ISSN 1819-1878

Asian Journal of Animal Sciences

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Asian Journal of Animal Sciences 9 (6): 370-378, 2015
ISSN 1819-1878 / DOI: 10.3923/ajas.2015.370.378

Growth Performance of West African Dwarf Goats Reared in the Transitional Zone of Ghana

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ABSTRACT
The West African Dwarf (WAD) goats are the predominant breed of goats in Ghana. The present study aimed at assessing the growth performance (Birth weight-BWT, Pre-weaning growth rate-PREWGR, Weaning weight-WWT, Post-weaning growth rate-POSWGR and Yearling weight-YWT) of WAD goats reared in the transitional zone. About 809 breeding records from 2005-2012, live weight and linear body measurements (of 325 animals) were collected on WAD goats and subjected to GLM procedure to determine the fixed effects of sex, type of birth, season of birth and year of birth on growth performance. The fixed effects of sex and age on body measurements were also tested and then regression analysis done with body measurements. The sex of kid had significant effect ($p<0.05$) on pre-weaning growth rate and weaning weight, with males recording 32.42 g day^{-1} and 5.30 kg and females recording 31.75 g day^{-1} and 5.21 kg, respectively. Only birth and weaning weights were significantly ($p<0.01$) affected by type of birth as single born kids recorded highest values for BWT (1.56±0.02) and WWT (5.49±0.03). Kids born in the rainy season had significantly ($p<0.05$) higher values for POSWGR and YWT. The influence of year of birth was significant ($p<0.05$) on all growth parameters. The highest BWT (1.50 kg), PREWGR (39.05 g day^{-1}), WWT (6.23 kg), POSWGR (24.66 g day^{-1}) and YWT (11.09 kg) were recorded in 2009, 2005, 2010, 2012 and 2012, respectively. Oldest goats had significantly ($p<0.01$) highest body measurements in all traits. Heart girth was better in predicting live weight, but highest accuracy of 63% was obtained from combination of heart girth and body length. Conclusively, sex of kid, birth type, season of birth and year of birth affected growth performance of the WAD goats, while age of kid affected body measurements.

Key words: Birth weight, body measurements, prediction, weaning, yearling weight

INTRODUCTION
Goats are livestock species that are well adapted to and reared in most parts of the world. They are efficient converters of forage feeds to meat and milk irrespective of the environment in which they are kept (Lebbie, 2004). According to Karikari and Blasu (2009), the West African Dwarf (WAD) goat is the predominant breed of goats in Ghana though its productivity is below expectation. The low productivity is partly due to slow growth rate resulting from poor genetic and environmental (non-genetic) factors. Such factors do not allow animals to express their real genetic potential (El-Hassan *et al*., 2009). Nevertheless, goats remain to be one of the main sources of dietary livestock protein to many households, hence the need for improvement of this species.

Generally, most livestock improvement programmes in developing countries are based on open nucleus herds where the indigenous breeds are kept under selection (Philipsson *et al*., 2011). A nucleus breeding scheme is a centralized improvement program in which very superior animals are brought together from supply farms to form an elite nucleus flock. The nucleus may remain open to the best animals from the supply flocks. According to Philipsson *et al*. (2011), a nucleus herd programme is used to both conserve an indigenous breed and to upgrade the local population.

In Ghana, some measures that have been adopted to help boost livestock production include the establishment of nucleus breeding stations for genetic improvement, selection of superior strains and importations of exotic breeds to cross the indigenous breeds to improve weight gain and other economic traits (Ahunu and Boa-Amponsem, 2001). The National Goat Breeding Station at Kintampo is one of the stations with the mandate of improving the WAD goat. Any genetic improvement in a nucleus herd could bring about permanent changes which can be transmitted with little cost in the whole population as long as environmental changes are not too drastic and natural selection is not antagonistic to the changes.

Knowledge of the phenotypic and genetic parameters of growth traits is of utmost importance in goat production. The growth performance of an animal is a function of its genetic merit and the environment. It is therefore a pre-requisite that knowledge of environmental influences and magnitude of their effects should be known in genetic improvement and decision making that can enhance productivity. This study therefore seeks to examine the growth performance of WAD goats reared in the transitional zone of Ghana.

MATERIALS AND METHODS

Location of study area: The study was carried out at the National Goats Breeding Station at Kintampo, which is located on latitude 8°02' N and longitude 1°43' W (Owusu-Ansah, 2009). The area is in the transitional zone and has single rainy-season from May to October and dry season from November to April. The mean annual rainfall is between 1,400-1,800 mm and the mean temperature ranges between 24 and 30°C. The vegetation is semi-deciduous forest type which graduates into the woody savannah type characterized by scattered shrubs and dawadawa, baobab and sheanut trees in the northern sector.

