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SONOGRAPHIC IMAGING AS A MEANS OF IMPROVING THE REPRODUCTIVE PERFORMANCE OF WEST AFRICAN DWARF GOATS

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ABSTRACT

Transabdominal B-mode real- time ultrasonography was used to detect pregnancy, perform foetal biometry and determine foetal number antenatal, in the West African Dwarf goat. Following oestrous synchronization and detection, 11 West African Dwarf does were hand-mated using 2 virile bucks of proven fertility. Starting from Day 15 (Day of oestrus/breeding = Day 0 of gestation), transabdominal B- mode real-time ultrasound scanning was performed daily until evidence of pregnancy was detected. Pregnancy was confirmed sonographically by imaging an embryo with a beating heart on Day 23.8 ± 0.91 of gestation. The beating heart also served as evidence of conceptus viability. Thereafter, sonographic biometry by means of CRL measurement was performed on alternate days starting from Day 23 until Day 59 of gestation. Out of 11 does bred, 10(90.09%) were diagnosed pregnant (sensitivity = 100%) while 1(9.91%) was diagnosed non pregnant (specificity = 100%) with 100% accuracy. Embryonal/foetal* **crown to rump length** ***measurements showed very high correlation (r^2 = 0.98) with gestational age between Days 23 and 59 of gestation. Regarding prenatal foetal number prediction, 3 pregnancies were correctly predicted on Day 25, 5 on Day 27, 1 on Day 29 and 1 on Day 39 with a mean gestational age of 27.8±1.3 with 100% accuracy. Four (40%) of the pregnant does were predicted to bear twin pregnancies while 6 (60%) does were predicted to bear singletons, with 100% accuracy. Sonographic imaging therefore, proved to be an effective management tool for appraising the reproductive performance of WAD goats in the antenatal period. Reproductive appraisal in the ante-natal period influences rational management decisions aimed at improving the performance of farm animals. Owing to the high accuracy of this technique in pregnancy detection and determination of viability, number and age of the conceptus, which in turn influence management decisions, it is concluded that sonographic imaging can be used to improve the reproductive performance of the West African Dwarf breed of goat.

Keywords: *West African Dwarf goats, reproductive performance, sonography*

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INTRODUCTION

Routine application of pregnancy diagnosis is profitable in animal husbandry. Various techniques have been employed with varying degrees of accuracy. Rectal palpation is an accurate method but the small size of the *West African Dwarf* (WAD) goat precludes the use of this technique in this breed. On the other hand, obstetric ultrasonography is a modern and contemporary tool for the non-invasive visualization of the uterus, early pregnancy diagnosis, assessment of conceptus viability, gestational age estimation and fetal number determination. Early and precise detection of pregnancy would afford separation of the flock or herd into pregnant and non-pregnant groups and allow appropriate and timely rebreeding [1,2] or culling of non-pregnant animals. When non pregnant goats are removed from the flock expenses saved on feed, labour or vaccination are more efficiently ploughed back into providing supplementary feed for pregnant animals [2, 3]. Estimation of gestational age of foetuses finds application in animal management, research or clinical theriogenology practice [4]. Uncertain gestational age is reported to be associated with adverse pregnancy outcomes such as low birth weight, spontaneous preterm delivery and peri-natal mortality, independent of maternal characteristics [5]. The determination of foetal numbers has the potential for improving reproductive efficiency [6,7], as it allows for appropriate nutritional management in late gestation and prevents pregnancy toxaemia [8], minimizes gestational feeding costs, optimizes weaning weight and survivability of neonates and reduces the incidence of dystocia [6,9,10,11].

Application of ultrasonography in veterinary practice and especially in small ruminants has developed to become the most efficient diagnostic tool for imaging reproduction. B-mode, real-time ultrasound examination is popular because it is easy to use, highly efficient in early pregnancy diagnosis, with the possibility of determining gender [12, 13], and estimating foetal age and weight [14, 15]; factors that are relevant for any type of breeding industry [15]. An accurate and timely use of this diagnostic modality would allow for a relatively rapid, inexpensive and non-invasive acquisition of clinically relevant data [16]. Transrectal or transabdominal ultrasonography has been recommended as a simple, rapid, practical and contemporary method for early pregnancy diagnosis in small ruminants [17, 18, 19]. The technique of transabdominal ultrasonography has been used with accuracy as a means of pregnancy detection and estimation of foetal numbers in sheep [20, 21, 22] and goats [23, 24, 25, 26]. However, in Nigeria information regarding the use of ultrasonography in reproductive management of small ruminants is only beginning to emerge in the last decade. The aim of this study is to validate the usefulness of ultrasonographic imaging technological innovation, as it becomes increasingly applied in veterinary practice in Nigeria, in improving the reproductive performance of the WAD goat.

