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APPENDICES

Appendix Table 1: Detailed findings from selected authors of ultrasound scanning in goat

Year	Author	Type of transducer used	Objective of study	Findings	Suggestion for future improvement
1997	Doize *et al.* (Theriogenology. 48: 449-460)	5 MHz linear-array transducer (transrectal)	1. To determine placentome development in ewes and goats throughout pregnancy.	Placentomes were first detected as small nodules on day-32 for ewes and day-35 for does. On day-42, the placentome in does were cup-shaped. In ewes, placentome visible as cup-shaped starting from day-39 of gestation. Maximal size of placentome for ewes and does were obtained on day-74 and day-90 respectively. Accurate measurements of placentome were difficult to obtain in both species due after day-90 of gestation due to the increased distension of uterus.	Author's suggestion: Additional study is needed to find higher correlation between placentomes and pregnancy age in ewes. My suggestion: Variations of the number, location and sizes of placentomes within uterus and among females might lead to poor correlation between placentome and gestational age. Additional study is needed to obtain more accurate gestational age estimation in both species.
			2. To establish the relationship between gestational age and	In both species, relationship between placentome development	

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Year	Author	Type of transducer used	Objective of study	Findings	Suggestion for future improvement
			placentome measurement.	and gestational age can be represented with a linear model up to day-90 of gestation. Does show higher correlation between placentome and gestational age as compared to ewes.	
			3. To present a formula for the accurate prediction of parturition at the time of pregnancy diagnosis.	In does: $Y = 28.74 + 1.80X + e$ In ewes: $Y = 47.98 + 0.62X + e$ Where; Y: gestational age (days) X: placentome diameter (mm) e: residual *this equation only valid until day-90 of gestation.	

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Year	Author	Type of transducer used	Objective of study	Findings	Suggestion for future improvement
				From blind test, above equation gave 66% accuracy with a range of ±7 days, and 96% with a range of ±14 days in does. *validation was only obtained for does due to the poor correlation in ewes.	
1998	Martinez *et al.* (Theriogenology. 49: 1555-1565)	5 MHz linear-array transducer (transrectal)	1. To evaluate the use of real-time B-mode ultrasonography for early pregnancy diagnosis in goats. 2. To define criteria for accurate diagnosis of pregnancy. 3. To monitor the foetal growth ultrasonically until day-40 after mating.	Real-time B-mode ultrasonography is a reliable method for early pregnancy diagnosis in goats. Presence of embryo with heartbeats is essential for an accurate pregnancy confirmation. Embryonic vesicles with diameter of more than 3 mm were first detected on day-18 of gestation in 7 out of 11 pregnant goats.	Author's suggestion: Further research should be done to describe foetal growth after day 38 of gestation. My suggestion: Linear regression obtained in this research cannot be applied on day-39 and 40 because the growth pattern changes. An appropriate regression model could be studied to describe foetal growth after day 38 of gestation.

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Year	Author	Type of transducer used	Objective of study	Findings	Suggestion for future improvement
				Foetus and its heartbeat can be detected at approximately day 21 of gestation. From days 19 to 38, foetal growth can be described as a linear regression by measuring CRL length. No difference was found in goats carrying single and multiple foetuses. The linear regression equation is as follows: Y = -2.23 + 0.13X Where; Y = gestational age (days) X = CRL (cm) Heartbeat cessations of two embryos which indicate embryonic mortality were detected in two females on day-34 (goat carrying twin) and day-35 (goat carrying triplet) of gestation.	

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Year	Author	Type of transducer used	Objective of study	Findings	Suggestion for future improvement
2004	Medan *et al.* (Journal of Reproduction and Development. 50: 391-397)	7.5 MHz linear-array transrectal transducer 5 MHz sector-array transabdominal transducer	1. To diagnose pregnancy at early stage by progesterone assay and real-time B-mode ultrasonography.	The accuracy of progesterone assay in diagnosing pregnancy on day-21 of gestation was 80%, and 100% for non-pregnancy. The accuracy of ultrasonography in diagnosing both pregnancy and non-pregnancy was 100% at approximately day-24 of gestation.	Author's suggestion: - My suggestion: Correlation equation between pregnancy-related structures could be established from the detected structures.
			2. To determine foetal number by real-time B-mode ultrasonography to improve reproductive efficiency.	Foetal number could be detected on day 40 of gestation and reached maximum accuracy (91.7%) on day 60. Placentomes were visible at approximately day-35 of gestation as small nodules. Skeletal structures (i.e. ribs, skull, long bones) were obvious at 2 months of pregnancy.	

