CAUSES OF VARIATION IN REPRODUCTIVE PERFORMANCE OF WEST AFRICAN DWARF GOAT

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ABSTRACT

Analysis was carried out on the reproductive performance of 59 WAD (*Fouta djallon*) goats over 8 year period 1982-1990 under intensive management. The data involving a total of 176 kiddings comprising 311 kids were analysed to provide some information on the reproductive potential and the distribution of the sexes on the WAD goats for an appraisal of its utilization in future genetic and environmental studies and the improvement of the breed in Nigeria. The results showed no significant seasonal effect on the kidding pattern. Singles, twins and triplets were 33.44, 48.23 and 16.40% respectively. Kidding interval varied from 91 to 240 days, annual kidding rate was 1.68 with mean kid birth weight of 1.5 ± 0.08 , 1.49 ± 0.65 and 1.31 ± 0.095 kg for single twins and multiple births respectively. The average sex ratio was 48.79 ± 0.18 . The least squares constants showed that the age of dam, kidding interval and season of kidding have significant effect on the sex ratio with more males born by those after 3 years of age particularly during the dry season at shorter kidding intervals or 191-220 days. Calculated frequency of sex combination of males to females was 0.4005, 0.4662 and 0.1333 trizygotic, dizygotic and monozygotic twins among the triplets - The frequency was 0.67 for monozygotic twinning among the twin births. Although preweaning mortalities of 12.26, 16.33 and 19.36% were recorded for single, twin and multiple births respectively, highly significant survival rate was recorded in the dry season (84.40 ± 0.75) than in the wet season 81.18 ± 0.75 whilst the kidding interval was between 200 - 240 days in about 56% of the population studied. The current emphasis on the presence

of monozygotic twins with a frequency of 67% among twin birth and 13.3% among the triplets is to assist in utilizing this trait in the goat for studies that could enhance the modification of the environment or improve the genetic potentials of the breed.

Key words: WAD Goat; Prolificacy, sex ratio, Sex combination, season, monozygotic twinning.

INTRODUCTION

Environmental and genetic differences have been associated with differences observed in the reproductive performance of different breeds of the goat (Devendra, 1962; Sacker and Trail, 1966). Although most investigations into goat production show that slightly fewer males than females are born (Epstain, 1953; Sacker and Trail, 1966; Wilkinson and Barbara, 1987) the WAD goats are very prolific, possessing high frequency of kidding and ability to survive under poor management particularly in Nigeria despite their poor genetic potentials for growth and milk production. Their average sizes are small and their weight at birth are often useful prediction of their future performance.

The remarkably high reproductive potential in terms of young produced per female per year (Wilson, 1989; Gall *et al* 1992) was found to follow the change of dry and rainy seasons and so influenced by temperature, humidity and nutritional status of the animals. The difficulty in identifying with accuracy, ideal materials for twin studies in species other than man and cattle has been one of the problems facing geneticists in the evaluation of genetic and environmental interaction. Hancock (1954), Brumby (1958) and Donald and Watson (1961) reported that twinning studies have been very useful in experiments to determine the effects of different diets, different therapy and any other

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modification of the environment particularly with monozygotic twins. Since both members of a pair have the same genotype, by using one as control and the other as the treatment effects any complication from differing genetic susceptibilities such as found in studies involving other relationship is eliminated. Investigations have shown that with larger numbers of twins for many kinds of expectations a single monzygotic twin as control is worth some 10 - 25 other combinations.

It is important that an appraisal of this herd of goats be made to assess their reproductive performance as related to their birth weights, sex ratio and sex combination as possible contributions to any breeding plans. Such information will be useful in recommending environmental modification for the improvement of the genetic potentials of the breed.

This paper therefore is an attempt to evaluate these parameters and investigate the extent to which performance in this herd could be modified for future breeding programmes.

MATERIALS AND METHODS

The data consisted of all animals born of the West African dwarf goat (*Fouta djallon*) at the Institute of Agriculture Research and Training Ibadan for nine recording years from 1982 to 1990. The Institutes goat herd was established in 1977 from animal purchases made around the South West Zone of Nigeria.

