ABDOMINAL ULTRASONOGRAPHY IN DOMESTIC SPECIES

by

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DECLARATION

The statistical analysis of data presented in Chapter 3, Section 3, was performed by a computer made available by the West of Scotland Agricultural College. In addition to ultrasonographic examinations performed by myself, the sheep used in Chapter 3, Section 3, were examined by either Dr. D. Logue or Mr. S. McRoberts, who are experienced operators.

The clinical and pathological investigations of cases were performed by members of the Departments of Veterinary Medicine, Veterinary Surgery and Veterinary Pathology, and appropriate data was then selected from the case records. Figs. 58, 61 and 62, abdominal radiographs were taken by members of the Department of Veterinary Surgery.

I declare that, with the exception of the above, all work included in this thesis was performed by myself.

Celia M. Marr.

GLOSSARY OF ABBREVIATIONS

AND DEFINITIONS

A mode: a display system which describes the amplitude and location of each echo in one-dimension and is used to determine tissue thickness.

Acoustic enhancement: an area of an ultrasonograph in which the amplitude of the echoes is increased. This is due to reduced attenuation of the ultrasound beam by an overlying interface at which there is a small difference in acoustic impedance.

Acoustic impedance: the resistance to passage of sound energy which is a function of the density of any medium.

Acoustic shadow: an area of an ultrasonograph in which the amplitude of the echoes is reduced. This is due to increased attenuation of the ultrasound beam by an overlying interface at which there is a large difference in acoustic impedance.

Anechoic / Echolucent / Non-echogenic: describes an area of an ultrasonograph which has no echoes. These areas represent tissues in which there are no interfaces between structures of different acoustic impedances.

B mode: a display system which produces a two-dimensional image. It describes the position of each echo on a two-dimensional plane and the brightness of each echo is determined by its amplitude.

B.P.H.: Benign prostatic hyperplasia.

B.S.P.: Bromosulphathalein.

Compound B mode: a display system which produces a two-dimensional image. This is achieved by the performance of numerous scans across the body by moving the transducer and display of the information simultaneously. This system is now obsolete.

Curved linear array: an arrangement of piezoelectric crystals within a transducer which produces a sound beam with a diverging shape.

Echogenicity: the echo-producing quality of tissues.

Grey-scale: the system in which echoes of different amplitudes are represented by pixels of different shades of grey which describe the size of the amplitude.

Hypoechogenic / hypoechoic: describes an area of an ultrasonograph which has echoes of low amplitude. These areas represent structures in which the difference in acoustic impedance at the tissue interfaces is small.

Hyperechogenic / hyperechoic: describes an area of an ultrasonograph which has echoes of high amplitude. These areas represent structures in which the difference in acoustic impedance at the tissue interfaces is large.

Linear array: an arrangement of piezoelectric crystals within a transducer which produces a rectangular shaped sound beam.

M mode: a display system in which the movement of tissues is described by display of a continuously updated image of structures in one-dimension.

mHz: megaHertz, a unit of frequency.

Real-time: the system whereby the ultrasonographic image is constantly updated to produce a dynamic image.

Piezoelectric crystal: a material which has the ability to convert sound energy to electrical energy and vice versa.

Sector array: an arrangement of piezoelectric crystals within a transducer which produces a sound beam which is a sector of a circle.

Transducer: the part of the ultrasonographic unit which converts electrical energy to sound energy and vice versa.

Ultrasound: sound which has a frequency outwith the audibility of the human ear.

EQUIPMENT

Three ultrasonographic units were used in this study.

Vetscan, Dynamic Imaging: a portable ultrasonographic unit with a 3.5mHz linear array transducer which was provided on loan by the West of Scotland Agricultural College.

Siemens Sonoline 1300: an ultrasonographic unit with 3 and 5 mHz sector transducers.

Concept 1, Dynamic Imaging: a portable ultrasonographic unit with a 3.5mHz curved linear transducer and a 5mHz linear array transducer which was provided initially on loan from Dynamic Imaging and was subsequently purchased with a grant from the Home of Rest for Horses.

Polaroid Camera: The ultrasonographic images were stored as photographs taken directly from the screen with a polaroid camera.

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S U M M A R Y

This study was designed to evaluate the use of abdominal ultrasonography in small animals and horses presented at Glasgow University Veterinary School for investigation of abdominal disease and to assess the application of ultrasonography in ovine, canine and feline pregnancy.

