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Research Article

Ultrasonographic Estimation of Gestational Age in Nilotic Goats Using Biparietal Diameter and Head Circumference

Deng Anthony Jong[1]*, Jubara Ambrose Samuel[2], Mohamed Mergani Abdalla[3], Ochi Erneo Bernardo[4] and Jaja Lewis Khamis[5]

[1]Lecturer of Theriogenology, Department of Clinical Studies, College of Veterinary Science, University of Bahr El Ghazal, South Sudan

[2]Professor of Gynaecology, Department of Clinical Studies, College of Veterinary Science, University of Bahr El Ghazal, South Sudan

[3]Assistant Professor of Obstetrics and Gynaecology, Department of Obstetrics and Gynaecology, School of Medicine, University of Juba, South Sudan

[4]Professor of Animal Health, Department of Clinical Studies, School of Veterinary Medicine, University of Juba, South Sudan

[5]Professor of Pathology, Department of Paraclinical Studies, School of Veterinary Medicine, University of Juba, South Sudan

***Corresponding Author:** Deng Anthony Jong, Lecturer of Theriogenology, Department of Clinical Studies, College of Veterinary Science, University of Bahr El Ghazal. South Sudan.

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Abstract

This research evaluates the relationship between gestational age and the measurements of Biparietal Diameter and Head Circumference via transabdominal ultrasonography in Nilotic goats with different parities. A total of twenty-four Nilotic goats: thirteen nulliparous and eleven multiparous, aged 1-4 years and weighing 12-33 kg were used. Estrus synchronization was conducted using intravaginal sponges impregnated with 20 mg of Cronolone controlled-release device for goats. The sponges were followed with a dose of 2 ml of estrumate after 12 days and goats came into estrus with 36-48 hours. Ultrasonographic examinations were performed using a 3.5-5MHz transducer from weeks 6 to 14 of pregnancy to measure the BPD, HC. The results demonstrated a highly significant relationship between gestational age, BPD, and HC, with $R^2 = 0.9967$ for BPD and $R^2 = 0.9964$ for HC. The study concluded that, gestational age of Nilotic goats can accurately be estimated by transabdominal ultrasonography measuring Biparietal Diameter and Head Circumference during the second trimester of pregnancy further study is needed for measuring BPD and HC in different breeds for prediction of gestational age in South Sudan.

Keywords: Ultrasonographic; Gestational Age; Nilotic Goats; Biparietal Diameter; Head Circumference

Introduction

Goats are one of the most domesticated small ruminants, primarily used for the production of milk, meat, wool, and leather, particularly in arid, semi-arid, and mountainous regions [1]. In South Sudan, the goat population is estimated to be 12.3 million head, a large number compared to other African countries [2]. The per capita red meat consumption in South Sudan is 1.1 kg of goat meat per person, with an estimated growth rate of 0.4. Goats in South Sudan are considered an essential part of the country's GDP, contributing 0.41979 billion SSP for meat offtake and 309.14 million USD for milk output [3].

Goats have been classified into four main groups; the Nubian, the Desert, the Nilotic, and the Dwarf. These breeds are distributed throughout the country [4]. Despite the major environmental changes, goats are still of considerable economic importance for poor families. They serve poor and affected people; therefore, improving goat production and breeding is a promising for more milk and meat to their needs.

Early and accurate diagnosis of pregnancy, determination of litter size, and estimation of gestational age in livestock are essential tools for improving reproductive efficiency in goats. This information is useful for making decisions regarding feed allocation and allows for the separation of pregnant and non-pregnant females to facilitate scheduled breeding [5-8].

Various methods can be used to diagnose pregnancy in sheep and goats [9,10]. Real-time ultrasonography has surpassed other methods due to its high accuracy and lack of deleterious effects on the dam, foetus, and operator. Ultrasonographic scanning of the genital tract offers an accurate, rapid, safe, and practical means for diagnosing pregnancy, determining litter size, and estimating gestational age [11].

Ultrasound is used not only for pregnancy diagnosis but also for evaluating ovarian functions and/or disorders, uterine pathophysiology, fetal sexing, and predicting the expected date of parturition [12,13]. Since. report on the use of ultrasound as a veterinary diagnostic aid, this imaging modality has become an important tool in veterinary medicine for evaluating intrauterine fetal life [14,15], detecting fetal movements and heartbeats accurately in advanced pregnancy, as well as assessing vitality and fetal growth [16,17], and the development and growth of small ruminant fetal organs and parts (crown-rump length, head, eye, stomach, bones, and heart) without endangering the pregnancy [18,19].