Data collected were those of birth weight and sex combination from 176 kiddings comprising 311 kids. Sex ratio was calculated as the number of surviving males to females. Actual and hypothetical frequency of sex combinations were calculated using Allen (1960) procedure. Least squares procedure (Harvey, 1960) was used to analyse possible environmental influence on the reproductive performance using the model.

$$Y_{ijklm} = \mu + a_i + b_j + c_k + d_l + f_m + g_n + (cg)_{kn} + (bg)_{jn} + e_{ijklmn}$$

where Y_{ijklmn} = record of dependent variable

$$\mu = \text{mean}$$

- a_i = effect of age of dami $i = 1 \dots 4$
- b_j = effect of sexj $j = 1 \text{ and } 2$
- c_k = effect of average weight of kids $k = 1 \dots 3$
- d_l = effect of litter size $l = 1 \dots 3$
- f_m = effect of season of kidding, $m = 1 \text{ and } 2$
- g_n = effect of year of kidding, $n = 1 \dots 9$
- $(cg)_{kn} \text{ \& } (bg)_{jn}$ = interaction effects

Repeatability estimates of birth and kidding rates were calculated using 30 dams with 3 repeated records while heritability estimates were based on daughter dam comparison (Berker, 1975). Chi-Square was used to test the significance of difference among observed and expected values of the sex ratio and sex combinations. Percentage mortality before weaning over the years and within the types of birth (singles, twins and multiples) was calculated. The average weights of kids were separated for type of birth while the dams ages were categorised according to parity. Seasons were classified under the dry period (November to March) and wet period (April to October).

The procedure of Allen (1960) was used to evaluate the proportion of monozygosity among the like sexed twinning in this herd whilst its modification using Weinbergs method (Bulmer, 1970) was used to calculate monozygosity amongst the triplets. Thus if N is the total number of twin pairs the proportion of monozygotic twinning M is estimated as

$$M = \left\{ \frac{L - U}{N} \right\} 100$$

L = ratio of like-sexed twinning

U = ratio of unlike sexed twinning

N = Total number of twin pairs (Allen, 1960)

Using Bulmers (1970) procedure the frequency of zygotity among triplets was calculated as follows:

If M is the rate of monozygotic twinning and D the dizygotic twinning rate, then the frequency of dizygotic triples T_2 is $2MD$. Half of these are expected to be like-sexed triplets. If the number of unlike-sexed triplets is denoted as U, the number of like-sexed triplet which are not dizygotic will be $U - \frac{1}{2}T_2$. This being the value of $\frac{3}{4}$ of the trizygotic triplets. Hence the total number of Trizygotic triplets T_3 is $\frac{3}{4}$

$(U - \frac{1}{2}T_2)$ If L is the number of like-sexed triplets, the number of monozygotic triplets T_1 as shown by Allen (1960) becomes $L + U - T_2 - T_3$

RESULTS

Birth Weights

The average age at first kidding in this herd was found to be 18.61 months with a range of 15-28 months. The mean birth weight recorded was 1.51 ± 0.08 for singles, 1.49 ± 0.065 for twinning and 1.31 ± 0.095 for multiples. Males were slightly smaller than females with a birth weight of 1.47 ± 0.008 and 1.51 ± 0.003 respectively (Table 1). Heavier offspring was born during the rainy season (1.56 ± 0.07 kg) than during the dry season (1.44 ± 0.001 kg). The analysis of variance showed significant differences in birth rate ($P < 0.001$) within the years and ($P < 0.01$) within the seasons (Tables 2 & 3). The mortality records revealed a significant relationship with the birth weight and type of birth. Percentage mortality obtained for singles, twins and multiple births were 12.26, 17.33 and 19.37% respectively while mean mortality over the years was 15.6% during the dry season and 18.82% during the wet season.