MATERIALS AND METHOD

Experimental Animal Handling

Twelve cyclic female West African Dwarf (WAD) goats of varying parities and 2 bucks belonging to the small ruminant experimental animal unit of the Department of veterinary Obstetrics and Reproductive Diseases, University of Nigeria, Nsukka were used for this study. The oestrous cycle of the does was synchronized using 2 injections protocol, 11 days apart, of 250 μg per doe-goat of Cloproject® (0.025% cloprostenol; analogue of $PGF_2\alpha$). Hand-mating of the does was allowed following detected oestrus.

Ultrasound equipment

Ultrasonographic examination was performed using SA600V® (Medison, Co. Ltd, Seoul, Korea) scanner equipped with a multiple frequency (5.0 - 8.0 MH_z) transducer. Results of the examinations were recorded using a thermal video printer (UP-897MD) and ultrasound paper, UPPS 110(Sony Corporation, Japan). The transducer head and the skin of the animal in the area to be scanned were liberally lubricated with acoustic ultrasound gel (Wavelength®, Aqueous coupling gel for ultrasound transmission, National Therapy Products, Canada).

Ultrasound scanning, pregnancy detection, foetal biometry and number determination

Prior to scanning, each doe was fasted overnight and until scanning was over the following day. The does were restrained on either lateral or dorsal recumbent position as previously described [27], and applied [28, 29]. Transabdominal B-mode real-time ultrasonography was performed daily starting from Day 15 (day of oestrus/breeding = day 0 of gestation) [30] until pregnancy confirmation on Day 23.8 ± 0.91 of gestation. Thereafter, sonography was performed on alternate days until Day 59 of gestation. The result and accuracy of sonographic pregnancy diagnosis were computed and presented in percentages. The sensitivity (Se) and specificity (Sp) of the test were also computed and presented in percentages.

Ultrasound foetal biometry was performed on alternate days starting from Day 23 until Day 59 of gestation. During a scanning session 3 to 5 measurements of the foetal crown-rump length were taken and the computed mean was recorded as the dimension of the parameter for the given gestational age. Foetal crown to rump length (CRL) was measured using in-built electronic callipers of the scanner. The CRL was taken as the greatest length of the embryonal or foetal mass before differentiation of foetal parts of the body [31]. Thereafter, the CRL was measured when the top of skull and rump could be distinguished [32]. The measurements were taken from the most upper part of the skull to the end of the sacrum when the foetus was fully extended. When the foetus adopted a curved posture, the measurements were taken in phases [33], depending on the posture adopted by the foetus. All foetal measurements were in millimetres (mm). The results were presented as Means ± standard deviation (SD). The relationship between foetal CRL measurement and gestational age was plotted as linear regression and expressed as straight-line graphs using SPSS version 15 (SPSS Inc., Illinois, USA). The coefficients of correlation (r) and determination (R^2) between gestational age and embryonal or foetal measurements were established by standard regression with computer program EXCEL, 2003 and package data analysis. The effectiveness of the regression equation was determined by value of R^2 and the significance of the regression by the *p*-value.

The study also sought to determine the earliest gestational age at which to accurately predict prenatal foetal number and the accuracy of the prediction. All 10 pregnant does were subjected to foetal number count. Following the detection of evidence of pregnancy during ultrasound scanning, efforts were made on each scanning session to count and record foetal number. The accuracy of prediction of foetal number by real-time ultrasonography, its sensitivity (Se), specificity (Sp), positive predictive value (+PV) and negative predictive value (-PV) were computed [34]. Sensitivity of the diagnostic method was defined as the proportion of true positives that were detected by the method and specificity was defined as the proportion of true negatives that were detected by the method [35]. The positive predictive value or precision rate was defined as the proportion of positive test results that were correctly diagnosed and negative predictive value was the proportion of negative test results that were correctly diagnosed. The accuracy of foetal number determination was computed by comparing actual number of kids born with the expected number as predicted by ultrasonography (26). The accuracy of foetal number determination was computed and expressed in percentages.