Its application to the study of animal reproduction represents a technological breakthrough that has revolutionized our understanding of reproductive biology and has become the most efficient diagnostic tool for managing reproduction [20,21]. It has been used to assess several measurable objective variables, such as fetal head size (biparietal diameter), thoracic depth, and embryo length, as well as to determine gestational age in small ruminants [22,23].

Another measurable variable assessed using ultrasound is the placentomes [24,25], which are readily observable via transabdominal ultrasonography throughout pregnancy in small ruminants [26,27]. Transabdominal ultrasonography can diagnose pregnancy from day 25 to 30 post-breeding onward [21]. During the last week of pregnancy, ultrasonographic estimation of the skull becomes more challenging.

In South Sudan, ultrasonography studies of reproduction in farm animals have not yet been conducted. Therefore, this study aims to investigate the relationship between Biparietal Diameter (BPD) and Head Circumference (HC) for predicting gestational age in Nilotic goats. This is intended to establish equations for estimating gestational age via fetal biparietal diameter and head circumference, construct reference gestational charts for fetal biparietal diameter and head circumference, and compare the accuracy of BPD and HC for predicting gestational age in goats during the second trimester using real-time ultrasonography. As South Sudan's economy relies on oil, this research will contribute to enhancing the reproductive performance of Nilotic goats, ultimately increasing the country's GDP.

Materials and Methods

Sample size

Animal selection

24 Nilotic goats were locally and housed in a fence donated by the Egyptian Coptic Church where the shelter was constructed for the research to compare the accuracy of head circumference and biparietal diameter in estimating foetal gestational age. The purchased goats were between the ages of 1 to 4 years with different parity. 6 proven fertile bucks were used for mating during the research period.

Estrus synchronization

24 goats (13 Nulliparous and 11 multiparous) aged of 1-4 years and 12-33 kg body weight with different parity were used. After the adaptation period of 14 days, all goats (30) were examined to confirm the possibilities of pregnancy; after the goats were successfully confirmed not pregnant through ultrasound examination, it was decided to synchronize their heat to allow for accurate mating and monitoring of gestation length with the known pregnancy date. Intravaginal sponges (Chronogest CR) impregnated with 20 mg of Cronolone controlled release device for goats were implanted using an applicator. During the process of insertion, goats were controlled by animal attendants, with their prpenial regions cleaned, followed by lubrication of vulva region to avoid any injuries with applicator. The sponges were then removed from the package and placed in applicator which is opened at both ends, followed by carefully and slowly insertion into vagina. After insertion, a small cord of sponge thread was left protruding from the vulva so that it could be easily removed. Goats were checked regularly for any bleeding or loss of sponges for period the goats were with sponges in their vagina. After 12 days all the goats implanted with sponges received intramuscular doses of 2 ml estrumate hormone at the level of scapula.

On the 14th day, sponges were removed from the vagina followed with cleaning, drying and disinfection of vulva region to avoid any infection. Goats started showing estrus within a few hours (36-48 hours). The signs of heat were, vaginal discharge, mounting on each other, searching for bucks that were housed separately.

Mating process

During the mating, all the goats were mated naturally with 6 proven fertile bucks through the hand mating process. This involves detecting females in estrus and bringing them to breeding males. In such a system, regular and efficient heat detection methods are essential [28].

The goats that showed male acceptance were controlled by assistants and bucks were allowed to mount. After confirming the mating took place, the does were separated into different fences to mate twice or more. Some of the goats that came on heat in the morning were mates in the afternoon and those that came on heat in the late evening were mates early morning of the next day. All the bucks were allowed to stay with the does for two more days to monitor whether there was mating or not. The first day of mating was recorded as day zero before the confirmation of the pregnancy.

