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Gestational Age Estimation of Sahraoui Dromedary Camel Based on Fetomaternal Measures and Phenotypic Characteristics

[1, 2]Gherissi Djallel Eddine, [1, 2]Afri-Bouzebda Farida and [1, 2]Bouzebda Zoubir
[1]Department of Veterinary Medicine, Institute of Agronomic and Veterinary Sciences,
University of Souk Ahras, Ahras, Algeria
[2]Laboratory of Biotechnology, Animal Production and Health,
University of Souk Ahras, Ahras, Algeria

Abstract: This study was conducted to assess the chronological evolution of the fetal external features and body measurements to monitoring the pregnant reproductive tract and placental dimensions for prediction of gestational age in Sahraoui camel breed. The reproductive tracts of 34 gravid she-camels between 70-391 day were collected and the following biometric parameters were recorded, i.e., LLUH, WLUH, LRUH, WRUH, LUB, DCL, PL, PW, CRL, SH, BPD, HL, FL, ED and AC. The fetal biometric parameters were the best predictors of the gestational age (R^2 = 0.99, p<0.001, Se_{pred} = 2.40 day). However, the maternal and placental parameters were less accurate to fetal aging (R^2 = 0.89, p<0.001, Se_{pred} = 15.23 day and R^2= 0.80, p<0.001, Se_{pred} = 12.37 days, respectively). According to the three periods of gestation the LH and LF had the most significant role in predicting gestational age at the 1st third of pregnancy (R^2 = 0.99, Se_{pred} = 0.22 day, p<0.001). At the 2nd third, the LH was the best predictor of gestational age (R^2 = 0.99, Se_{pred} = 2.14 day, p<0.001) and at the last third of gestation the BPD was the most accurate (R^2 = 0.97, Se_{pred} = 6.64 day, p<0.001). The general stepwise regression formula including the BPD gave the most accurate prediction (R^2 = 0.99, p<0.001, Sepred = 1.24). The obtained results can assist practitioners in the rapid fetal aging using ultrasound examination, on aborted camels at prematurity and in scientific research on the reproduction and development of camels.

Key words: Biometry, camel, fetus, gestational age, placenta, uterus

INTRODUCTION

Camels are ideal species for exploitation under the arid and semi-arid land conditions. Most often a negative argument against camel breeding is quoted that their reproduction rate is low and uncertain (Tibary and Anouassi, 1997; Skidmore, 2005; Mayouf *et al*., 2014). Effective pregnancy is an essential factor in the maintenance of good levels of productivity by reducing losses due to the fetal and neonatal mortality, postpartum infertility, reform of females and treatment costs. In pregnant females, understanding the synchronous development between the age of the fetus and the genitalia female segments needs an accurate pregnancy age determination using fetal and maternal biometry (Richardson *et al*., 1990). These informations are of great interest in the diagnosis of gestation during clinical and ultrasound examinations and in the exploitation of reproductive technologies such as artificial insemination (Vyas *et al*., 2002; Skidmore, 2005). They are also important for understanding obstetric problems in order to propose their appropriate treatments (Tibary and Anouassi, 1997) and to study aborted fetuses and those collected at slaughter houses (Mcgeady *et al*., 2006). The present study is carried out to describe the progressive changes in the external features of the dromedary camel fetuses, to record the dimensions of the different fetal-maternal measurements according to the stage of gestation and to establish linear regressions to accurately predict gestational age in Sahraoui breed at the South Eastern of Algeria. This research constitutes one of the essential bases for the interpretation of the ultrasound monitoring of pregnancy in the she-camel.