RESULTS

Following treatment for oestrous synchronization, 11 out of the 12 does treated exhibited standing oestrus and were hand-mated by 2 virile bucks of proven fertility. Ten (90.91%) of the 11 does were subsequently diagnosed pregnant by ultrasound while 1 (9.09%) doe was diagnosed non pregnant, with 100% accuracy. Pregnancy confirmation by sonography was by imaging of an embryo with a beating heart seen on Day 23.8 ± 0.91 of gestation. The beating heart served as evidence of conceptus viability. All ten pregnant does subsequently kidded after an average gestation length of 144.4 ± 0.12 days. All pregnant does showed at least one embryo that typically appeared as an area of high echogenic density (Fig. 1).

Regression equation for the estimation of gestational age from ultrasound measurements of foetal CRL is shown in Fig. 2. The equation for the estimation of gestational age by crown-rump length ($y = 0.43X + 22.52$: Graph a), has a very high coefficient of determination $R^2 = 0.98$ where y is gestational age in days

and X is foetal CRL measurement in millimeters. Prenatal foetal number predictions could be made between gestational ages of Day 25 and 39 with a mean gestational age of 27.8 ± 1.3 days with 100% accuracy. Foetal number was predicted in 3 pregnancies on day 25, 5 on day 27, 1 on day 29 and 1 on day 39 (Fig. 3). All foetuses were alive due to their heart beats and movements. The mean gestation length in this study was 144.4 ± 0.12 days. Four (40%) does were predicted to bear twin pregnancies while 6 (60%) does were predicted to bear singletons, with 100% accuracy.

Fig. 1. Pregnancy diagnosis using ultrasound in WAD goats. Twin pregnancy: A and B = areas of high echogenic density (embryos).

Fig. 2. Graph of correlation between crown-rump length (CRL) and gestational age in WAD goat fetuses showing regression equation, correlation coefficient and the degree of confidence. (y = gestational age (days); X = CRL measurement (mm); r2 = coefficient of determination)

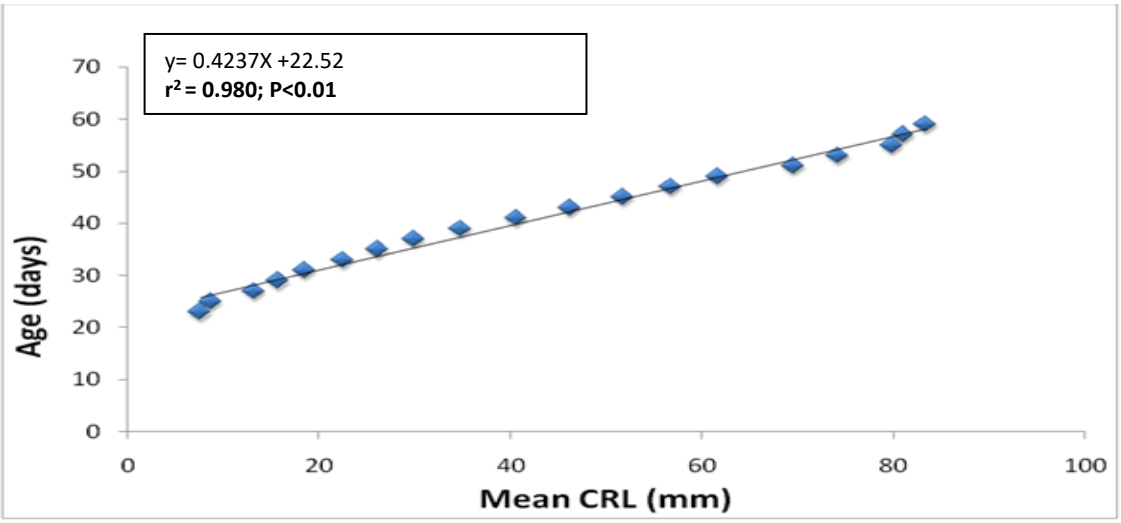
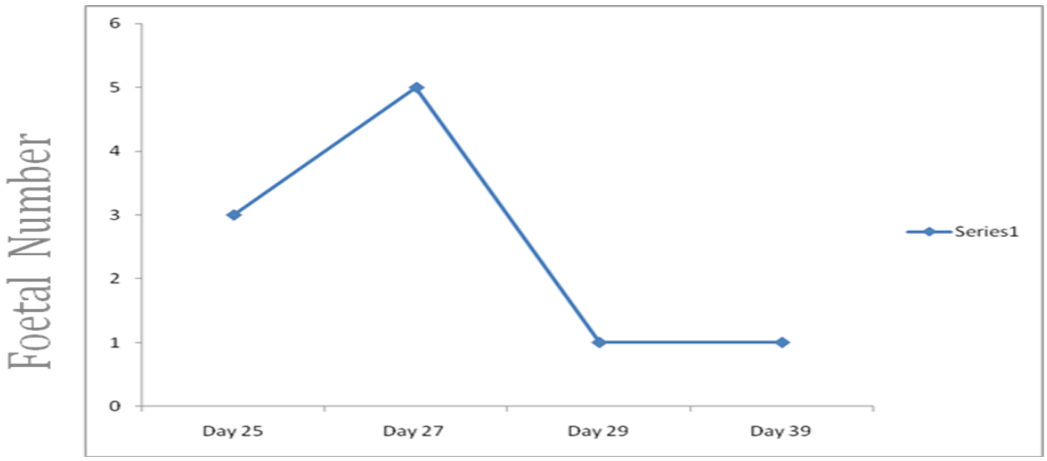


