heritability estimates by paternal half sib analyses, after appropriately adjusting data for the fixed effects, were 0.41 ± 0.08 and 0.12 ± 0.07 for BWT and LBWT, respectively. These results indicate that high genetic response is expected from selection for BWT, while low response is expected for LBWT. Adjustment for environmental effects is necessary to enhance the accuracy of selection for superior individuals in terms of gene expression for these traits.

Key words: Birth/Litter Weights, Environment/Additive adjustment factors, Heritabilities

INTRODUCTION

Weight of lamb at birth is an important parameter as it influences subsequent growth rate. Strong and healthy lambs that are heavy at birth are generally found to be superior in vigor and tend to be heavier in weight postnatally (Hammada, 1976). Twins and triplets are smaller at birth than singles but their total weight may be more (Goodwin, 1971). Average birth weights for several indigenous breeds range from about 2.12kg (twin) for Nigerian Dwarf (Taiwo *et al.*, 1982) to 3.8kg (single) for Uda (Adu, 1978). While 3.08kg has been recorded for LBWT in Yankasa sheep (Osinowo *et al.*, 1993). High mortality rates of 44.8% and 13% have been reported for Bannur lambs (Narayanakswamy and Yadav, 1981) and Menz ewe lambs (Muka-Mugerwa *et al.*, 1991), respectively, weighing less than 1.3kg at birth.

The size of offspring at birth is controlled by factors other than nutrition during pregnancy, the more important of which are sex (Goodwin, 1971, Hassan, 1987 and Osinowo *et al.*, 1990; 1993), breed type (Goodwin, 1971), parity of dam (Hassan, 1987; Ganai and Pandey, 1990; Osinowo *et al.*, 1990; 1992), type of birth, (Goodwin, 1971; Adu, 1978, Adu and Ngere, 1979; Buvanendran *et al.*, 1981, Hassan, 1987; Osinowo *et al.*, 1990, 1993) and season of birth (Hassan, 1987; Osinowo *et al.*, 1989; 1992). Size at birth is also controlled by the dam by means of a special substance in the mother's blood stream which prevents the foetus from growing to such a size as to prevent parturition (Goodwin, 1971). Generally, lambs born from hoggets and yearlings are lighter in weight than those from older ewes, likewise, females are lighter than male lambs. Poor nutrition of pregnant ewes

especially during the dry season tends to BWT while lambs born during the rainy season are generally heavier (Eltawil *et al.*, 1970). Very few investigations have so far been made on BWT and LBWT for indigenous sheep breeds and, in most cases, with much fewer records on environmental factors influencing these traits and heritability estimates. There is therefore need for broader investigation with larger data sets to obtain more reliable estimates of correction factors and heritabilities.

The main objective of this study is to examine the influence of some environmental factors on BWT and LBWT, derive adjustment factors for BWT and obtain heritability estimates for both traits.

MATERIALS AND METHODS

The environment and management of the flock had been previously described by Osinowo *et al.* (1993). Yankasa sheep at the National Animal Production Research Institute were routinely bred to lamb twice a year. Ewes were either artificially inseminated or mated to rams following heat detection using aproned rams. Not more than 15 ewes were allowed to a ram. Following lambing, lambs were individually identified and weighed. The 2490 records employed for analyses of BWT were obtained from 1756 dams and 133 sires, while 1225 lambings from 798 dams and 120 rams were used for LBWT.

Statistical analyses.