MATERIALS AND METHODS

Collection of samples: This study was carried out on 34 pregnant she camels from the Sahraoui breed aged between 5 and 20 years old slaughtered at El oued central abattoir. This region is located at lat. About 33-34°N and long.6-8°E in an arid environment in Southeastern of Algeria (average altitude 80 m, average

Corresponding Author: Gherissi Djallel Eddine, Department of Veterinary Medicine,
Institute of Agronomic and Veterinary Sciences, University of Souk Ahras, Ahras, Algeria

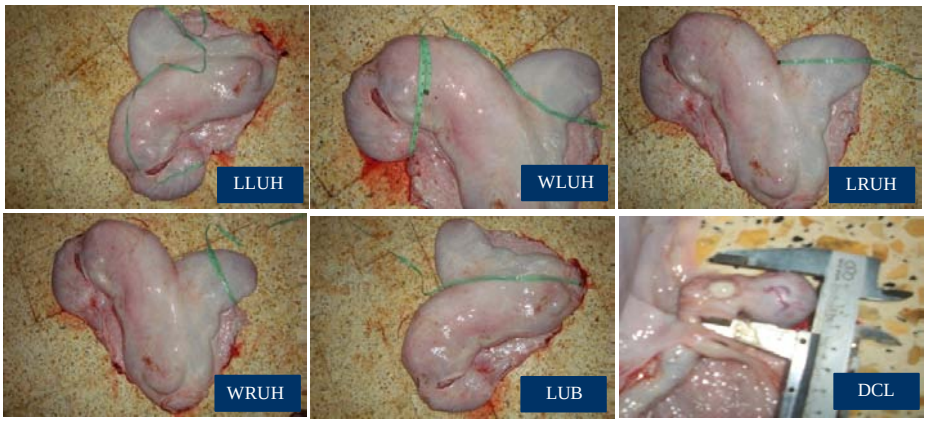

Fig. 1: Genital tract measurements for estimating of gestational age in Sahraoui she-camel LLUH: Length of the Left Uterine Horn, WLUH: Width of the Left Uterine Horn, LRUH: Length of the Right Uterine Horn, WRUH: Width of the Right Uterine Horn, LUB: Length of the Uterine Body and DCL: Diameter of Corpus Lutum

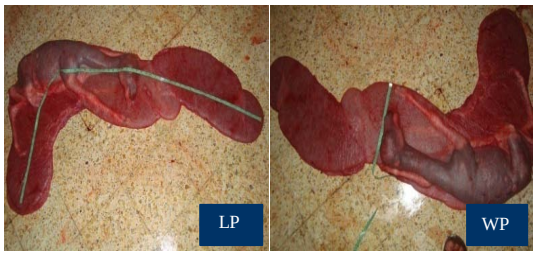

Fig. 2: Placental measurements for estimating of gestational age in Sahraoui she-camel LP: Length of the Placenta and WP: Width of the Placenta

annual temperature of 25°C and mean annual precipitation of 80 mm). After slaughter, the pregnant reproductive tracts, fetuses and placentas were immediately collected and measured.

Fetal and genital tracts examination and measurements: The genital tracts were examined and measured in a progressive ascending sequence. Each tract was then incised and opened for examination of the lumen and to take measurements separately of fetal annexes and different body parts of the fetus. The measurements showed in Table 1 and Fig. 1-3 were recorded for each sample.

The Gestational Age (GA in days) was determined by the following formula established by Elwishy (1988) and described by Shehu *el al.* (2012) and Elrazik *et al.* (2013): GA = (CRL+23.99)/0.366; CRL: Crown Rump Length in cm. The gestation length in days was divided into three-thirds according to the number of days obtained by the above formula: 1st third of gestation = <130 days, 2nd third = 131-260 days and last third = 261-390 days. On the other hand, the fetal development characteristics were identified according to the previous reports (Evans and Sack, 1973; Sivachelvan *et al.*, 1996).

Table 1: Fetal and maternal measurements for estimating of gestational age in Sahraoui she-camel

Abbreviation	Signification
LLUH	Length of the Left Uterine Horn
WLUH	Width of the Left Uterine Horn
LRUH	Length of the Right Uterine Horn
WRUH	Width of the Right Uterine Horn
LUB	Length of the Uterine Body
LP	Length of Placenta
WP	Width of the Placenta
SH	Shoulder Height of the fetus
BPD	Biparietal Diameter
LH	Length of the Humerus
LF	Length of the Femur
AC	Abdominal Circumference
ED	Eye Diameter
DCL	Diameter of the Corpus Lutum