Management of goats at the station: The goat pens are mainly stalls with concrete floors filled with litter. The goats were stratified and housed according to their ages in groups of lactating dams and kids, adult breeding does and pregnant does. Usually, kids are weighed within 24 h after birth with a spring balance and are identified using indelible ink. Pasture mating is practised where males are introduced to does during a mating period of 45 days at a ratio of 1:30. The animals are allowed to graze on cultivated pastures made up of *Cajanus cajan*, *Panicum minimum* and *Ficus* spp. Routine feed supplementation and medication regimes are followed.

Data collection: Data on breeding records (including date of birth, sex of kid, birth type, season of birth, year of birth, birth weight, weaning weight, monthly weight and yearling weight) of 809 goats born from 2005-2012 was taken from the breeding station. Also, the live weight, body length and heart girth were measured on a total of 325 adult goats using Griffith Elder weighing scale and measuring tape. The variables considered are explained as follows:

Sex	: This was observed at birth as male or female
Type of birth	: This refers to the number of kids born per kidding doe. Kids were classified into single, twin and triplet births
Season of birth	: This refers to the climatic (rainy or dry) season during which a kid was born
Year of birth	: This refers to the year in which each kid was born, ranging from 2005-2012
Birth weight-BWT (kg)	: This is the weight of kid taken within 24 h of birth
Weaning weight-WWT (kg)	: This is the weight of kid weaned 120 days postpartum
Yearling weight-YWT (kg)	: This is the weight of a young goat when it is 365 days old
Monthly weight (kg)	: This refers to the weight of kids taken every month for one year
Pre-weaning growth rate-PREWGR	: This is the average weight gain per kid per day from birth to weaning and it was determined as follows:

$$\text{PREWGR (g day}^{-1}) = \frac{\text{WWT} - \text{BWT}}{120 \text{ days}} \times 1000 \text{ g}$$

Post-weaning growth rate-POSWGR: This is the average weight gain per kid per day from weaning to one year and it was determined as follows:

$$\text{POSWGR (g day}^{-1}) = \frac{\text{YWT} - \text{WWT}}{245 \text{ days}} \times 1000 \text{ g}$$

Live body weight-BW (kg)	: This is the weight measured on the live animal
Body length-BL (cm)	: This is the distance between the point of the shoulder (lateral tuberosity of the humerus) and the pinbone (tuber ischii) measured with a measuring tape
Heart girth-HG (cm)	: This is the circumference of the chest just behind the front legs measured by using a measuring tape

Statistical analysis: The General Linear Model (GLM) was used to test the main effects of sex, season of birth, type of birth and year of birth on birth, weaning and yearling weights and pre-weaning and post-weaning growth rates. The fixed effects of sex and age on body measurements (BW, HG and BL) were also tested using GLM. All means were separated using least significant difference at 5% level of significance. Live-weight was regressed on linear body measurements to develop weight estimation equations. All analyses were done in SPSS version 17. Average monthly weights were used to plot growth curves using excel in Microsoft office 2010.

RESULTS AND DISCUSSION

Growth traits of WAD goat: The fixed effects of sex, type of birth, season and year of birth on growth traits are presented in Table 1. The sex of kid had no significant effect ($p>0.05$) on birth weight, yearling weight and post-weaning growth rate as both male and female kids were very comparable in these traits. The similarity in birth weight in this study may be attributed to the use

Table 1: Least square means (±SE) of growth traits of WAD goat as affected by sex, birth type, season and year of birth