Fixed effects of parity (1-6), sex (male, female or mixed sexes), type of birth (single or twin), season of birth (late dry, early wet or early dry) and year of birth (1983-1993) were examined using mixed model least-squares and maximum likelihood computer program (Harvey, 1990). The factors were incorporated in the following linear additive model:

$$B_{ijklmn} = U + P_i + S_j + T_k + Z_l + Y_m + E_{ijklmn}$$

where B_{ijklmn} is BWT (kg) of individual lambs of LBWT (kg) of lambs per ewe lambing, U is the overall mean BWT or LBWT, P_i is the fixed effect of i^{th} parity ($i =$

1, ..., 6), S_j is the fixed effect of j^{th} sex of lamb ($j = \text{Male, female or mixed}$) T_k is the fixed effect of k^{th} type of birth ($k = \text{Single or twin}$), Z_l is the fixed effect of l^{th} season of birth ($l = \text{Late dry, early wet, late wet or early dry}$) Y_m is the fixed effect of m^{th} year of birth ($m = 1983-1993$) and E_{ijklmn} is the random error associated with each record, (normally, independently and identically distributed with mean, zero and variance, σ^2)

Least-squares constants for the fixed effects obtained from fitting the model above were used to derive additive adjustment factors, thus:

$$a_{ijkl} = - (P_i + S_j + T_k + Z_l)$$

where a_{ijkl} is the additive factor for i^{th} parity of dam j^{th} sex of lamb, k^{th} type of birth and l^{th} season of birth, and P_i , S_j , T_k and Z_l were additive constant estimates (deviations from P_i , S_j , T_k and Z_l) for i^{th} parity of dam, j^{th} sex of lamb, k^{th} type of birth and l^{th} season of birth respectively. The additive factor for a female lamb born single to a fourth parity dam in the late wet season was set to zero as a base class from which additive correction factors were constructed.

Heritabilities were estimated by intra-class correlation method using paternal half-sibs, following adjustment of records for environmental effects. The sources of variation were between (σ^2_s) and within (σ^2_e) sires. Since sires were mated to random females from the population, it was assumed that the between sire variance component estimate will contain 25% of the additive genetic variance while the within sire variance component estimate will contain 75% of the additive genetic variance (Harvey, 1990). Therefore,

$$h^2 = \frac{4\sigma^2_s}{\sigma^2_s + \sigma^2_e}$$

where h^2 is the heritability, σ^2_s is the between sire variance component and σ^2_e is the within sire variance component

RESULTS

Least-squares means ($\pm$ SE) for BWT and LBWT are shown in Table 1. The overall

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mean value were 2.48 ± 0.01 kg for BWT and 3.57 ± 0.03 kg for LBWT. Parity of dam, sex of lamb, type of birth, season and year of birth constituted highly significant ($P < 0.001$) sources of variation for both traits. Year of birth was also significant ($P < 0.01$) for LBWT. The five environmental factors accounted for 19.8 and 22.37% of total variation in BWT and LBWT, respectively. Multiparous ewes tended to produce heavier lambs at birth than primiparous ewes which were best represented at sixth parity for both traits, the mean difference being 0.32 vs 0.54kg in favour of sixth parity ewes. BWT decreased by 0.39kg in twins while LBWT increased by 0.84kg for twins. Males were heavier by 0.12 kg at birth than females. Average BWT and LBWT were higher in the late wet season than in the late dry season. Yearly variation in body weights at birth was inconsistent. Estimates of additive correction factors (Table 2) derived from least-squares constant estimates (Table 1) indicate that the best subclass was a male lamb born in the late wet season in the sixth parity. A female lamb from the same subclass formed the base class from which correction factors (Table 2) were constructed. Heritabilities for BWT and LBWT were estimated as 0.41 ± 0.08 and 0.12 ± 0.07 , respectively.

DISCUSSION

The overall estimated mean BWT of 2.48kg from the current study falls within the range of 2.32-2.68 kg given in literature for Yankasa sheep (Buvanendran *et al.*, 1981; Hassan, 1987;). Adu and Ngere (1979) reported higher BWT estimated at 3.6 vs 3.0kg for single vs twin lambs in Yankasa sheep at Katsina. Location of breed has been suggested (Odubote, 1992) to have an effect on BWT, either as a result of differences in management systems or feeding regime and feed-stuffs offered. Differences in estimates could, to an extent, be influenced by data size. Yankasa bred was found to be superior in BWT to WAD, but inferior to Uda and Balami (Adu and Ngere, 1979). LBWT estimated at 3.57 ± 0.03 was higher than 3.08 ± 0.05 kg reported by Osinwo *et al.* (1993) from 834

lambings on the same farm. This could partly be accounted for by improvement in the trait over the years and partly due to differences in data size. Observed LBWT was however inferior when compared with an estimate of 4.06kg for WAD sheep (Odubote, 1992).