Statistical analysis: Statistical analyses were performed by statistica Software (V.7.0.61.0). Means per third of gestation were compared by one-way ANOVA for multivariate tests of significance followed by post-hoc test using Duncan's Multiple Range Test (DMRT). A simple and multiple linear regressions were performed in order to relate morphologic fetal and maternal dimensions and GA (Y) variation by applying the following Eq. 1:

$$Y = b_1x_1 + b_2x_2 + b_3x_3 + ... + b_nx_n \quad (1)$$

Where:

a = The intercept coefficient on the y axis

b = The related coefficients of independent variables in predicting the dependent variable

The 95% confidence limits were calculated in stepwise regression in order to determine the most

Fig. 3: Fetal measurements for estimating of gestational age in Sahraoui she-camel. CRL: Crown Rump Length, SH: fetal Shoulder Height, BPD: Biparietal Diameter, LH: Length of the Humerus, LF: Length of the Femur, AC: Abdomen Circumference and ED: Eyes Diameter

important variables (independent variables) that predict significantly the GA (dependent variable). Determination coefficient (R^2) and standard error of prediction (SE_{pred}) were used when appropriate to know how well observed outcomes are replicated by the models and to measure the accuracy of predictions made with a regression line. Results are expressed as mean±SE and significant difference were considered at a $p<0.05$, 0.01 and 0.001.

RESULTS AND DISCUSSION

Fetal identifying characteristics

First third of pregnancy (Fig. 4a and b): The fetuses at this stage had size of a mouse to a football and were clearly recognizable as fetal camel. The studied fetuses aged between 70 and 86 days did not show signs of sexual differentiation. From age 92 day, fetuses showed vulva and breast buds in females and penile sheath and scrotum without testicular descent in males. Until the age of 98 day fetuses appeared hairless with a thin and pale skin but from the age of 100 day fetuses had slightly pink skin. The calvarium of fetuses was flexible, membranous and transparent, particularly in the occipital region until the age of 98 day. The buds of eyes and ears were clearly apparent from the age of 70 day. The jugular venousroute was well marked and some internal organs appeared under translucent abdominal wall until the end of the first third of pregnancy. Legs were thin and length ending with hoof-shaped feet with rubbery pad on the bottom of the foot.

Second third of gestation: The fetus at this stage had a definite dorsal hump, eyes and ears (Fig. 4c). Between the ages of 203 and 232 day, the hair begin to comb the lips, muzzle, eyelids and eyebrows of the fetuses although they still hairless with a pinkish skin, thicker and less transparent except the legs and medial ventral parts of the body (Fig. 4c). A little hair covered the heads and the neck of fetuses from age of 259 day. The hooves still soft and pads covered with a soft, wrinkled and very mobile skin which didn't show any signs of keratinization (Fig. 4c). Breast buds and vulva are more apparent at this stage. At the age of 192 day the scrotum became more important with palpable structures inside and apparent interscrotal septum. The jugular vein was only prominent at the early stages of the 2nd third of pregnancy and did not appear in fetuses older than 149 day. At 166 day of pregnancy the fetus still had soft calvarium. Form 192 day of pregnancy, the calvarium became more solid except at the center of the occipital part with interboney clefts that ossified later (Fig. 4c).

Last third of pregnancy (Fig. 4d): Fetuses have long, thin limbs with a thin and small body (Fig. 4d). From the age of 268 day the calvarium was completely ossified and became hard with several mobile interboney clefts. From