Fig. 3. Prepartum foetal number prediction using ultrasound in WAD goats showing foetal numbers (vertical axis) and gestational age (horizontal) axis.



DISCUSSION

In the antenatal period, the main aim of obstetric monitoring is to determine the pregnancy status including the evaluation of viability, age and number of the conceptuses. A method of pregnancy diagnosis that depends on the visualization of the conceptus is the most accurate and specific for pregnancy [26]. B-mode real-time ultrasonography is an imaging modality that is used to view the entire reproductive tract. In the present study an animal was considered pregnant when a fluid-filled embryonic vesicle (EV), whole embryo/foetus, a foetal part, foetal membrane or placentome was recognized sonographically [7, 18, 21]. Ten (90.91%) of the 11 does that were hand-mated were diagnosed pregnant (sensitivity = 100%) while 1 (9.09%) doe was diagnosed non pregnant (specificity = 100%). The percentage and accuracy of ultrasound pregnancy diagnosis in this study was therefore 90.91% and 100% for positive cases. The percentage and accuracy of pregnancy diagnosis in the present study is similar to the 95.5% and 100%, respectively reported by Amer [36]. Also, in this study the accuracy of detection of either pregnancy or non-pregnancy by ultrasound was 100%. This finding is in agreement with previous reports [26, 34, 36, 37, 38] that recorded accuracies of 100% working with different breeds of goats. Similar results were recorded in the ewe [6, 9, 3]. Ultrasonography is therefore, an accurate and important tool for early pregnancy diagnosis in goats (39) including the WAD goat. B-mode real-time ultrasonography is an imaging modality that is used to non-invasively visualize the entire reproductive tract [18]. Furthermore, in this study, the gold standard for pregnancy detection was that a doe diagnosed pregnant should kid after a normal gestation period or have a visible abortion. All ten does diagnosed pregnant by ultrasound subsequently kidded following an average gestation length of 144.4±0.12 days.

Crown Rump Length (CRL) measurements have been used to predict gestational age in different species [40, 41]. In the present study CRL was easily measured from Day 23 to 59 of gestation. The CRL could not be measured beyond Day 59 of gestation, whereas the length of the foetus, 83 mm, exceeded the viewing field of the screen. In previous studies, Karen *et al*. [40] measured CRL between the gestational ages of Days 25 and 70 while Martinez *et al.* [24] measured CRL between Days 19 and 40 of gestation. The differences in the gestational ages of measurement of CRL among these studies could be due to the different ultrasound scanners used [42]. It has been shown that sonographic measurement of CRL is limited by the viewing field and the penetration depth of the ultrasound scanner [43]. In the present study foetal biometry by CRL measurement correlated well with gestational age ($p < 0.01$; $R^2 = 0.98$). Similar high correlation

($p < 0.0001$; $R^2 = 0.94$) was reported between Days 25 and 70 in the Egyptian native goats [40] and between 19 and 40 days in Anglo-Nubian goats [24]. Slightly lower correlation ($R^2 = 0.90$) was reported in Saanen goats between the 5th and the 10th week of gestation [33]. The higher correlation ($R^2 = 0.98$) between CRL and gestational age in the present study than previous reports of $R^2 = 0.90$ [33] and $R^2 = 0.94$ [24,40], probably due to decreased intervals of successive ultrasound scanning, every other day compared to 7 days [33] and 3-5 days [24,40]. Breed differences could also be responsible for some of the variations in correlation coefficients among these studies [44].