Ultrasonography of goat

Before ultrasonic measurements, goats were fasted for 12 hours to allow quality images [29]. The inguinal area up to the ventral midline was shaved 5-6 cm and thoroughly cleaned for better probe skin contact, goats were then taken to the shelter where the ultrasonography was performed. Some were restrained in a standing position with the help of animal attendants for scanning while some were scanned on the special table designed for ultrasonography measurements. The ultrasound machine and probes were properly set up. Ultrasound scanning examinations were executed using transabdominal probes (3.5-5.0 MHz frequency). An adequate quantity of ultrasound gel was applied over the probes to eliminate the air spaces to obtain better contact of skin with the probe surface which could enhance the image quality [30]. The transducer was moved perpendicularly towards the ventral abdominal wall until the urinary bladder became visible on the monitor. Parameters on early pregnancy such as sac [31], non-echogenic (NE) area, amniotic fluid, and foetal heartbeat were indicators of early pregnancy. The foetal structural images and other related images, such as the presence of placentomes, ribs, spinal cord, limbs, head, and other skeletal structures were the indicators during the stages of the second trimester. Pregnancy-positive does were scanned for measuring foetal parameters on weekly bases. The measurements of foetal Head Circumference(HC) and biparietal Diameter (BPD), were measured by electronic Ellipse after freezing the desired image to estimate the gestational age in the goat. During the measurement of the HC, the below formula was used BDP+OFD = *1.62 [32].

Foetal parameters

Biparietal diameter (BPD)

During ultrasound examination in the first trimester of pregnancy in Nilotic goats, it was also possible to determine the BPD of the foetal head. During the scanning process, the foetal skull was visualized in its transverse axial plane and the axis of the head symmetry was perpendicular to the ultrasound beam. The largest

distance between the outer limit of the two parietal bones of the foetal skull is measured [33]. The cross-sectional images obtained were used to measure BPD with a transabdominal convex probe 3.5-5 MHz after freezing it on the monitor. For the twin foetuses, the means for both foetuses for BPD are recorded as the actual age estimation after taking the two measurements.

Head circumference (HC)

Ellipse was traced at the outer skull border to measure the circumference of the foetal head and similar results were obtained [32]. Similarly, the HC was calculated from the BPD and OFD: HC = 1.62 × (BPD + OFD) This formula was based on the circumference of an ellipse with diameters BPD and OFD.

For the OFD measurement, one calliper was placed in the anterior midline in the middle of the echogenic line of the frontal bone, and the second is placed posteriorly in the middle of the echogenic line of the occipital bone [34].

Statistical analysis

Gestational formula was established using Statistical Packages for Social Sciences (SPSS) vision 22.0.

Results

Relationship between GA and BPD

This result shows a close correlation between measurements with gestational age increase as data scar closely around the regression line. The also result shows that BPD can be measured at 6(42 days) weeks of gestation to increases 10.51 ± 0.18 mm, the mean weekly increase rapidly reaching 41.75 ± 0.67 mm at 14 weeks (98 days). After 14 weeks BPD becomes difficult to measure as the head increases in size (Figure 1).

The above simple regression equation is described as follows y = 0.2588x + 3.2776.

Where y = gestational (weeks) and x is the BPD. A high correlation shows R^2 = 0.9967 (Plate 1,2).

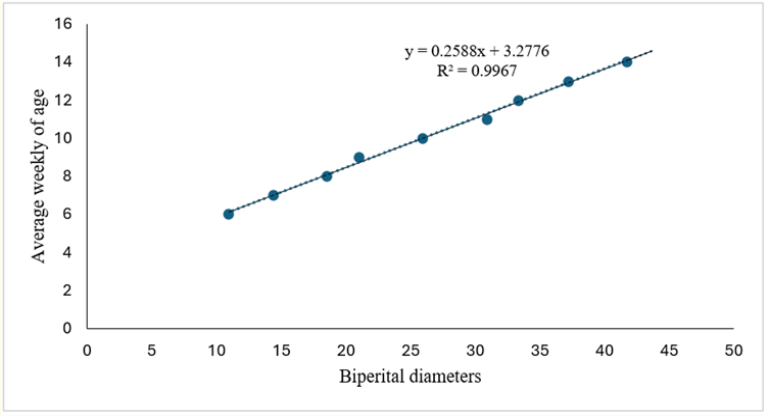

Figure 1: Relationship between GA and BPD.