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Year	Author	Type of transducer used	Objective of study	Findings	Suggestion for future improvement
				Determination of foetal number and viability were clear advantages of real-timeB-mode ultrasound over the progesterone assay.	
2008	Suguna *et al.* (Small Ruminant Research. 80: 80-86)	6 MHz linear-array transrectal transducer 5 MHz sector-array transabdominal transducer	1. To evaluate the use of real time B mode ultrasonography for early diagnosis of pregnancy using different approaches.	Transrectal ultrasound technique is reliable for the first two trimesters of pregnancy. Transabdominal ultrasound technique can be applied throughout the whole trimester of pregnancy, even though it detects structure a bit later (1 week) as compared to transrectal ultrasound. The 5^{th} to 7^{th} week of gestation was the best period for differentiation between singles and twins in goats.	Author's suggestion: - My suggestion: For foetal heart measurement, manual counting as performed in this research is not so accurate. M-mode ultrasonography should be conducted for more accurate exact value. Blind test could be performed to confirm the realiability of equation established.

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Year	Author	Type of transducer used	Objective of study	Findings	Suggestion for future improvement
			2. To monitor the different anatomical features throughout pregnancy and to establish the relationship between gestation age and certain foetal anatomical structures.	Embryonic vesicles were detected on day-21, proper embryo on day-28 of gestation via transrectal approach. Meanwhile, embryonic vesicles were detected on day-28 of gestation via transabdominal approach. Using transrectal approach, heartbeat was detected on day-21 of gestation, and measureable on day-28 up to day-98. The heart rate was detected earliest and counted on day-35 up to day-130 of gestation. Placentomes are detectable between day-42 and 98 of gestation via transrectal approach. As for transabdominal approach, they were detected between day-50 and 130 of gestation.	

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Year	Author	Type of transducer used	Objective of study	Findings	Suggestion for future improvement
				Placentome diameter shows high correlation with gestational age (r = 0.99). Y = 42.5x – 5.2 Where; Y: gestational age (days) x: placentome diameter (cm) Skeletal structures were first viewed on day-56 following the transrectal and transabdominal methods, and were detectable up to day-98 and 130, respectively. Foetal head diameter and thoracic diameter shows high correlation with gestational age (r = 0.99). For head diameter; Y = 41.0 + 13.8x Where; Y: gestational age (days) x: head diameter (cm)	

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Year	Author	Type of transducer used	Objective of study	Findings	Suggestion for future improvement
2009	Karen *et al.* (Animal Reproduction Science. 114: 167-174)	7 MHz linear-array transrectal transducer 3.5 - 5 MHz linear and sector-array transabdominal transducer	1. To determine the earliest day at which the sign of pregnancy can be detected by transrectal and transabdominal ultrasonography.	The embryonic vesicles were first detected by transrectal and transabdominal scanning at approximately day-17 and day-28 respectively. The embryos proper with heartbeat were first detected by transrectal and transabdominal scanning at approximately day-22 and day-30 respectively.	Author's suggestion: - My suggestion: Specific gestational age predicting chart for each breeds need to be established since there is variations reported in pregnancy-related structures detection and measurement in different breeds.
			2. To estimate the gestational age of Egyptian goats by B-mode ultrasound measurement of embryonic or foetal parts throughout pregnancy.	CRL was difficult to be measured after day-70 of gestation. (R^2=0.94) $Y = 0.028x^{2.4896}$ Where; Y : Crown rump length (CRL) (mm) x: Gestational age (days)	

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Year	Author	Type of transducer used	Objective of study	Findings	Suggestion for future improvement
				BPD was highly correlated up to day-105 of gestation (R^2=0.956). X = 1.53y + 22.51 Where; X: Gestational age y: Bi-parietal diameter (BPD) (mm) Foetal trunk diameter (FTD) (R^2=0.96) gave the highest correlation with gestational age between day-40 and 130. Y = 0.8308x – 23.11 Where; x: gestational age Y: FTD (mm) Placentomes are easily recognized and measured throughout pregnancy. They are highly correlated with gestational age (R^2=0.86).	