The observation that primiparous ewes tended to produce significantly lighter lambs at birth and at weaning than multiparous ewes has been demonstrated in Yankasa sheep (Osiowo *et al.*, 1990; 1992). Hafez (1980) advanced an explanation that reproductive efficiency is not fully attained at first oestrus. Young ewes are still growing and thus must provide for their own growth in addition to the foetal demand (Inyangala *et al.*, 1992). In agreement with the current study, several reports are of the view that single born lambs are generally heavier than twin born lambs at birth (Adu and Ngere, 1976, Buvanendran *et al.*, 1981; and Osinowo *et al.*, 1990; 1993). This has been attributed to limited uterine capacity and insufficient nutrient supply to meet individual lamb requirement for faster growth rate *in utero*. As number of foetuses increase, the number of caruncles attached to each foetus decreases, thus reducing feed supply and hence, birth weights of lambs (Robinson *et al.*, 1977). Taking LBWT into consideration, Odubote (1992) found that, in WAD ewes, twin and triplets were heavier than singles as observed in this study. Low BWT for twin and triplets is offset by higher litter weight. Superiority of male lambs at birth confirm earlier results on the same farm (Hassan, 1987; Osinowo *et al.*, 1990; 1993). It has been attributed to hormonal differences between sexes and their resultant effect on growth (Inyangala *et al.*, 1992).

That study confirms that the preponderance of males in a litter led to an increase in LBWT and BWT (Odubote, 1992). Buvanendran *et al.* (1981) however, reported non-significant sex differences in BWT in Yankasa sheep. Significant influence of season of birth on BWT has been favourably supported by Hassan (1987) and Osinowo *et al.* (1989; 1992) in Yankasa sheep. The latter further reported that the difference in BWT between months

TABLE 1. LEAST-SQUARES MEANS (±SE) FOR BIRTH WEIGHT (BWT) AND LITTER BIRTH WEIGHT (LBWT)

Subclass		No	BWT (kg) LSM	SE	NO	LSM	LBWT (kg) SE	Constant
								Estimate (BWT)
Overall		2490	2.48	0.01	1225	3.57	0.03	
Variable								
Parity:	1	821	2.29	0.02	333	3.29	0.04	-0.20
	2	620	2.45	0.02	348	3.52	0.04	-0.03
	3	452	2.54	0.02	239	3.58	0.05	0.05
	4	295	2.52	0.03	145	3.58	0.06	0.04
	5	167	2.49	0.04	105	3.63	0.07	0.01
	6	105	2.61	0.05	55	3.83	0.01	0.12
F. test		(P < 0.001)			(P < 0.001)			
Type of birth:								
Single		1756	2.68	0.02	978	2.88	0.04	0.19
Twin		734	2.29	0.02	247	4.26	0.05	-0.19
F. test		(P < 0.001)			(P < 0.001)			
Sex:	Male	1240	2.54	0.2	557	3.49	0.04	0.06
	Female	1250	2.42	0.02	541	3.35	0.04	-0.06
	Mixed				127	3.87	0.07	
F. test		(P < 0.001)			(P < 0.001)			
Season:	J-M	646	2.32	0.2	275	3.41	0.05	-0.16
	A-J	660	2.49	0.02	331	3.58	0.05	0.01
	JL-S	491	2.65	0.03	229	3.76	0.06	0.17
	O-D	693	2.45	0.02	390	3.52	0.05	-0.01
F. test		(P < 0.001)			(P < 0.001)			
Year:	1983	87	2.44	0.06	68	3.41	0.10	
	1984	196	2.41	0.04	117	3.50	0.07	
	1985	190	2.52	0.04	154	3.58	0.06	
	1986	106	2.53	0.05	87	3.57	0.08	
	1987	213	2.50	0.04	88	3.71	0.08	
	1988	450	2.47	0.03	247	3.58	0.06	
	1989	251	2.42	0.03	75	3.03	0.09	
	1990	369	2.53	0.03	47	3.35	0.11	
	1991	308	2.66	0.03	171	3.75	0.06	
	1992	145	2.45	0.04	64	3.53	0.09	
	1993	175	2.430	0.04	107	3.72	0.07	
F. test		(P < 0.001)			(P < 0.001)			