Initially, the normal ultrasonographic appearance of the liver and spleen were determined by examination of four dogs, six horses and two cats. The appearance of these organs was found to be consistent within and across the species. The most suitable anatomical sites from which these structures could be imaged in these species and the most appropriate equipment were also determined in this study.

Twenty-seven dogs and three cats were selected for hepatic ultrasonography and the clinical, radiographic and laboratory indications for the procedure were considered. In twelve out of the thirteen cases of confirmed hepatic disease ultrasonographic abnormalities were detected and these were subsequently compared with the findings at post-mortem examination or exploratory laparotomy in the majority of the cases.

Twenty dogs and one horse were selected for splenic ultrasonography and in four of these abnormalities were detected. The indications and final diagnoses were reviewed to evaluate the merits and limitations of this procedure.

An experiment was designed to determine the accuracy of ultrasonographic estimation of ovine foetal number and to compare the results of inexperienced and experienced operators at various stages of gestation. The optimum efficiency was obtained by ultrasonographic examination at, or around, day 60 of gestation and considerable improvement was observed during the training period of the inexperienced operator.

The efficiency of ultrasonographic determination of pregnancy and estimation of foetal numbers in bitches and queens was evaluated by examination of thirty-six bitches and four cats referred to this hospital. Sensitivity of pregnancy diagnosis was 100% but the sensitivity of estimation of foetal number was found to vary with the stage of gestation and the litter size. The most sensitive estimations were obtained in medium sized litters (four to eight foetuses) at days 37 to 43 of gestation.

Two methods of estimation of ovine foetal age were developed which were based on ultrasonographic measurement of biparietal and transthoracic diameters, but the estimated age range obtained with these methods was wide.

Nine dogs were selected for prostatic ultrasonography. In all of these cases there were clinical signs referrable to the prostate and prostatic disease was subsequently confirmed. Ultrasonographic abnormalities were detected in all of these cases.

GENERAL INTRODUCTION

A: THE DEVELOPMENT OF ULTRASONOGRAPHIC TECHNOLOGY.

In 1880, the Curie brothers first discovered the means to produce high frequency sound waves electronically, utilizing the piezoelectric effect (Curie and Curie, 1880). This discovery was fundamental to the development of the science of ultrasonics. Apparatuses to detect submerged objects and potential hazards by fog-bound ships, based on ultrasonic waves were first patented in 1912 (Richardson, 1912[a]; Richardson, 1912[b]) and further development of this concept led to the invention of a device for the detection of submarines (Langevin, 1924). During the Second World War, Langevin's system was improved as SONAR (Sound Navigation and Ranging) became widely used (Shirley, Blackwell, Cusick, Farman and Vicary, 1978). The same principle was also applied in the detection of flaws in metals (Sokolov, 1935).

The development of medical ultrasound has been slow. In 1945, the use of ultrasound as a diagnostic aid was proposed (Dussik, 1942) and in 1947 "hyperphonograms" of the head were produced (Dussik, Dussik and Wyt, 1947). Ultrasound was next used to identify gallstones and foreign bodies by the acoustic shadows which they produced (Ludwig and Struthers, 1949) and throughout the 1950's reports of the identification of intracranial masses appeared (Ballantine, Bolt, Heuter and Ludwig, 1950; Wild, French and Neal, 1950; Miyajimia, Wagai, Uchid and Hagiwara, 1952;

Leskell, 1956).

The use of ultrasonography to image the heart was proposed in 1955 (Edler, 1955; Edler and Hertz, 1955) and the following year it was used to demonstrate the structure of the eye (Henry, Mundt and Hughes, 1956). In animals, ultrasound formed the basis of a technique for assessing carcass quality by the measurement of back fat (Temple, Stonaker, Howry, Posukany and Hazelus, 1956; Hazel and Kline, 1959).

The first compound waterbath scanner was described in 1958 (Howry, 1958). This system required total submersion of the subject in water to achieve acoustic contact and, therefore, its use was limited to experimental situations (Shirley et al, 1978). Subsequent refinement of the technique in Glasgow led to the production of the first contact scanner (Brown, 1960). This apparatus was used by gynaecologists to distinguish between cystic and solid lesions in the female reproductive tract using the full urinary bladder to create an acoustic window (Donald and Brown, 1961).

The early ultrasonographic units utilized analogue conversion systems (Wells and Ross, 1969). Analysis of small echoes arising within organs to produce an image had originally been proposed in 1950 (Wild, 1950), but it was not until the application of a digital computer system that this was achieved successfully (Kossoff, Fry and

Eggleton, 1971; Milan, 1972). This innovation has led to the development of grey-scale systems, the present form of two dimensional ultrasonographic imaging (Shirley et al, 1958). Further major improvements followed the development of sector scanning (Northeved, Holm and Gammalgaard, 1971), and real-time systems (Griffith and Henry, 1973).