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Year	Author	Type of transducer used	Objective of study	Findings	Suggestion for future improvement
				$Y = -0.0031x^2 + 0.8131x - 18.172$ Where; Y : Placentome diameter (mm) X : gestational age (days) Foetal heart rate decreased with the progressing of pregnancy. Absolute value of heartbeat rate reported in this research is higher than those reported by Martinez *et al.*, (1998) due to the difference of method used to measure. Method used in this research is more accurate since it used M-mode ultrasound technique instead of clockwatch. Foetal heart rate (FHB) has the lowest correlation with the gestational age (R^2=0.55). Y = -0.4415x + 236.24 Where; Y : FHB (bpm) X : gestational age (days)	

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Year	Author	Type of transducer used	Objective of study	Findings	Suggestion for future improvement
2009	Azevedo *et al.* (Medicina Veterinaria. 3: 21-29)	6.0 and 8.0 MHz linear-array transrectal transducer	1. To describe the ultrasonographic planes used to sex foetuses in goats and ewes.	There are three ultrasonographic planes to sex foetus, namely: 1. Longitudinal. 2. Transverse. 3. Sagittal.	Author's suggestion: It was convenient to first look for fetal landmarks for orientation purposes and also detailed observation of other embryonic structures with ultrasonographic appearance similar to that of the genital tubercle. Therefore, if the ultrasonographer attempted to hurry the examination, misinterpretations could be made. My suggestion: For more accurate and consistent diagnosis, it is needed for parameters to be observed from a fixed position or plane of foetus. In future, it is possible to study development of specific pregnancy-related structure from a fixed plane.
			2. To point out the ideal plane to locate and identify the genital tubercle, prepuce, scrotal bag, nipples and vulva.	Locating foetal landmark such as umbilical cord, heart beating and head was essential for orientation purposes. For positive male diagnosis, a bilobar hyperchoic structure (genital tubercle) appeared near or in close proximity to the umbilical cord. For positive female diagnosis, this structure was absent in this region. For both sexes, the genital tubercle and external genitalia were easily imaged in longitudinal view.	