Sex Ratio

The average sex ratio was found to be 48.76 ± 0.18 (Table 3) representing a ratio of 1:1.07 which was not significantly different from 1:1 with chi-square of 0.302 at 1 d.f. hence there was no variation between the observed and expected ratios among the sexes. A significant influence of litter size on sex ratio is indicated from single births to twin births, there is a drop in sex ratio from 49.56 to 48.47. The sex ratio is a little higher among the triplets and quadruplets. The sex ratio is greatly influenced by the season of kidding ($P < 0.01$) (Table 4) with average sex ratio for kids born in the wet season about 15 units below the sex ratio of kids born in the dry season. Does mated during the dry season are often leaner and in poorer condition at the time of mating than those mated during the rainy season. This may have influence on loss of embryos. The influence of kidding season on

the frequency of multiple births also shows a reduction of litter size for kids born early and later in the year which coincides with the dryer period of the year. Similar variation in the sex ratio and age of dam ($P < 0.05$) and kidding interval were also recorded ($P < 0.01$).

Sex Combination

Prolificacy increases with age hence is the ability to produce twins. Proportion of twins and triplets is found to increase from 12% at first kidding to 54% in second and subsequent kiddings whilst multiple births increased up to 4 years of age. Out of 176 kiddings in this herd 33.44% were singles, 48.23% were twins and 18.32% were multiples.

A comparison between the actual and hypothetical frequencies of sex combinations (Table 5) may indicate a greater intra uterine death rate for males with increasing litter size. The proportionate increase in the number of monozygotic twinning is expected to increase the proportion of like sexed kids which could be available for nutritional and milk production studies in different environments. When no monozygotic twinning occurs, the ratio of like sexed to unlike-sexed twins is expected to be 1:1 within the sex ratio of 0.5. 18.32% of kids born in this herd were triplets. The equal proportion of like-sexed female triplets to male triplets (15.78%) is as would be expected (Table 5) taking the average sex ratio into account and the small numbers of samples recorded. Using Bulmers (1970) procedure, the frequency of trizygotic triplets was found to be 0.4005 whilst that of di- and monozygotic triplets were 0.4662 and 0.1333 respectively. The proportion of like-sexed triplets was then 0.5652. Hence out of the 57 kids born as triplets 7.60 are expected to be monozygotic, 26.57 dizygotic and 22.83 trizygotic. Only 4.8% of all births were recorded as quadruplets.

Heritability

The Repeatability of birth weight using dams repeated records was 0.128 ± 0.92 . The heritability of birth weight, sex ratio and sex combination among twins and triplets using the calculated frequency of monozygosity to other

combination (Table 6) revealed very high genetic variance of 0.14, 32.56 and 42.12 for birth weight, sex ratio and sex combinations respectively relative to 0.092, 12.75 and 18.82 values for the environmental variances. These resulted in heritability estimates of 0.59 ± 0.45 , 0.72 ± 0.54 and 0.69 ± 0.66 for these traits. This in essence further confirmed the fact that these traits are highly genetic, coupled with the no interaction effect between these traits over the years (Table 2) it means that the goats' potential for these traits could be further exploited in its future improvement programmes.

DISCUSSION

Indigenous small ruminants have been reported to have a remarkable reproductive potential in terms of numbers of young produced per female per annum, (Wilson 1989), because day length is relatively constant in the tropical locations. However, reproductive activities do follow the change of dry and rainy season and are influenced by temperature and humidity. Among the small ruminants the WAD goats appear to be the most prolific with more twins and triplets born than singles. Whilst singles were found to vary from 7 - 10% among West African Dwarf goats, 25 - 35% in Sokoto red goats 32 - 42% in the WAD sheep and 50.60% with Ouda and Yankasa sheep where multiple births could be as low as 1-4% (Olawale, 1989), it was much higher in this herd with a value of 33-44%. Prolificacy is found to increase with age hence is the ability to produce twins which tends to increase from first kidding 15-25% to 60-79% in second and subsequent kiddings and that multiple births increased up to 4 years of age (Sacker and Trail, 1966, Kurtze 1981 and Okoroji, 1986).