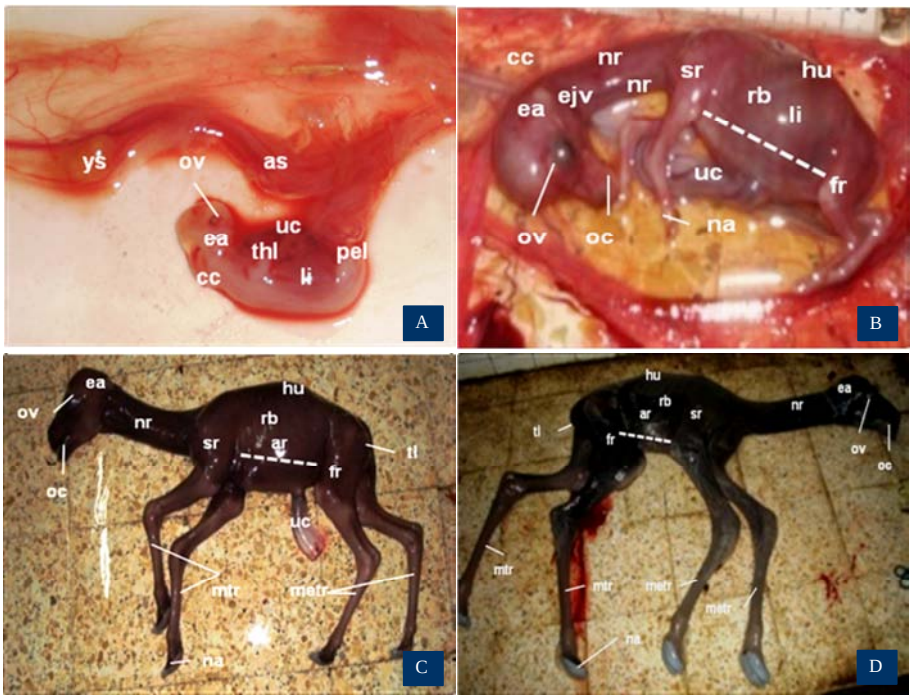

Fig. 4: Examples of lateral view photographs of camel fetuses used for the gross morphology descriptions and gestational age prediction. The specimens presented are the following: A) Day 78 fetus; B) Day 98 fetus; C) Day 267 fetus; D) Day 420 fetus. am, amniotic sac; ar, abdominal region; cc, cervical curvature; ea, ear; ejv, external jugular vein; fr, femoral region; li, liver; metr, metatarsaus region; mtr, metacarpal region; na, nail apparatus; nr, neck region; oc, oral cavity; ov, optic vesicle with the retinal pigment epithelium; pel, pelvic limb; rb, ribs; sr, scapular region; thl, thoracic limbs; tl, tail; uc, umbilical cord; ys, yolk sac

381 day of age the whole body of fetuses was covered with crud, fine hair of silky texture. At the end of this period the inner face of the legs became covered by soft and fluffy hair.

Biometric changes of genital, placental and fetal parameters: The 34 recovered fetuses were aged between 70 and 391 day; among them 14 (41.11%) females and 20 (58.23%) males. According to their age; 18 (52.94%) were in the first third of pregnancy, 10 (29.41%) were in 2nd third and 6 fetuses (17.64%) were in the last third of pregnancy with respective average CRL of 11.16±7.52, 46.38±12.03 and 98.53±25.70 cm and respective average GA of 96.04±20.56 day, 192.27±32.88 day and 334.76±70.21 day (Table 2).

All the studied fetuses were located at the left uterine horn of the pregnant females. However, the chorion and the large allantoic sac extended early into the other uterine horn. According to Table 2, the passage from the first third to the second third of pregnancy was marked by a significant increase in LLUH, LRUH, WRUH ($p<0.001$) and WLUH ($p<0.01$) and a non-significant change of LRUH ($p>0.05$). The LUB increased significantly in the second and the last third of pregnancies ($p<0.01$ and 0.001, respectively). The following fetal measurements CRL, SH, BPD, HL, FL, ED and AC were all significantly increased from one stage of gestation to another ($p<0.001$) (Table 2). Moreover, the LP increased at the second and last third of pregnancy ($p<0.01$, $p<0.001$, respectively), in contrast, WP did not showed a significant difference between the first and second third ($p>0.05$) but increased significantly in the last third of pregnancy ($p<0.001$).

The rates for pregnant females with ipsilateral, contralateral and multiple corpus lutum were 41.17, 55.88 and 2.94%, respectively (Fig. 5). The mean diameter of the CL did not showed significant difference between the three stages of gestation ($p>0.05$).