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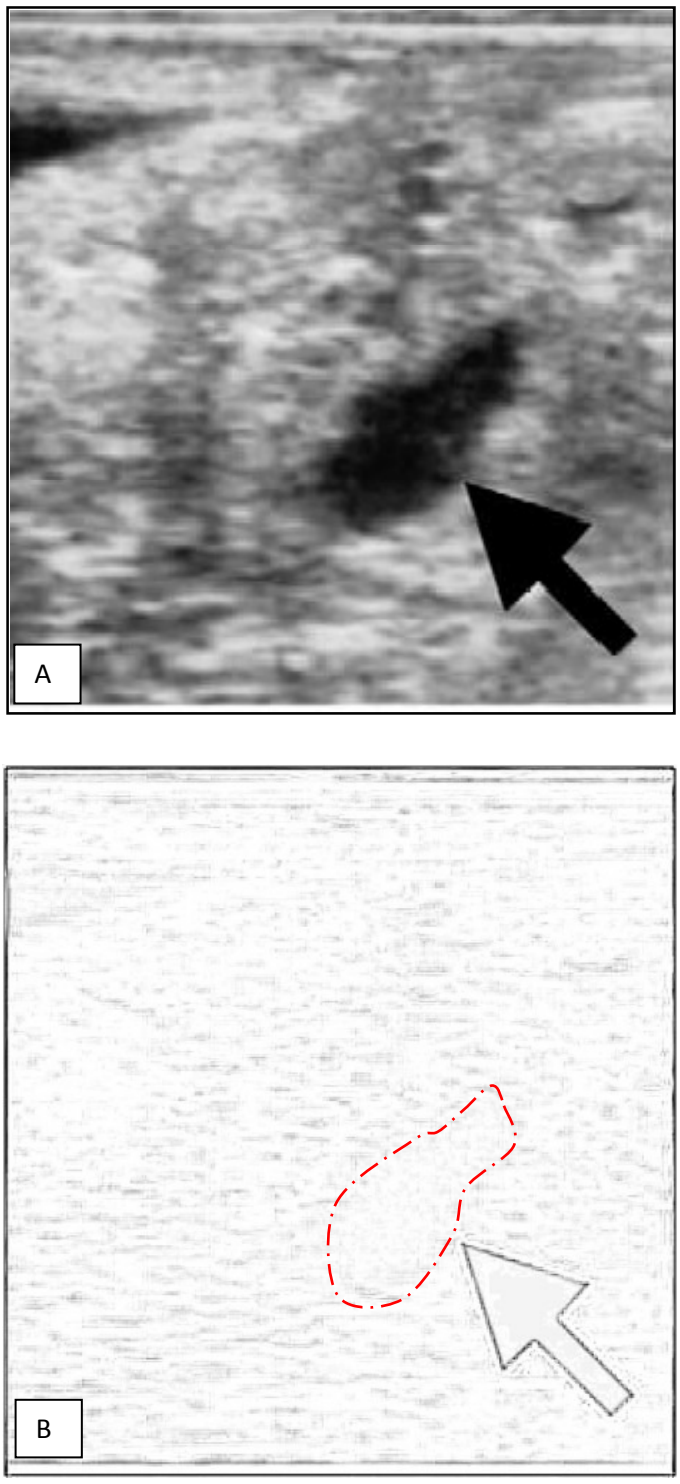
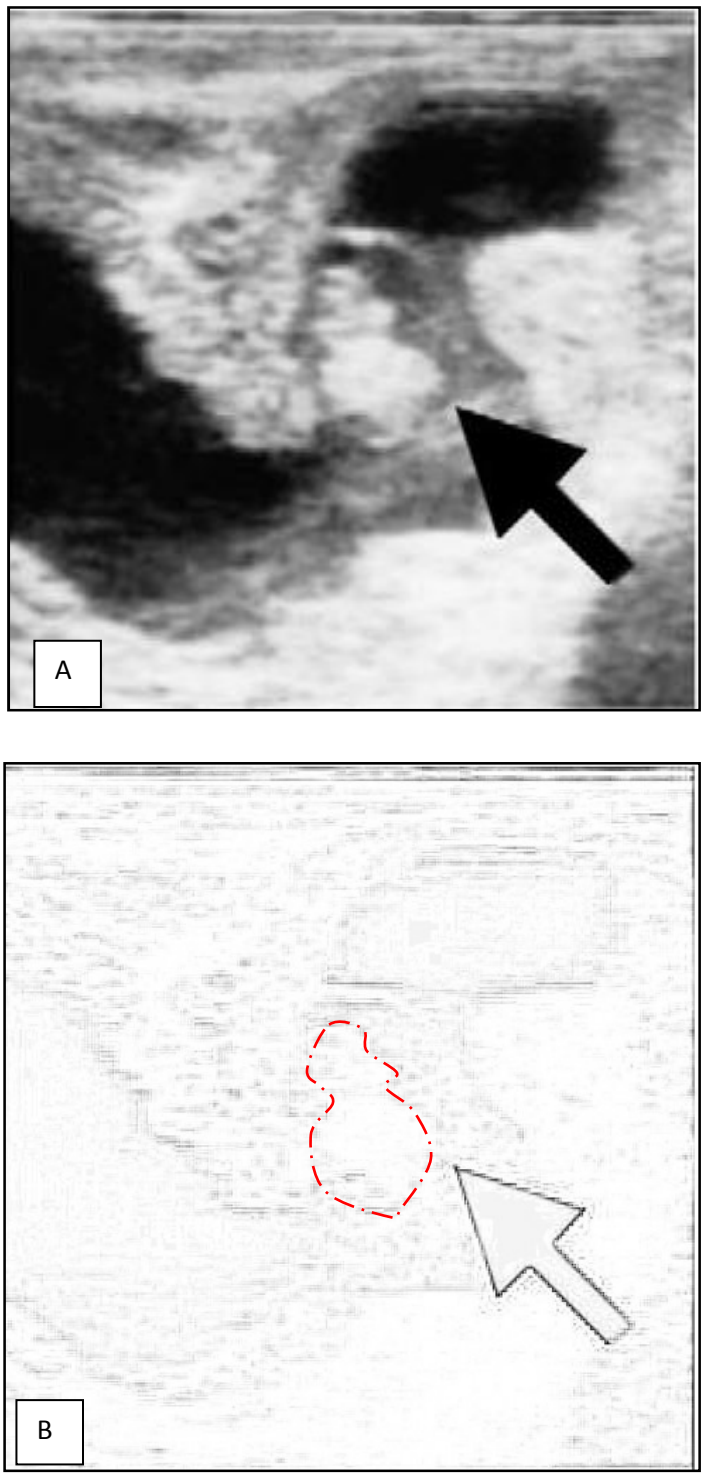
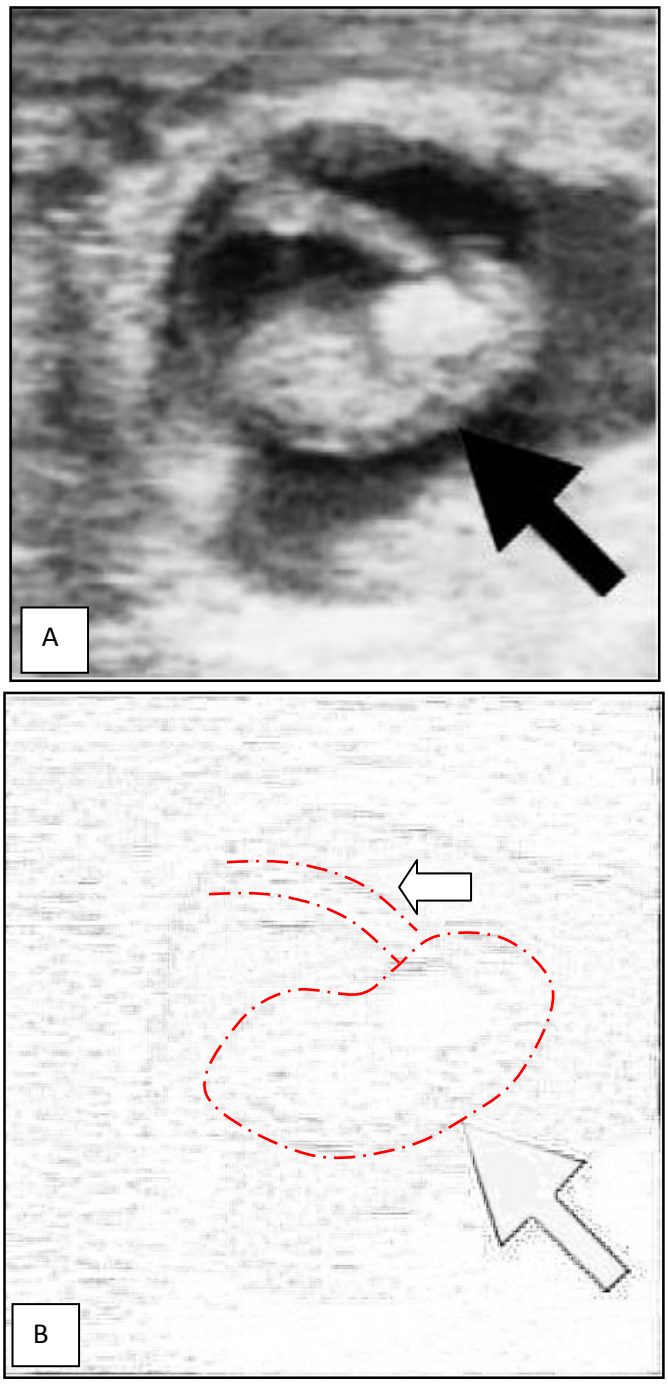
Year	Author	Type of transducer used	Objective of study	Findings	Suggestion for future improvement
				The scrotum, when present, was usually seen in longitudinal plane. As of transverse plane, a cross section of the vertebrae column could be visualized directly opposite to the scrotum. The mammary gland could be seen in older female fetuses in cross section. Sagittal plane of the foetus was rarely obtained. The position of hind limbs in sagittal plane could block visualization of the genital tubercle, nipples and scrotum. Foetal sex identification according to plane: Longotudinal plane: 73.93% Transverse plane: 22.14% Sagittal plane: 3.93%	