Variables	BWT (kg)	WWT (kg)	YWT (kg)	PREWGR (g day^{-1})	POSWGR (g day^{-1})
Overall mean	1.40±0.06	5.25±0.15	10.20±0.21	32.08±1.09	20.14±0.68
Sex					
Male	1.41±0.06	5.30±0.15^{a}	10.22+0.21	32.42±1.10^{a}	20.07±0.68
Female	1.40±0.06	5.21±0.15^{b}	10.17+0.22	31.75±1.11^{b}	20.21±0.69
Probability	0.306	0.031	0.380	0.036	0.417
Type of birth					
Single	1.56±0.02^{a}	5.49±0.03^{a}	10.25±0.05	33.09±0.25	19.27±0.15
Twins	1.33±0.03^{b}	5.26±0.04^{b}	10.08±0.05	32.53±0.30	19.12±0.18
Triplets	1.50±0.50^{ab}	5.00±1.00^{ab}	10.00±0.00	30.50±1.50	19.00±3.00
Probability	<0.001	<0.001	0.070	0.296	0.816
Season of birth					
Dry season	1.40±0.06	5.24±0.15	10.01±0.21^{b}	32.10±1.09	19.83±0.67^{b}
Rainy season	1.41±0.06	5.26±0.60	10.28±0.22^{a}	32.06±1.13	20.45±0.70^{a}
Probability	0.822	0.937	0.002	0.863	0.012
Year of birth					
2005	1.15±0.06^{d}	5.86±0.39^{a}	10.90±0.22^{a}	39.05±1.15^{a}	20.55±0.71^{b}
2006	1.36±0.06^{c}	5.40±0.72^{b}	10.44±0.23^{b}	33.20±1.16^{b}	20.82±0.72^{b}
2007	1.37±0.07^{bc}	5.45±0.72^{b}	10.06±0.24^{c}	32.76±1.22^{b}	19.46±0.75^{c}
2008	1.45±0.06^{ab}	5.32±0.83^{b}	10.05±0.22^{c}	31.13±1.14^{cd}	19.79±0.71^{c}
2009	1.50±0.06^{a}	5.07±0.74^{c}	9.33±0.24^{d}	28.70±1.21^{e}	17.75±0.75^{d}
2010	1.42±0.06^{bc}	5.35±0.84^{b}	10.17±0.23^{bc}	31.78±1.15^{bc}	20.15±0.17^{bc}
2011	1.47±0.06^{a}	5.25±0.80^{bc}	9.52±0.22^{d}	30.48±1.12^{d}	17.91±0.70^{d}
2012	1.49±0.08^{ab}	5.24±0.66^{bc}	11.09±0.28^{a}	29.58±1.43^{de}	24.66±0.88^{a}
Probability	<0.001	<0.001	<0.001	<0.001	<0.001

^{a,b,c,d,e}Means within the same column having different superscripts differ significantly for sex, type of birth, season of birth and year of birth, BWT: Birth weight, WWT: Weaning weight, YWT: Yearling weight, PREWGR: Pre-weaning growth rate, POSWGR: Post-weaning growth rate

of genetically superior breeding animals in a planned breeding and selection programme at the breeding station. This finding is in agreement with Mioc *et al*. (2011) who reported no significant difference in birth weight as a result of the sex in Croatian multicolored goat kids. In Ethiopia, male and female kids of Abergele goats were statistically similar from birth to one year old (Deribe and Taye, 2013). However, Akusu and Ajala (2000) reported significant differences between male and female kids at birth. The significantly (p = 0.036) higher pre-weaning growth rate of male over female kids clearly translated into significantly (p = 0.031) higher weights of males at weaning. This is in consonance with the findings of Turkson *et al*. (2004) for Ghanaian WAD goat. Much higher values of 81 and 73 g day^{-1} for males and females respectively were reported for Blended goat of Tanzania (Das *et al*., 1996). The superiority of males may be attributed to the fact that male kids are more vigorous than female kids and thus have greater access to their dam's milk resulting in rapid growth.

The results revealed a significant (p<0.01) effect of type of birth on birth weight and weaning weight, but growth rates and yearling weight were not significantly (p>0.05) affected (Table 1). Single born kids weighed heaviest followed by twin born kids. The finding in this study agrees with earlier reports (Deribe and Taye, 2013; Gbangboche *et al*., 2006) of the superiority of single born kids over twins and triplets. This may be due to absence of intra-uterine nutritional and space competition in single born kids unlike in multiple born kids where there is competition (Deribe and Taye, 2013). Previous study also reported that single born kids weighed significantly (p<0.05) heavier than multiple born kids at weaning in WAD goat. Clearly, birth weight had direct effects on weaning weight. Probably, heavier kids at birth have advantage over lighter ones in struggle for milk, feed utilization and conversion efficiency.

The season of birth did not have significant effect ($p>0.05$) on most growth traits up to weaning stage but after weaning, rainy season born kids grew significantly ($p = 0.012$) faster resulting in significantly ($p = 0.002$) higher yearling weight than their dry season born counterparts (Table 1). Season of birth was a significant source of variation on birth, weaning and yearling weights (Deribe and Taye, 2013). Luginbul (2002) and Steve (2001) proposed that growth during pre-weaning period is largely determined by maternal milk production and competition for it amongst litter mates and hence, the differences in their post-weaning growth rate. The higher post-weaning growth rate and eventual yearling weight for wet season born kids might have resulted from availability of more succulent and nutritious feeds in the wet season. Since the goats were kept on-station under proper management practices, their productivity will therefore, depend on how management handles seasonal variations in feed, water and health care.