Reports of imaging of the breast (Kossoff, 1974) and thyroid gland (Crocker, McLaughlin and Kossoff, 1974) marked the beginning of the clinical application of grey-scale technology, and the successful demonstration of the anatomy and pathology of the liver (Taylor, Carpenter, Hill and McCready, 1976) stimulated interest, which led to the widespread adoption of the technique in many fields of medicine and revolutionised non-invasive imaging.

B: INITIAL VETERINARY APPLICATIONS OF ULTRASONOGRAPHY.

In 1966, A mode ultrasonography was successfully used in the diagnosis of pregnancy in the ewe (Lindahl, 1966). Throughout the 1970's this application continued to be developed in ewes, goats and pigs (Fraser and Robertson, 1968; Fraser, Nagartham and Callicott, 1971; Lindahl, 1972; Lindahl, 1976; Inaba, Nakajima, Matsui and Imari, 1983). In 1980, the first report of intrarectal imaging of the reproductive tract of the mare using B mode ultrasonography was published (Palmer and Draincourt, 1980). Initially ultrasonography was principally used in mares for early detection of pregnancy. However, techniques have been developed for examination of the ovaries to determine cyclicity and for assessment of ovarian and uterine pathology (Ginther, 1986). Equine reproductive tract examinations remain the most widely used ultrasonographic technique in both clinical practice and research. The other major application in equine medicine was in assessment of the soft tissues of the limb and the ultrasonographic appearance of the soft tissues of various regions of the limb has been described (Hauser, Rantanen and Modransky, 1982; Rantanen, 1982; Hauser and Rantanen, 1983; Modransky, Rantanen, Hauser and Grant, 1983; Rantanen, 1983; Rantanen, Genovese and Gaines, 1983; Hauser, Rantanen and Modransky, 1984; Hauser, Rantanen and Genovese, 1984; Genovese, Rantanen, Hauser and Simpson, 1986; Hauser, 1986; MacLellan and Colby, 1986).

Ultrasonographic examinations of the abdomen of domestic animals was first performed in 1975 using compound B mode ultrasonography (James, Sanders, Osterman, Novak and Bush, 1975). In 1980, Cartee, Seller and Patton described several advantages of abdominal ultrasonography. In addition to being safe for both operator and subject, ultrasonography was able to detect changes in tissue density rather than simply the increase in overall size of organs which was evident radiographically (Cartee, Seller, Patton, 1980). In recent years, reports have appeared in the literature which described both the normal ultrasonographic appearance of the abdomen and the changes which were detected in association with various abdominal diseases (Cartee et al, 1980; Cartee, 1981; Nyland, Park, Lattimer, Lebel and Miller, 1981; Nyland, 1982; Feeney, Johnston and Hardy, 1984; Yamaga and Too, 1984; Feeney, Johnston and Walker, 1985; Rantanen, 1985; Konde, Lebel, Park and Wrigley, 1986; Rantanen, 1986, 1986a). However, the literature concerning veterinary abdominal ultrasonography was miniscule when compared to that available to the human abdominal ultrasonographer.

C: AIMS OF THIS STUDY.

The overall aim of this study was to describe the clinical application of abdominal ultrasonography and the ultrasonographic appearance of various abdominal diseases. Findings of abdominal ultrasonographic examination were compared to radiographic findings and those produced by various other diagnostic procedures to assess the value of the information obtained. Particular emphasis was placed on the indications for abdominal ultrasonography. Also, an experiment was designed to assess the accuracy of pregnancy diagnosis in sheep at various stages of gestation and to determine if ultrasonography could be used to monitor growth.

D2 PHYSICS AND PRINCIPLES OF THE PRODUCTION OF B MODE ULTRASONOGRAPHIC IMAGES.

Sound energy has been defined as the vibration of molecules within a medium such that pressure changes resulted in the formation of a longitudinal waveform. The term "ultrasound" was used to define those waves which have a frequency outwith the range of the human ear. In the production of ultrasonographic images for medical purposes the frequency range of 1-10 mHz has been used (Shirley et al, 1978; Powis and Powis, 1984). In the production of ultrasound, the piezoelectric principle was utilized. An electric current passing through a piezoelectric material deformed the internal structure of that material in such a way that a pressure change was induced. This pressure change could be transmitted across a medium, in this case the body tissues, such that the molecules vibrated to propogate a wave (Shirley et al, 1978; Bartrum and Crow, 1983; Powis and Powis, 1984). This mechanism was acting essentially in the same way as a gong, although in that case kinetic energy was transformed to pressure (Bartrum and Crow, 1983). This mechanism could also work in reverse and a piezoelectric material could also convert pressure changes into electrical voltage changes.