Regarding foetal number prediction, all the 10 pregnant does used in this study were subjected to foetal count. Foetal number count was based on the number of embryonic vesicles (EVs), whole embryos/foetuses or foetal heads visible on the screen during an ultrasound scan. Foetal number predictions were done on day 27.8 ± 1.3 of gestation. Six (60%) does were predicted to bear singleton pregnancies while 4 (40%) were predicted to bear twin pregnancies, with 100% accuracy. The 100% accuracy of litter size prediction in this study is higher than the 92.5% accuracy reported by Abdelghafar *et al*. [34]. The higher accuracy of litter size prediction recorded in the present study was probably because the does had only two pregnancy types (singletons and twins) whereas Abdelghafar *et al*. [34] recorded singleton, twin as well as triplet births in their study. It has been reported that litter type (singletons, twins and multiples) and stage of pregnancy at which predictions were made affect overall accuracy of litter size prediction (45).

It has been reported that the accuracy of differentiating singletons from twins was higher than the accuracy of differentiating twins from triplets and quadruplets [46, 47, 48, 49]. The higher accuracy of foetal number prediction reported in this study compared to the work of (35) was also due to the earlier stage of pregnancy at which the predictions were made. In this study prenatal foetal number could be counted on day 27.8 ± 1.3 of gestation with 100% accuracy. In the work of Abdelghafar *et al*. [34], only one of the four triplet pregnancies that were correctly diagnosed was predicted on day 47 of gestation while the other three that were incorrectly diagnosed were predicted on day 90 of gestation. This is consistent with the recommendation that foetal number counts be performed prior to day 50-55; later the large size of the conceptuses impedes a correct visualization of the entire uterus [45]. Out of the 10 pregnant does in this study, 6 were diagnosed as bearing singleton foetuses (sensitivity = 100%) with 100% accuracy while 4 were diagnosed as bearing twins (sensitivity = 100%) with 100% accuracy. The sensitivity and specificity in determining singleton or twin foetuses was 100%. This finding is in agreement with Abdelghafar *et al*. [34] who also reported sensitivity and accuracy of 100% for both singleton and twin pregnancies. The result of the present study demonstrates clearly that real-time B-mode ultrasonography could accurately detect singleton (sensitivity= 100%) and twins (sensitivity= 100%) in WAD goats with 100% accuracy.

Withholding food from the does prior to scanning ensured that the gastrointestinal tract was evacuated of gases which facilitated the transmission of ultrasound waves. This is in agreement with Karen *et al*. [50] who reported that the sensitivity of ultrasound for early pregnancy in ewes by using 5 MHz trans rectal probe was lower in the absence of fasting and without lifting of the abdominal wall in comparison to scanning diagnosis after fasting for 12 hours. Furthermore, careful shaving and clipping of hair and the use of coupling gel provided suitable contact between the probe and the doe. These measures coupled with the small size of the WAD goats and the use of 5 MHz trans-abdominal probe made for clear visibility of the uterine content and differentiation of singleton from twin foetuses early in gestation. Fourteen kids were born from 10 deliveries recorded in this study. All foetuses were alive due to their heart beats and movements. The mean gestation length of does in this study was 144.4 ± 0.12 days. Gestation length is affected by factors such as season of year, parity and age of dam, sex and number of offspring at birth, weight of doe at service and weight of kids at birth [51].

CONCLUSIONS

In conclusion, therefore, ultrasound imaging by being able to differentiate early pregnancy from non-pregnancy, determine viability, age and number of fetuses, has been shown to be very valuable in appraising

the reproductive performance of the WAD goat in the ante-natal period. These factors may, in turn, influence nutritional and other rational management in-puts as a result of its accuracy in determining the reproductive status of the does in this study. Consequently, sonographic imaging may be a useful tool in improving the reproductive performance of WAD goats.

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