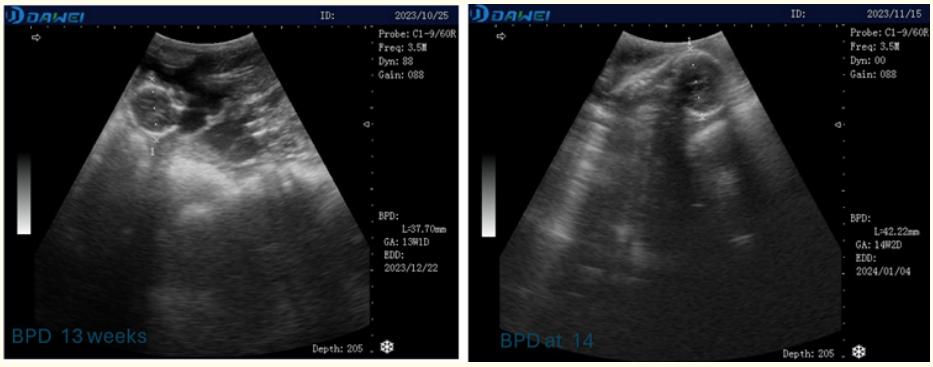

Plate 1: Ultrasonic measurements of BPD at 13 and 14 weeks.

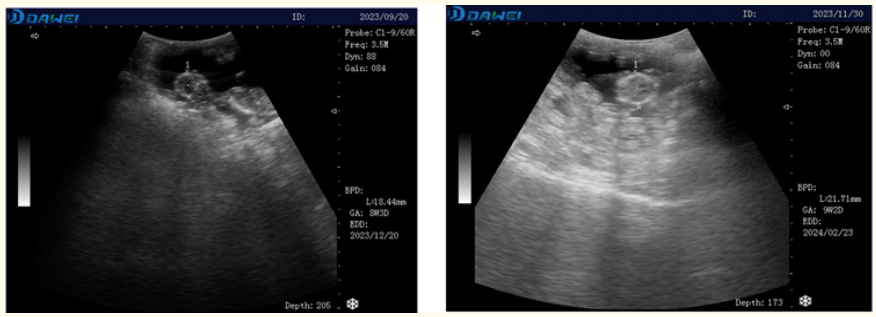

Plate 2: Ultrasonic measurements of BPD at 8 and 10 weeks.

Mean (± SD) of weekly measurements of the BPD (Table 1).

Weeks	BPD(M ± St.d) measurement mm
42	10.51 ± 0.18
49	14.45 ± 0.75
56	18.53 ± 1.07
63	21.06 ± 1.62
70	25.99 ± 1.62
77	30.97 ± 1.37
84	33.39 ± 1.48
91	37.22 ± 1.21
98	41.75 ± 0.67
P-value	0.000

Table 1: Mean (± SD) of weekly measurements of the BPD.

Relationship between GA and HC

This figure shows a close correlation between measurements with gestational age increase as data scar closely around the regression line. This indicates that HC can accurately be measured on week 6(4 days) of gestation when it measured 36.72 ± 0.64 mm and increased to 87.34 ± 5.09 mm in week 10(70 days) and advanced until 138.57 ± 1.89 mm at 14 weeks (98 days); similarly, HC is difficult to measure after 14 weeks as the head becomes outside the monitor.

Mean (± SD) of weekly measurements of the HC (Table 2, Plate 3).

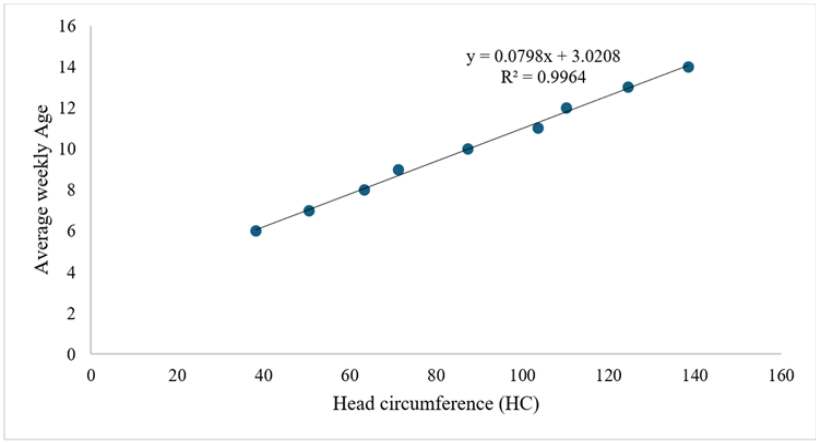

Figure 2: Relationship between GA and HC.