The year of birth significantly ($p<0.01$) affected all growth traits of kids (Table 1). The highest birth weight, weaning weight and yearling weights were obtained in 2009, 2005 and 2012, respectively while the highest pre-weaning and post-weaning growth rates were obtained in 2005 and 2006, respectively. Obviously, pre-weaning growth rates were generally higher than post-weaning growth rates. The overall post-weaning growth rate was lower than 29.26 g day^{-1} in Abergelle kids of Ethiopia (Deribe and Taye, 2013). However, there was a decrease in weaning weight from the period of 2005-2009. This could be partly due to change in breeding stock (genetic potential) as aging stock is replaced by younger stock and variations in climatic conditions and management practices. Earlier, Baiden (2007) observed differences in birth weight of WAD kids over the years. In the present study, the range of yearling weight (9.33±0.24 to 11.09±0.28 kg) was higher than the 8.00 kg reported from the same location (Turkson *et al*., 2004). This suggests that some improvement in yearling weight has been achieved at the station. Knowledge on yearling weight is very important especially in decision making as it serves as basis for selection and retention of replacement stock for breeding.

The overall mean birth weight obtained in the present study (Table 1) was higher than 1.20 kg reported by Turkson *et al*. (2004) for WAD goats from the same location. The variability may be attributed to maternal effects as well as management and climate conditions that influence the availability of feeds and feeding. The overall mean weaning weight in this study was lower than 5.75 kg reported for the same breed in Gambia (Bosso *et al*., 2007). The difference in weaning weight could be attributed to differences in the mothering ability of the dams, climate, nutrition and general management conditions.

Growth patterns of WAD goat: The growth patterns of yearling WAD goats from 2005-2012 are presented in Fig. 1. The curves indicated a cumulative increase in weight with the passage of time in each year (Fig. 1a-b). Clearly animals grew at a steady rate from birth to 12 months of age, except the following: In 2006 there was a decrease in the average growth by the 12th month (Fig. 1a), the growth curves were fluctuating in the first four months of 2009 and from the 5th-10th months of 2012 while there was a slight drop in the curve in the 3rd month of 2010 (Fig. 1b). There were no clear differences in these growth curves. Probably the animals were quite homogenous genetically since in each year, the kids being measured became the resultant parents for subsequent generations. Also, management practices and environmental conditions might have been fairly uniform over the period under consideration. All the growth curves observed herein were closely similar to those reported in Angora goats (Ozdemir and Dellal, 2009) and goats in

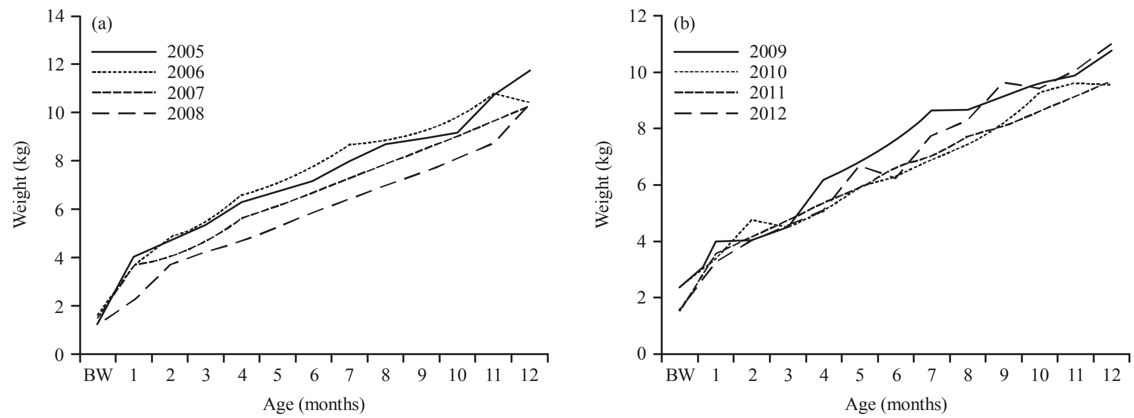

Fig. 1(a-b): Growth patterns of WAD kids from birth (BW) to 12 months, (a) 2005-2008 and (b) 2009-2012

Table 2: Least square means (±SE) of live weight (kg) and linear body traits (cm) of WAD goat

	Body measurement		
Variables	Live body weight	Heart girth	Body length
Overall mean	25.99±0.41	53.56±0.79	50.60±0.48
Sex			
Male	25.50±0.74	53.46±1.44	50.36±0.88
Female	26.49±0.25	53.66±0.49	50.84±0.30
Probability	0.115	0.669	0.331
Age (years)			
1	18.32±0.65[c]	39.82±1.27[c]	46.13±0.77[b]
2	26.96±0.40[b]	57.82±1.27[b]	52.50±0.48[a]
3	32.70±0.52[a]	63.49±1.01[a]	53.18±0.62[a]
Probability	<0.001	<0.001	<0.001

[a,b,c]Means with different superscripts in a column differ significantly (p<0.01) for age

southern Nigeria (Ogebe *et al*., 1995). Since the data covered only the first year of life, the normal classical sigmoid (S-shaped) growth curves expected in growing animals (Karakus *et al*., 2008; Topal *et al*., 2004) were not observed. It implies that records on growth parameters need to be recorded up to full maturity of the animal in order to observe the true nature of its growth curve.