The prolificacy in this herd, the litter size and age at first kidding compare favourably well with the results of Osuagwuh and Akpokodje (1982, 1984) who reported litter size of 53.29% for twins and 27% for triplets. The proportion of multiple births was, however, increasing with the rate of parturition which is bound to ensure high rate of population turnover. The combined

effect of multiple birth of 66.6% is much lower than 80.6% reported by Osuagwuh and Akpokodje (1984) although higher than 10.15% twinning incidence reported by Mason and Maule (1960) in East African Dwarf goats and 30% for Mubende goats in Uganda (Sacker and Trail 1966).

Even though more kiddings occur during the rains (April-October) 58%, the season of the year had no significant effect on the kidding rate. Similar observation was made in Dwarf goats of Southern Ghana (Devendra and Burns 1970), although a peak of kidding rate was reported around April and another small peak in September in these goats. The lack of interaction between birth weight and the sexes within the years indicated lack of variation in these traits showing that little improvement has occurred in this herd for these two traits and that with proper breeding programme and improved system of management, the genetic potential of these goats could be maximized to ensure increased productivity

The significant role that birth weights play in early mortality of the WAD goats (Osuagwuh and Akpokodje 1981, Devendra and Burns 1970) calls for an urgent attention to both genetic and environmental factors to ensure higher birth weight through selective breeding and intensive research on nutritional needs of the WAD goats during gestation.

The age of dam often reveals some of the environmental variances in reproductive rate. The sex ratio increases with the age of dam, the birth weight of the kids and the average litter size. The age effect is significant, similar to results of Skjervold (1979) in sheep. Higher sex ratio is to ensure rapid turn over of males in the population and profitability to the producer, since greater percentage of males are often destined for local meat production.

The comparison between the actual and hypothetical frequency of sex combinations may indicate a greater intra uterine death rate for males with increasing litter size. The difference in sex ratio between singles and multiple births relative to their sex combinations may be due to

an excess of males among embryos and foetuses which are lost. Hennig (1939) showed that mortality of sheep foetuses increases as the number of corpora lutea increases from one to three. Dolling and Nicolson (1967) also found a significant greater loss of embryo in ewes with two active corpora lutea than did ewes with one. The proportion of like-sexed twins which is in the region of 50.67% is higher than 25% found in sheep and among human data from Britain, U.S.A. and Italy (Bulmer 1970). The excess of like-sexed females among twins and triplets goes to further confirm a greater differential loss of predominantly male embryos or foetuses in this herd.

Mortality of lambs and kids (Gall *et al.*, 1992) was reported to be very common and could be as high as 40% of the young, causing great wastage of resources. Similarly high mortality rate of 38.6% during the first 3 months of birth was reported by Osuagwu and Akpokodje (1981, 1984). However, this was significantly lower in this herd. Early kidding age of 18.61 months was also in the range of 19.8 months reported by Osuagwu and Akpokodje (1984) although the kidding interval (191-240 days) was much shorter than 242.33 ± 50.63 days reported in the same study. The high frequency of monozygotic twinning 67.01% among kids born as twins and 13.33% among kids born as triplets will be an asset if these could be utilized for genetic studies of the different twins pairs under different environments. Sex ratio and type of birth have been effectively utilized to provide information about the stress effect of the environments. Hence similar studies within this herd are expected to effect better management practice for small ruminant production.

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Table 1 FREQUENCY OF SEX RATIO AND BIRTH WEIGHT IN DIFFERENT YEARS

YEARS	N	SEX RATIO	SINGLES	BIRTH WEIGHTS TWINS	MULTIPLES
1982	16	49.22	1.48±0.05	1.48±0.012	1.21 + 0.015
1983	47	48.60	1.60±0.02	1.52±0.07	1.35 + 0.103
1984	41	48.32	1.54±0.05	1.59±0.11	1.28 + 0.09
1985	40	48.25	1.87 ±0.021	1.54 ± 0.125	1.32 + 0.09
1986	50	48.78	1.28±0.03	1.45±0.201	1.49 + 0.08
1987	40	49.34	1.39±0.02	1.51±0.05	1.32 + 0.012
1988	26	48.97	1.55±0.04	1.43±0.15	1.40 + 0.113
1989	18	49.54	1.45±0.08	1.54±0.021	1.22 + 0.115
1990	33	48.99	1.44±0.05	1.38±0.05	1.19 + 0.103
1982-1990		48.79±0.181.51±0.08		1.49±0.065	1.31 + 0.095
N311			104	150	57
%Mortality			12.26±1.19	17.33±1.23	19.39 + 0.95