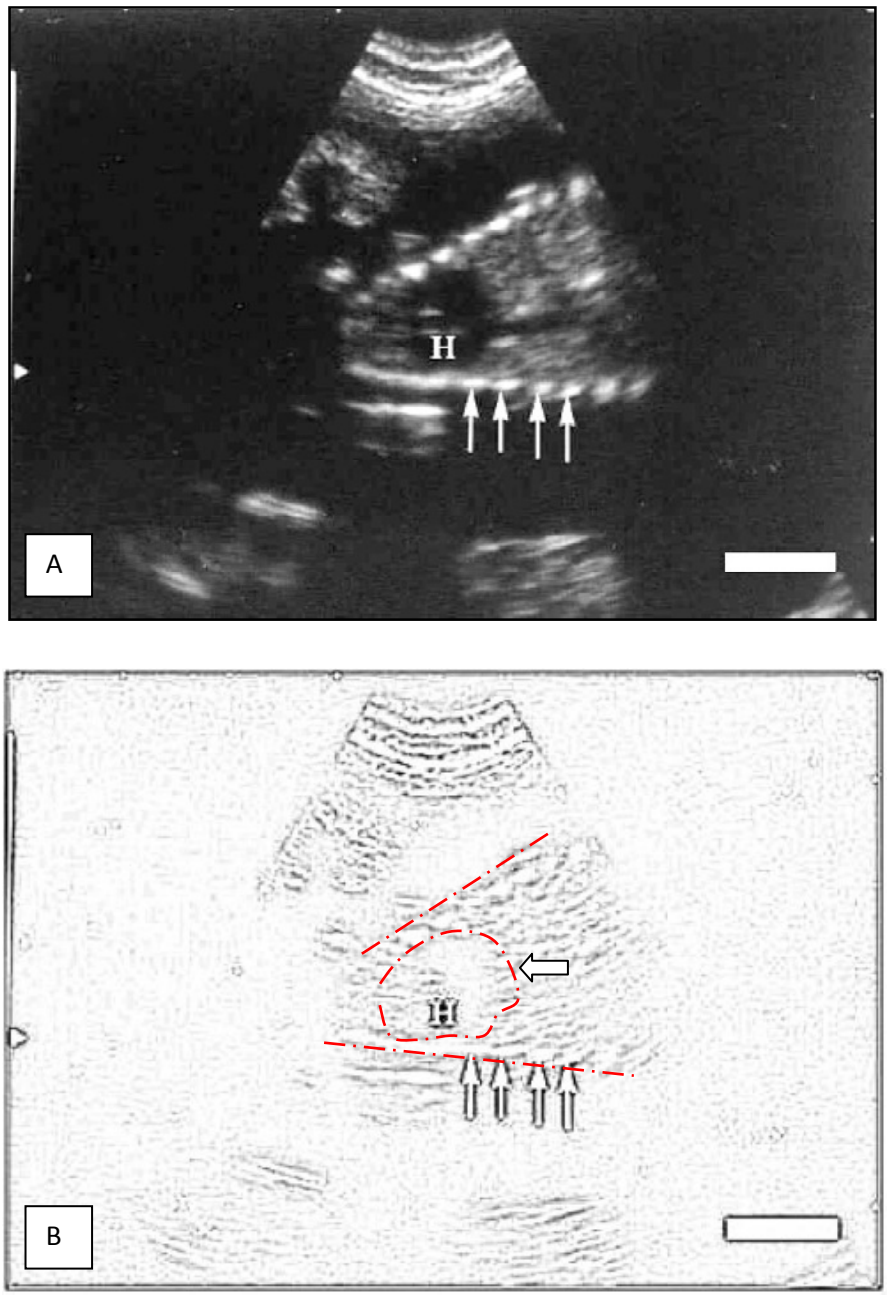
Appendix Figure 1: Image of fluid-filled vesicle (arrow) in the uterine lumen of pregnant doe at day 22 of gestation, observed by transrectal real-time ultrasonography with a 7.5 MHz linear-array transducer (Modified from: Padilla-Rivas *et al.,* 2005). A) Original image. B) Labelled image.