J-M, A-J, JL-S, O-D = January-March (late dry), April-June (early wet), July-Sept. (late wet), October-December (early dry) respectively.

apparently follow seasonal variation in forage availability. Seasonal influence on a trait such as birth weight has been shown to operate through its effect on dam's uterine environment (Eltawil *et al.*, 1970). This may explain the higher BWT and LBWT of lambs obtained in the late wet season compared with lighter lambs from dams that underwent a nutritionally stressful period especially during the late dry season. Significant yearly variation on BWT in Yankasa sheep has been documented (Hassan, 1987; Osinowo *et al.*, 1992) in agreement with the current observation. However, Osinowo *et al.* (1989) reported insignificant year effect. Inconsistent yearly variation in body weights at birth has been observed (Kanthraju *et al.*, 1980; Adu *et al.*, 1985; Buvanendran *et al.*, 1992 and Osinowo *et al.*, 1992). This could be partly accounted for by variation in climate which

directly influences water and feed availability and slight differences in general husbandry practices between years (Adu *et al.*, 1985).

Assessing genetic merit for lamb weights involves adjustment for dam's parity, lamb's sex, type of birth and season of birth, since lambing frequently occurs throughout the year (Osinowo *et al.*, 1993). Fourth parity ewes were ideal as a base class in construction of additive adjustment factors because they adequately represent older ewes and most ewes are likely to approach fourth than higher parities, as demonstrated by the number of observations within each subclass.

The heritability estimate of 0.41 ± 0.08 (1639 records) obtained in this study for lamb BWT closely agrees with 0.46 ± 0.08 from 931 lambings of Yankasa sheep (Osinowo *et al.*, 1993) but higher than most estimates earlier obtained including: 0.21 ± 0.19 (Buvanendran *et al.*

TABLE 2: LEAST-SQUARES CONTANTS (LS) AND ADDITIVE CORRECTION FACTORS (ACF) FOR BIRTH WEIGHT (KG)