Weeks	HC (M ± St.d)measurement mm
42	36.72 ± 0.64
49	50.53 ± 2.58
56	63.31 ± 4.02
63	71.36 ± 5.54
70	87.34 ± 5.09
77	103.64 ± 4.55
84	110.34 ± 7.88
91	124.56 ± 4.49
98	138.57 ± 1.89
P-value	0.000

Table 2: Mean (± SD) of weekly measurements of the HC.

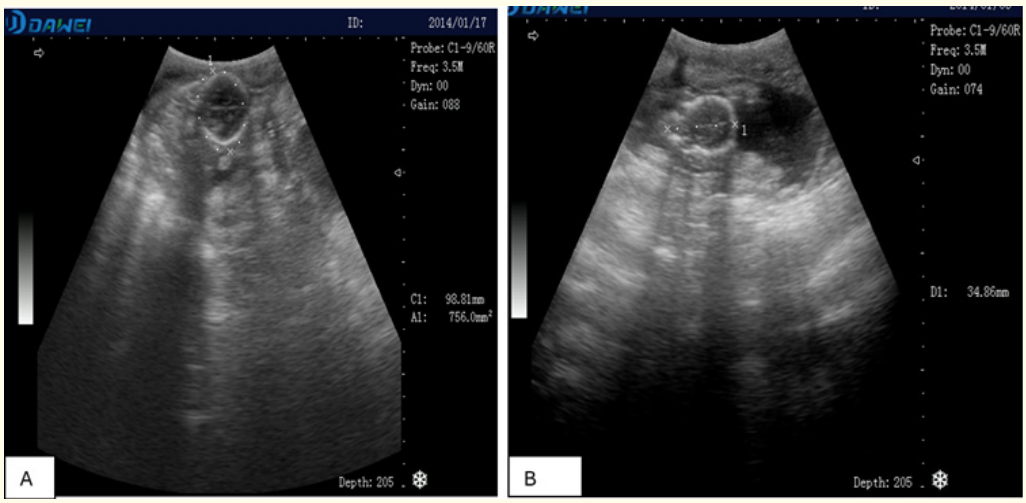

Plate 3: Ultrasonic measurements of HC in 11weeks (A) and OFD 11 weeks (B).

Discussion

Estimation of gestational age by measuring BPD

In the present study, the delay in ultrasonic measurements until 6 weeks is due to the type of probe used; which was confirmed by measurements performed from week 4-6 in the same experiments This is in agreement with [35] who reported that the bi-parietal diameter in Saanen goats could be measured starting from week 6 of gestation with 1.1 ± 0.3 cm using a trans-abdominal approach. The measurement of BPD in this study was ended in 14 weeks as the head increased in size and BPD became difficult to measure as it became out of the monitor, this agreed with [36] who measured the BPD in sheep and goats between days 40-100 of gestation using trans-abdominal ultrasound. The use of BPD for determination of gestational age in Nilotic goats is due to the fact that it is a

liable means of estimation of gestational age in second trimester, this agreed with These measurements were reliably predictive of gestational age during the 2nd trimester. [37]. who reported that the measurements of BPD proven to be an efficient parameter for predicting gestational age in Jamnapari goats in second trimester which is in agreement with the present result where the BPD was measured for determination of gestational age in second trimester in Nilotic goats.

The current finding found the correlation between the BPD and HC, which revealed that the highest significance ($P < 0.01$) with high correlation ($r = 0.998$) between the two measurements and GA from week 6 up to 14 weeks of gestation. This study strongly agrees with [38] who reported a high correlation between fetal BPD and gestational age in Purebred Toggenburg goats (R2 = 0.9949), Purebred Nubian goats (R2 = 0.9875) and Angora goats (R2 = 0.9775) between Day 40 and 100 of gestation; [37] in Jamnapari goats reported strongly correlated (0.980) between BPD and gestational age [39]; obtained a high correlation (R2 = 0.98) between fetal BPD and gestational age from Days 39 to100 after mating in dairy goats.