Table 2 LEAST SQUARE ANALYSIS OF VARIANCE

Source	df	MS	F	LEVEL OF SIGNIFICANCE
Age of dam	3	2.269	6.304	P < 0.01
Birth Weight	2	0.465	1.292	NS
Sex	1	0.210	0.583	NS
Year	8	11.65	32.36	P < 0.001
Season	1	3.988	11.077	P < 0.01
Litter size	2	0.4149	1.525	NS
Birth Weight x year	16	1.19	3.306	NS
Sex X Year	8	0.47	1.31	NS
Error	270	0.36		
Total	311	122.65		

Table 3 MEANS OF BIRTH WEIGHT AS A SIGNIFICANT SOURCE OF VARIATION

TRAIT		NO. OF KIDS	MEANS	STANDARD ERROR	LEVEL OF SIGNIFICANCE
Age of dam at kidding	1 - 2 Years	90	1.56	0.15 - 0.35	P < 0.01
	2 - 3 Years	140	1.62		
	3-4 Years	55	1.45		
	>4 Years	26	1.56		
Sex	Male	152	1.47	0.03 - 0.15	NS
	Female	159	1.51		
Season	Wet	170	1.56	0.01 - 0.08	P < 0.05
	Dry	141	1.44		
%Mortality	Wet	32	18.82	0.75 - 0.98	P < 0.05
	Dry	22	15.60		

Table 4 CONSTANTS FOR SOURCES OF VARIATION FOR SEX RATIO

		NO. OF	SEX RATIO	CONSTANTS	S.E.	LEVEL OF SIGNIFICANCE
Age of dam at kidding	1 - 2 Year	90	48.21	-0.64	0.16-0.29	P < .05
	2-3 years	140	48.71	-0.90		
	3-4 Year	55	49.54	-0.101		
	>4Years	26	49.41	0.63		
Litter size	Singles	104	49.56	-0.32	0.15-0.36	NS
	Twins	150	48.67	-0.20		
	Triplets	57	49.12	-0.13		
Season	Dry	141	49.45	0.20	0.25-0.35	P < 0.01
	Wet	170	48.30	-0.22		
Kidding Interval	191-200 days	5 dams	49.81	-0.22	0.17-0.24	P < 0.01
	201-220 days	17 dams	49.25	0.33		
	221-240 days	16 dams	48.61	0.46		
	240 days	21 dams	48.92	0.07		

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Table 5 FREQUENCY OF SEX COMBINATION AMONG TWINS AND TRIPLETS

Births	N	%IN EACH COMBINATION		SEX RATIO
Singles	104	-	-	49.56±0.24
Twins	2 Males	36	24.00	
	2 Females	40	26.67	
	1 Male 1 female	74	49.33	48.67±0.89
Frequency of monozygotic twins		0.67		
Triplets	All female	9	15.78	
	All male	9	15.78	49.12±0.56
	2 males 1 female	18	13.58	
	1 male 2 females	21	36.84	
Frequency of monozygotic Triplets		0.1333		
Frequency of Dizygotic Triplets		0.4662		
Frequency of Trizygotic Triplets		0.4005		
Proportion of like sexed Triplets		0.5652		

Table 6 COMPONENTS OF VARIANCES WITHIN BIRTH WEIGHTS, SEX RATIO AND SEX COMBINATION

BIRTH WEIGHT			SEX RATIO m.f.	SEX COMBINATION MZ: others
σ^2_g	0.139	32.56		42.12
σ^2_e	0.092	12.75		18.82
σ^2_p	0.226	45.31		60.94
H^2	0.5929	0.7186		0.6912
Se.	±0.45	±0.54		±0.66
σ^2_g H^2	= σ^2_e ; σ^2_p = = Heritability			Genetic, environmental and phenotypic variances