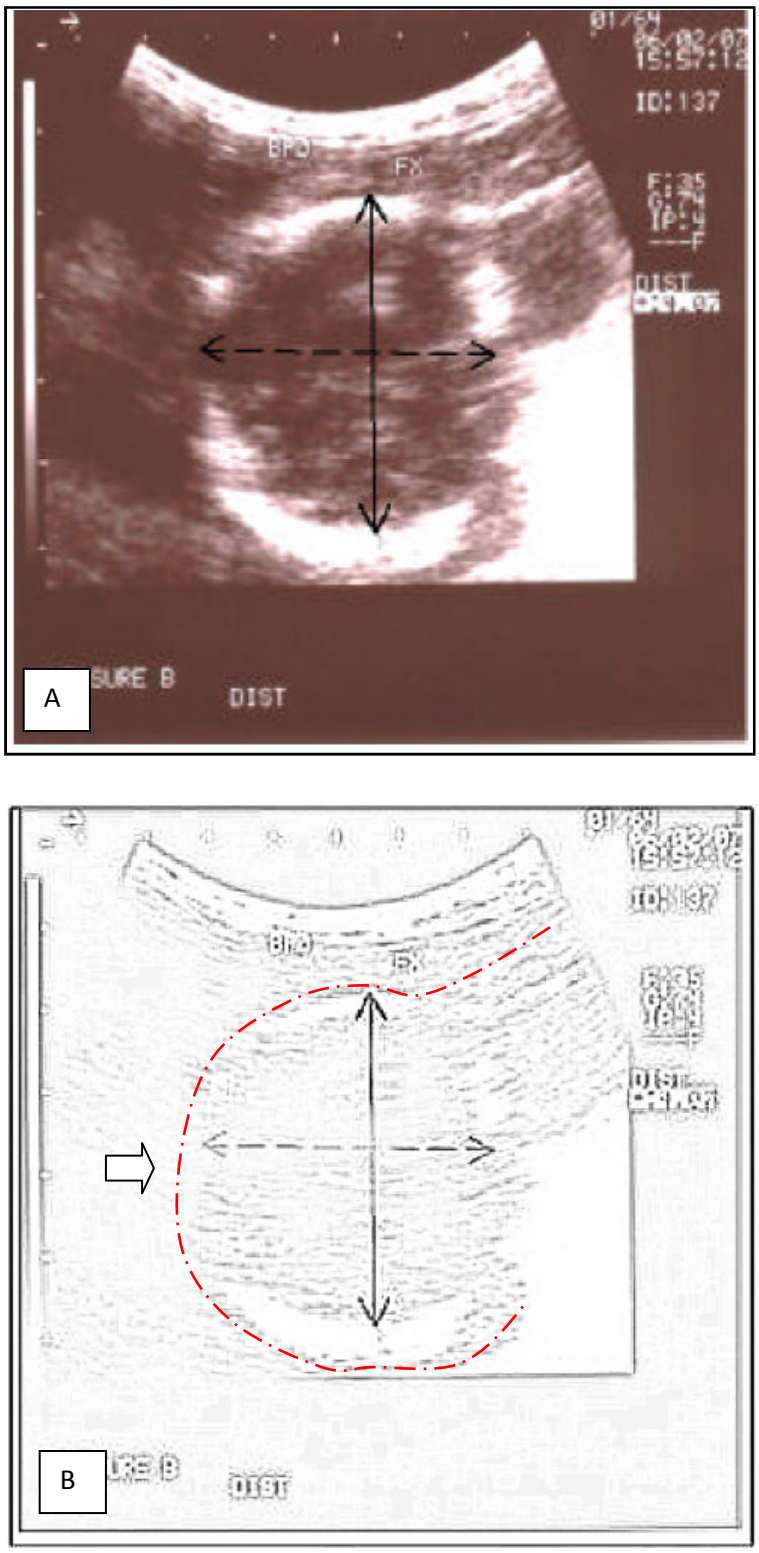
Appendix Figure 2: Image of small foetus (arrow) immersed in embryonic fluid of a doe at day 28 of gestation, observed by transrectal real-time ultrasonography with a 7.5 MHz linear-array transducer (Modified from: Padilla-Rivas *et al.,* 2005). A) Original image. B) Labelled image.



Appendix Figure 3: Image of larger foetus (big arrow) and umbilical cord (arrow: ←) immersed in embryonic fluid of a doe at day 34 of gestation, observed by transrectal real-time ultrasonography with a 7.5 MHz linear-array transducer (Modified from: Padilla-Rivas *et al.,* 2005). A) Original image. B) Labelled image.



Appendix Figure 4: Image of heart (arrow: ←) and thorax in goat foetus at 2 months of gestation using 5.0 MHz transabdominal transducer (note that the heart (H) appears as an anechoic structure between the white dots which represents ribs (arrow: ↑) (Modified from: Medan *et al.,* 2004). A) Original image. B) Labelled image.



Appendix Figure 5: Foetal head (arrow) detected in Saanen does using 3.5 MHz transabdominal convex transducer (Modified from: Abdelghafar *et al.,* 2007). A) Original image. B) Labelled image.