Regression equations for fetal aging: The equations derived from simple and multiple linear regressions for gestational age estimation are presented in Table 3. The obtained results showed that the prediction model for Gestational Age per camel (GA) derived from the various biometric fetal, uterine and placental indices without the CRL was Eq. 2 as follows:

Table 2: Changes in of the sizes of uterine, fetal and placental characteristics used for estimation of gestation age

Variables	1er trimester (n = 18)	2eme trimester (n = 10)	3eme trimester (n = 6)	Mean±SD	Min.-Max.
Rates (%)	52.94	29.41	17.64		
AGA (days)	96.04±20.56[a]	192.27±32.88[d]	329.07±62.84[g]	165.47±93.94	70-391
LRUH (cm)	13.3±7.16[a]	39.94±10.50[d]	51.11±14.48[d]	27.85±18.58	5.20-68.00
WRUH (cm)	7.86±4.92[a]	19.12±3.58[d]	25.73±4.29[f]	14.27±8.54	3.40-32.00
LLUH (cm)	26.01±12.07[a]	55.02±9.60[d]	85.47±18.48[g]	45.09±25.98	8.80-110.0
WLUH (cm)	13.96±7.19[a]	20.42±5.06[c]	33.30±2.52[f]	19.27±9.28	4.00-37.50
LUB (cm)	17.29±7.63[a]	29.90±11.76[f]	59.02±12.86[f]	28.37±18.20	7.64-71.00
LP (cm)	51.12±26.63[a]	107.86±23.64[d]	148.14±36.38[f]	84.93±47.20	14.30-175
WP (cm)	24.13±16.94[a]	22.78±7.30[a]	54.32±23.78[f]	29.06±19.73	3.30-80.00
CRL (cm)	11.16±7.52[a]	46.38±12.03[d]	96.45±23.00[g]	36.57±34.38	1.50-119.2
SH (cm)	7.35±5.38[a]	29.02±8.70[d]	66.73±20.67[g]	24.20±24.31	0.50-91.00
BPD (cm)	1.42±1.00[a]	5.77±1.50[d]	11.92±3.00[g]	4.55±4.26	0.19-15.36
LH (cm)	1.84±1.24[a]	7.65±1.98[d]	13.38±2.40[g]	5.58±4.77	0.25-16.38
LF (cm)	2.09±1.40[a]	7.49±2.25[d]	17.18±4.17[g]	6.34±6.05	0.29-22.87
AC (cm)	6.86±3.92[a]	21.64±6.11[d]	44.83±8.37[g]	17.91±15.21	1.51-55.38
ED (cm)	0.40±0.28[a]	1.78±0.55[d]	3.42±0.63[g]	1.34±1.23	0.25-4.15
DCL (cm)	1.84±0.23[a]	1.88±0.23[a]	2.00±0.42[a]	1.88±0.27	1.40-2.60

p<0.01: (a-c), (d-f); p<0.001: (a-d), (a-f), (a-g), (c-f), (d-g)

Table 3: Comparison of the accuracy of gestational age prediction by the various simple and multiple linear regression models containing different indices