Parity	Type of birth	Season ^a	No	Male LSC	ACF	No	Female LSC	ACF
1	Single	LD	80	0.11	0.45	62	0.23	0.57
		EW	89	-0.66	0.12	49	0.10	0.24
		ED	97	-0.04	0.30	94	0.08	0.42
	Twin	LD	16	0.49	0.83	26	0.61	0.95
		EW	35	0.32	0.66	33	0.44	0.78
		LW	14	-0.16	0.18	88	0.28	0.62
		ED	26	0.34	0.68	34	0.46	0.80
	2	Single	LD	54	-0.06	0.28	71	0.06
EW			62	-0.23	0.11	51	0.23	0.23
LW			42	-0.39	-0.05	46	-0.27	0.07
ED			63	-0.21	0.13	80	-0.09	0.25
Twin		LD	13	0.32	0.66	19	0.44	0.78
		EW	22	0.15	0.49	34	0.27	0.61
		LW	12	-0.01	0.33	10	0.11	0.45
		ED	26	0.17	0.51	15	0.29	0.63
3	Single	LD	41	-0.14	0.20	50	-0.02	0.32
		EW	28	-0.31	0.03	28	-0.19	0.15
		LW	39	-0.47	-0.13	36	-0.35	-0.02
		ED	42	-0.29	0.05	46	-0.17	0.17
	Twin	LD	27	0.14	0.48	17	0.36	0.70
		EW	18	0.07	0.41	19	0.19	0.53
		LW	7	-0.09	0.25	10	0.03	0.37
		ED	19	0.09	0.43	25	0.21	0.55
4*	Single*	LD	24	-0.13	0.21	20	-2.01	0.33
		EW	19	-0.30	0.04	19	0.19	0.53
		LW	7	-0.09	0.25	10	0.03	0.37
		ED	21	-0.28	0.06	18	-0.16	0.18
	Twin	LD	15	0.25	0.59	18	0.37	0.71
		EW	18	-0.08	0.42	18	0.20	0.54
		LW	15	-0.08	0.26	10	0.04	0.38
		ED	11	-0.10	0.24	7	0.22	0.56
5	Single	LD	12	-0.10	0.24	18	0.02	0.36
		EW	9	-0.27	0.07	16	-0.15	0.19
		LW	14	-0.45	-0.09	20	-0.31	0.03
		ED	13	-0.25	0.09	10	-0.13	0.21
	Twin	LD	17	0.28	0.62	13	0.40	0.74
		EW	11	0.11	0.45	9	0.23	0.57
		LW	10	-0.85	0.29	6	0.07	0.41
		ED	10	0.13	0.47	9	0.25	0.59
6	Single	LD	9	-0.21	0.13	4	-0.09	0.25
		EW	6	-0.38	-0.04	5	-0.26	0.08
		LW	6	-0.54	-0.20	8	-0.42	-0.08
		ED	9	-0.36	-0.02	6	-0.24	0.110
	Twin	LD	10	0.17	0.51	10	0.29	0.63
		EW	5	0.00	0.34	8	0.12	0.51
		LW	2	-0.16	0.18	5	-0.04	0.30
		ED	3	0.02	0.36	9	0.04	0.38

*Base class = Single female born in the late wet season to a 4th parity dam

^aSeason: LW, EW, LW, ED = late dry, early wet and early dry seasons respectively.

al., 1981), 0.22 for 357 records (Hassan, 1987) and 0.27 ± 0.003 for 529 records on the same farm (Osinowo *et al.*, 1990), while a higher figure of 0.693 ± 0.224 has been reported in Patanwadi sheep (Qureshi and Shukla, 1990). Several reasons could be adduced for these differences between earlier and current observations: Uncontrollable environmental factors might have been responsible for low

heritability values obtained in most studies; current reported estimates were based on reasonable large number of degrees of freedom which were considered more reliable than estimates from smaller data sets; Since heritability is a function of genetic variance, any change in gene frequency will probably alter its value. It is possible therefore, for estimates to change with time depending on

such factors as the action of genes, selection genetic drift and mutation (Turner and Young, 1969). Consequently, periodic re-estimation of heritability for traits of economic importance is necessary, particularly for flocks under artificial selection. The heritability estimates for LBWT of 0.12 ± 0.07 from 1185 records compares favourably with an estimates of 0.05 ± 0.09 for 667 records on the same farm (Osinowo et al., 1993). This value suggests that environmental factors in relation to additive genetic factors had more influence on LBWT than on BWT.

It is clear from the foregoing that the effects of parity, sex of lamb, type of birth, season and year of birth are more important in sheep productivity in terms of BWT and LBWT. Adjustment for these effects is necessary in order to better determine genetic differences for more accurate selection. Significant progress could be made in selecting for BWT while moderate to low response is expected in selecting for LBWT.

It is recommended that breeding ewes should be exposed to rams from early wet to late wet season in this region in order to take advantage of forage availability. Furthermore, periodic re-estimation of adjustment factors and heritability estimates should be embarked upon, using large data sets as estimates are subject to change depending on a number of factors.

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