Similarly, [40] reported biparietal (R = 0.98) in red Sokoto goats; [41] found correlation of (R2 = 0.9831) between fetal BPD and gestational age between Day 56 and 130 gestations in Indian crossbred goats; [41,42]. also reported a correlation (R2 = 0.9831) between fetal BPD and gestational age between Day 56 and 130 gestations in Indian crossbred goats [43] reported that the ultrasonic measurements of fetal head diameters were well correlated with gestational measurements of BPD ($r = 0.9687$) in Nellore Brown ewes.

[44] in their research on Ultrasound foetometry in Egyptian sheep and goats found highly a coefficient of BPD as R2 = 0.9601 [45] measured the BPD of pygmy goat fetuses between Days 36 to 102 of gestation at two to three days' intervals and reported a significantly high correlation (R2 = 0.97) between BPD and gestational age of fetuses; Similar results were also obtained by [46] who conducted an assessment of gestational age in goats by Real-Time Ultrasound and reported that Bi-parietal diameter was highly significant ($P < 0.01$) Bi-parietal diameter (R2 = 0.95), In the present study, the BPD was highly significantly correlated (P 0.000, R^2 = 0.9964) with gestational age and increases throughout the gestational period; This result is in agreement with [47] who obtained positive correlations (P 0.001, R^2 = 0.91) in Saanen goats [48] reported significant correlation (R2 = 0.956) between foetal BPD and gestational age between Days 30 and 105 of gestation, although his measurements were conducted earlier and ended late compared to the present study both results were in conformity [49] reported (R2 = 98.1) in Red Sokoto goats between 57- 124 days of gestation. [50] measured the BPD between 49- 119 days of gestation in Booroola x South Australian Merino ewes, they found correlation coefficient of about (R2 = 0.96).

The current results slightly disagreed with [51], who reported a BPD correlation (R2 = 0.87) however, two months of gestation till birth in Swedish Pelt sheep, the two results disagree because of species variation and duration of parameters measurements. [44] in his research on Ultrasound guided fetometry in Egyptian sheep and goats throughout the gestational cycle between 26 and 112 found correlation coefficient of BPD (R2 0.898 and 0.903); it seems that, there are many factors that might have dictated the lower result which may include, breed type, duration of research and operator errors as well as the type of machines used. [52] studied dairy ewes between gestation day 25 and 63, and reported a similar correlation ($r = 0.93$) for the BPD which might have lower the results of the present research. The disparity is may be due to duration of study, type of probe and machine used and breed of the animal.

Estimation of gestational age by measuring HC

The HC tended to be difficult to measure after 14 weeks as the head becomes outside the monitor [53]. To obtain the HC in a device that doesn't support its measurement, the difference between the BPD and OFD can be used to calculate the HC in human, This method agrees with [34] who measured the HC in breech-presented foetuses between 31st - 38th weeks of gestation; and recorded a difference between BPD and HC as 16.2 days. In similarly manner, Ellipse was traced at the outer skull border to measure the circumference of the foetal head that agreed with [32].

In this study there was a very high significance correlation between HC and GA with (R2 = 0.9796 P < 0.00.) in current research, the result positively supported that HC can be used for prediction of gestation age in Nilotic goats as the delivery days in all 24 have been confirmed within the expected delivery day.

Conclusion and Recommendations

Conclusion

Ultrasonography is non-invasive, not time consuming and comfortable method for detection of pregnancy diagnosis in Nilotic goats. Additionally, foetal viability, twining can be detected as well as estimation of gestational age by measuring BPD and HC. There was strong correlation between biparietal diameter and head circumference for prediction of gestational age in Nilotic goats which gives farmers a reliable method pregnancy diagnosis.

Gestational age equation was formed to give farmers better breeding plan to improve future productivity.

There was a reduction in prevalence of foetal wastage, which can increase the future generation in Nilotic goats.

Recommendations

Different probe such as transrectal probe, can be used to measure both biparietal diameter and head circumference for prediction of gestational age in Nilotic goats at different trimesters.

Different parameters such as CRL, PD, UC, TD, OND and FL can be used for prediction of gestational age in Nilotic goats.

An additional research can be conducted measuring both Biparietal Diameter and Head Circumference in different breed of goats for prediction of gestational age in South Sudan and elsewhere in the region.

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