Independent variables	Regression equations	R^2	p-values	SE_{pred} (days)
Maternal parameters				
LRUH (cm)	GA (days) = 40.98+4.46LRUH	0.78	<0.001	10.54
WRUH (cm)	GA (days) = 24.97+9.89WRUH	0.80	<0.001	10.04
LLUH (cm)	GA (days) = 13.76+3.36LLUH	0.86	<0.001	8.120
WLUH (cm)	GA (days) = 3.70+8.39WLUH	0.68	<0.001	12.45
LUB (cm)	GA (days) =33.29+4.65LUB	0.81	<0.001	9.500
DCL (cm)	GA (days) = 77.68+46.63DCL	0.01	>0.05	21.89
	GA (days) = 39.82+0.28LRUH+3.04 WRUH+ 1.88LLUH-3.79WLUH+2.42LUB-3.15DCL	0.89	<0.001	15.23
Placental parameters				
LP (cm)	GA (days) = 17.26+1.74LP	0.76	<0.001	10.75
WP (cm)	GA (days) = 67.44+3.37WP	0.50	<0.001	15.56
	GA (days) = 10.32+1.43LP+1.14WP	0.80	<0.001	12.37
Fetal parameters				
SH (cm)	GA (days) = 72.88+3.82SH	0.98	<0.001	3.070
BPD (cm)	GA (days) = 65.25+22.01BPD	0.99	<0.001	1.240
LH (cm)	GA (days) = 57.04+19.41LH	0.97	<0.001	3.820
LF (cm)	GA (days) = 67.83+15.38LF	0.98	<0.001	2.780
AC (cm)	GA (days) = 56.05+6.10AC	0.97	<0.001	3.030
ED (cm)	GA (days) = 63.98+75.72ED	0.98	<0.001	3.430
	GA (days) = 65.27-0.04SH+21.05 BPD+2.29LH-1.76LF-0.55AC-6.36ED	0.99	<0.001	2.400
General regression equation	GA (days) = 72.61-0.03LRUH-0.61 WRUH-0.46LLUH+0.55WLUH+0.01LUB+0.17 LP-0.17WP+0.42SH+22.71DBP+6.09LH+3.61 LF-1.80AC-16.98 ED-2.16DCL	0.99	<0.001	3.150

LLUH: Length of the Left Uterine Horn, WLUH: Width of the Left Uterine Horn, LRUH: Length of the Right Uterine Horn, WRUH: Width of the Right Uterine Horn, LUB: Length of the Uterine Body, LP: Length of Placenta, WP: Width of the Placenta, SH: Shoulder Height of the fetus, BPD: Biparietal Diameter, LH: Length of the Humerus, LF: Length of the Femur, AC: Abdominal Circumference, ED: Eye Diameter, DCL: Diameter of the Corpus Lutum R^2: determination coefficient, SE_{pred}: Standard Error of prediction (SE_{pred}), p-value: significant level

$$GA\ (days) = 72.61-0.03LRUH-0.61RUH-0.46LLUH+0.55WLUH+0.0LUB+0.17LP-0.17WP+0.42SH+22.7BPD+6.09LH+3.61LF-1.80AC-16.98ED-2.16DCL \quad (p<0.001,\ R^2 = 0.99,\ SE_{pred} = 3.15) \quad (2)$$

This model showed that the fetal and maternal variables can be used to 99% for significant prediction of gestational age with SE_{pred} of 3.15 days while the remaining 1% perhaps was due to residual effects. Except the DCL (R^2 = 0.01; p>0.05), all considered parameters were significantly correlated with gestational age (R^2 = 0.50;

Fig. 5: Multiple corpora lutum on the ovary of she-camel at the 1st third of pregnancy

Table 4: Stepwise multiple linear regression models for prediction of gestational age by variable groups (fetal, placental and maternal)

Parameters	R^2	p-values	SE_{pred} (days)
Fetal parameters			
65.27-0.04SH+21.05DBP+2.29LH+1.79LF-0.55AC-6.36ED	0.99	<0.001	2.40
Placental parameters			
10.32+ 1.43LP+1.14WP	0.80	<0.001	12.37
Maternal parameters			
39.82+0.28LRUH+3.04WRUH+1.88LLUH-3.79WLUH+2.42LUB-3.15DLC	0.89	<0.001	15.02

SH: Shoulder Height of the fetus, BPD: Biparietal diameter, LH: Length of the Humerus, LF: Length of the Femur, AC: Abdominal Circumference, ED: Eye Diameter, LP: Length of Placenta, WP: Width of the Placenta, LLUH: Length of the Left Uterine Horn, WLUH: Width of the Left Uterine Horn, LRUH: Length of the Right Uterine Horn, WRUH: Width of the Right Uterine Horn, LUB: Length of the Uterine Body, DCL: Diameter of the Corpus Lutum R^2: determination coefficient, SE_{pred}: Standard Error of prediction (SE_{pred}), p-value: Significant level

Table 5: Stepwise regression models for prediction of gestational age according to three stages of pregnancy