Quantitative traits of the WAD goat: From Table 2, sex of animals had no significant (p>0.05) effect on body measurements. This finding is in agreement with Khan *et al*. (2006). The overall mean live weight of the WAD goat in this study was higher than those reported by Fajemilehin and Salako (2008) but lower than those of WAD goat in Nigeria (Yakubu *et al*., 2010). Okpeku *et al*. (2011) reported much higher overall means of 65.95 and 57.87 cm for HG and BL, respectively in Red Sokoto goat in Nigeria. These differences may be due to the breed type of animals as well as differences in response to environmental conditions thereby resulting in size differences. The knowledge of body size and weight of goats is of immense importance to farmers and breeders alike because it indicates clearly which animals to choose when the breeding objective is to improve productive traits. In Ghanaian sheep it was observed that an animal large for one trait was generally large for all traits (Birteeb *et al*., 2012). Hence, the measurement of one or two traits such as heart or chest girth, body length and weight could be informative enough for decision making by livestock farmers.

Table 3: Prediction equations for live weight using linear body measurements of WAD goat

	Parameters estimates							
Variables	β_0	±SE	β_1	±SE	β_2	±SE	Adj. R^2(%)	Probability
HG	3.12	1.16	0.43	0.02	-	-	58.70	<0.001
BL	-8.25	2.70	0.69	0.05	-	-	35.50	<0.001
HG+BL	-7.61	2.04	0.36	0.02	0.29	0.05	63.00	<0.001

Age was a significant (p<0.01) source of variation in all the body traits as the values increased with increasing age. This was in consonance with the report of Fajemilehin and Salako (2008) in the same WAD goat. The similarity in body lengths of animals aged 2 and 3 years may mean that bone growth in WAD goats slows down or even ceases after two years of age.

Live weight estimation from linear body measurements: When live weight was regressed on linear body measurements, all equations were highly significant (p<0.01) although the associated coefficients of determination (Adj. R^2) were quite low (Table 3). These prediction accuracies were lower than those of indigenous goats of Nigeria (Okpeku *et al*., 2011). Birteeb and Ozoje (2012) reported much higher prediction accuracies in Ghanaian sheep. The findings of the present study agreed with earlier researches (Birteeb and Ozoje, 2012; Okpeku *et al*., 2011; Olatunji-Akioye and Adeyemo, 2009) in which heart girth was found to be the single most important variable for predicting body weight. Badi *et al*. (2002) and Leng *et al*. (2010) recommended the use of heart girth as most reliable variable to estimate body weight under field conditions where weighing bridges or scales are unavailable. The importance of heart girth in weight estimation could be as a result of the muscle and a little of fat along with bone structure which contribute to its formation (Yakubu, 2010).

The combination of HG and BL ensured a better estimation of live weight. This implies that BL assumes importance in weight prediction when used alongside HG. The two dimensional traits (HG and BL) could symbolize body volume of an animal and so are indispensable in weight prediction in WAD goats. The better performance of the multiple regression equation (HG and BL) supports the report of Birteeb and Ozoje (2012) that estimation of live weight can be more accurate when heart girth is combined with one or two other measurements.

CONCLUSION

The results of the present study revealed that sex of kid had significant effect on pre-weaning growth rate and weaning weight, with males being superior to females. The type of birth also had significant influence on early growth performance as single born kids obtained the highest birth and weaning weights. Rainy season-born kids grew significantly faster at post-weaning growth period and this resulted into a higher yearling weight. The year of birth was a significant source of variation on all growth traits of WAD kids.

Among the two morphological traits measured, heart girth was a better predictor of live weight than body length but a combination of the two traits ensured a better estimation of live weight. The use of only one linear body trait to predict live weight may not be reliable in the WAD goat under consideration.

ACKNOWLEDGMENT

We wish to thank and appreciate the management and staff of the National Goat Breeding Station at Kintampo, for availing the breeding records of the station for this study. They were also very helpful in the data collection process, it is our prayers that God bless them.

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