Stages	R^2	p-values	SE_{pred} (days)
1st third GA (days) = 65.34+6.87LH+8.62 LF	0.99	<0.001	0.22
2nd third GA (days) = 65.54+16.57 LH	0.99	<0.001	2.14
Last third GA (days) = 82.86+20.65BPD	0.97	<0.001	6.64
General stepwise regression equation GA (days) = 65.25+22.01BPD	0.99	<0.001	1.24

LH: Length of the Humerus, LF: Length of the Femur, BPD: Biparietal Diameter; R^2: determination coefficient, SE_{pred}: Standard Error of prediction (SE_{pred}), p-value: Significant level

0.99; $p<0.001$) which indicated that their respective equations could be used to estimate the gestation age with SE_{pred} variable from 1.24-15.56 days (Table 4). The most accurate variable was the BPD while the most inaccurate was the WLUH.

Using linear regression by group of variables it was appeared that the fetal measurements group was the most useful to predict GA with high accuracy and less error (R^2 = 0.99, Se_{pred} = 2.40, $p<0.001$). The proposed regression Eq. 3 was:

$$\begin{aligned} &GA\ (days) = 65.27-0.04SH+21.05 \\ &PD+2.29LH-1.760LF-0.55AC-6.36ED \\ &(R_2 = 0.99, SE_{pred} = 2.40, p<0.001) \end{aligned} \quad (3)$$

In order to retain, the most predictable variables in regression model of GA the stepwise regression was used. An appropriate formula was indicated for each gestation period; nevertheless the most appropriate formula for the entire gestation period is given below (Table 5):

$$\begin{aligned} &GA\ (days) = 65.25+22.01BPD \\ &(R^2 = 0.99, p<0{,}001, SE_{pred} = 1.24) \end{aligned} \quad (4)$$

This study was performed on fetuses recovered at the slaughterhouse in order to identify pregnancy related biometrical and fetal changes in Sahraoui dromedary camels. The estimated gestational age in our study (70-391j) was in the range of the typical pregnancy length in dromedary camel species (Purohit, 2010). Among the many aspects that can be considered to determining the fetal age in domestic animals. Denneler (1971), Laing (1979), Evans and Sack (1973) stated that the following elements could be used: skeletal growth, developmental stages of external genitalia, emergence of the mammary gland, sheath, eyes and ears buds, transparency and pigmentation of the integument, visibility and prominence of some named blood vessels and organs underlying the integument, shape of the limbs and consistency hoofs and regional appearance of hair. The listed morphological features observed in studied fetuses of different ages corresponded to descriptions of Sonfada; Shehu for fetus aging from 75-366 days of pregnancy in Nigerian camels. The prenatal development of the calvarium as well as its hardening and soldering of its bones during the three thirds of pregnancy were similar to those given by Hena and Sonfada (2012). Contrary to the earlier observation (Denneler, 1971) all studied fetuses had two humps even the early stage of gestation which confirmed recently by Dioli (2014).

The averages of fetal CRL in each third of pregnancy were lower than those obtained by Sonfada, these researchers recorded mean of CRL varied from 37.44±7.10 to 109.13±10.21 cm. However, the results were comparable to those reported by Elrazik *et al.* (2013) who showed a mean CRL of 5-9.5, 14.5, 24-29.5, 32.5, 69.5, 89.5 and 120 cm for the dromedary fetuses in the third, fourth, fifth, sixth, ninth, tenth month and end of gestation, respectively. Factors such as breed, month of conception, means of measurement and nutrition can affect the fetal dimensions. The examined reproductive tracts reveled that all fetuses were located in the left horn. Many authors reported that in camelids nearly all pregnancies occur in the left side (Ghazi *et al.*, 1994; Skidmore *et al.*, 1996, Tibary and Anouassi, 1997; Ali, 2015), however Elwishy (1988) and Hussein *et al.* (1991) reported distant rates of 0.48 and 40%, respectively of gestation on the right uterine horn. The morphological prominence of the left uterine horn compared to the right one was observed even during fetal life (Rawy, 2011).

Factors such as blood vascularization and innervation should be investigated in this regard (Derar *et al*., 2005, 2012).

In this study, only one pregnant she-camel (2.94%) was found with multiple CL. Similar cases were reported in 6.7% (El Wishy 1988) and 44.4% (Ali, 2015) of slaughtered pregnant camels and in 52% ultrasound examined pregnant camels (Ali, 2015). This can be explained by the multiple ovulations, growth and development of Graufian follicles that will ovulate even in the presence of corpus lutum of pregnancy or the coexistence of several generations of corpus lutum. Ali (2015) added that the Intrauterine Growth Retardation (IUGR) was observed in all she camels of twins and triplets. Only one viable fetus could be detected after the ninth week of pregnancy in each pregnant animal (Ali, 2015).

The general means of the uterine dimensions of the studied pregnant females were comparable to those obtained by Umaru and Mera (2000). In general, the dimensions of the uterine horns and the uterine body increased significantly in the 2nd and the 3rd parts of gestation ($p<0.01$ and 0.001, respectively). Banerjee *et al*., (1981) noted an increase in the width of the left (pregnant) uterine horn from 40-45 days post-gestation according to the results of transrectal palpation. Elwishy (1988) reported that at 150 days of pregnancy, the diameters of pregnant and empty uterine horns are almost 4 times their original size. The hypertrophy to cells within the gravid horn suggests that it may be a response to the biological mechanical stretch of uterine walls by the growing fetus and placenta. The placental length increased constantly with the fetal age, however the placental width was significantly increased from the second third of gestation. Pervious study showed that the genetic variability may affect the placental morphology which is positively correlated with neonatal weight and dimensions of the camel (Atieh *et al*., 2014).

The present study showed that except the DCL, all fetal and maternal parameters were significantly correlated ($R^2 = 0.50$-0.99; $p <0.001$) with the gestational age and can be used for its prediction with a standard error of prediction of 1.24-15.56 days. These findings are consistent with correlations of the linear regressions stated by Ali *et al.* (2013, 2015) in camel ($R^2 = 0.78$-0.97) and by Herrera *et al.* (2002) in Lama species (0.71-0.99). In this regard, Hussein *et al.* (1991) suggested a highly significant correlation of CRL and other dimensions of camel conceptus (hump circumference, chest circumference and the length of the radius and tibia) ($p<0.001$). In the investigation, the simple regression formula including the BPD diameter was the most accurate to predict the GA and the group of fetal measurements gave the most accurate multiple regression formula. The high predictive variables in the first third of pregnancy were LH and LF. Those of the 2nd and last thirds of pregnancy were LH and BPD respectively. In other hand, recent studies demonstrated that the accessibility of the different fetal parameters depended on the stage of pregnancy and the area of ultrasonographic examination (Ali *et al*., 2013, 2015). The CRL measure was limited between the 3rd and 9th week of gestation (Ali *et al*., 2015) and none of the fetal biometrics could be determined 100% at all stages (Ali *et al*., 2015). The ED was determined as the most predictable parameter for gestation aging because the head and eye could be detected in most stages of pregnancy (Ali *et al*., 2013). The BPD, ABD (diameter of the abdomen) and RUD (intraluminal length of the rumen) could be scanned in the first third of pregnancy and the BPD was frequently measured during the last third of gestation. Finally, the ABD was the least predictable parameter because it became too long to be presented efficiently on the screen with the progress of pregnancy (Ali *et al*., 2013). Similar trends of high correlation between the BPD, ED and gestational age were recorded by Haibel and Perkins (1989) and Amer (2008) in sheep. In this species, Sergeev reported that the occipito-nasal length was more difficult to measure than BPD and had the same accuracy for predicting fetal age.

CONCLUSION

In conclusion, the association between the two approaches; chronological description of fetal development and fetal-maternal biometrics, reveal useful for obstetric evaluation of the fetal normal growth and to predicting with high precision the gestational age. Regression equations using fetal measurements have the highest accuracy and the lowest standard errors. However the choice of the formula to be used in ultrasound examination depends on accessibility depending on the stage of gestation. The regression formulas obtained by parameter groups or gestation stages can assist practitioners in the rapid assessment of gestational age on aborted camels at prematurity or in scientific research on the reproduction and development of camels.

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