When a beam of high frequency sound was produced and directed at a tissue, echoes were caused at each change in acoustic impedance within the body and some of those echoes were reflected such that they returned to their source. Within the transducer, which was a mechanism for converting one energy to another, an array of piezoelectric crystals was housed. When these crystals were not producing ultrasound they were receiving it and so they were alternatively being stimulated with and producing change in electrical voltage many times per second. This alteration between production and reception of sound was described as the pulse-echo principle (Shirley et al, 1978; Bartrum and Crow, 1983; Powis and Powis, 1984).

The voltage change which was induced by the returning echo could be recorded and transferred to a memory system for storage and processing (Shirley et al, 1978; Bartrum and Crow, 1983; Powis and Powis, 1984). In modern ultrasonographic units digital information storage was used (Bartrum and Crow, 1983). This system replaced analog scan converters, which were used in the past, because digital systems facilitated rapid processing and storage and they were more robust (Bartrum and Crow, 1983).

Sound has been found to travel at approximately the same speed throughout the body (1540 ms^{-1}) and, therefore, a computer could calculate the distance that an echo has travelled from its source by recording the time taken for the sound to return to the transducer (Shirley et al, 1978).

The two dimensional nature of the B mode ultrasonograph was achieved by placing multiple sources in an array so that they operated in conjunction with each other to produce a beam of sound (Shirley et al, 1978; Bartrum and Crow, 1983; Powis and Powis, 1984). Therefore, multiple sources were used, each interrogating the tissues in the path of the sound wave it produced. The information from each crystal was transferred to the digital storage system where the location of each echo-producing structure was defined by identifying the two co-ordinates which described it on a two dimensional matrix (Powis and Powis, 1984).

The amount of sound energy or amplitude of the echo returning from any interface was found to be dependent on the magnitude of the difference in acoustic impedance between the two tissue types. Thus, interfaces between tissues of differing acoustic impedances produced echoes of differing amplitude (Herring and Bjornton, 1985).

Further, sound has been found to react with interfaces within the body to produce reflections in one of two ways: specular and non-specular reflections. Specular reflections occurred at an interface which was larger than the sound beam. The direction of the reflected sound was dependent on the angle of incidence of the sound wave and, therefore, only those interfaces which lay at right angles to the sound beam could return to the transducer.

Non-specular reflection occurred at an interface which was smaller than the width of the beam. This was independent of angle but produced a scattering effect so that only a small amount of sound returned to the transducer (Bartrum and Crow, 1983). A large number of small echoes could be produced within an organ and, following amplification of the range of electrical changes which they produced, these data could be used to produce an image of the internal anatomy of an organ. In addition, the display of larger specular echoes demonstrated the boundaries of the organ (Bartrum and Crow, 1983).

The piezoelectrical crystals which were utilized produced a range of voltages dependent on the amplitudes of the echoes and, therefore, they had the ability to describe the interface that produced each echo in terms of the amplitude of that echo (Powis and Powis, 1984).

This information was then transferred to a display system based on a video monitor which was composed of many pixels. Each pixel represented one location on a two dimensional plane (Bartrum and Crow, 1983; Powis and Powis, 1984). These pixels could be illuminated in a range of brightnesses of light ranging from black to white. These different brightnesses were used to describe the amplitude of each echo (Shirley et al, 1978). Smaller echoes resulted in grey areas while large echoes produced bright illumination of the pixel. This concept, which was described as "grey-scale" (Shirley et al, 1978), enabled small echoes to be displayed as well as the larger ones which were used to produce compound B mode ultrasonographic scans prior to the introduction of grey-scale (Shirley et al, 1978). One of the earliest successful applications of this technique was in distinguishing between the ultrasonographic characteristics of normal and diseased livers (Joseph, Dewbury and McGuire, 1979).

To determine the shade of grey which represented each echo, the input signal amplitudes were grouped into several categories and each group was allocated a different shade of grey (Shirley et al, 1978). Initially this was a fixed function on each machine, but more sophisticated equipment became available in which the operator could select the grey-scale allocation to enhance different groups of echoes depending on the characteristics of the tissue under examination (Bartrum and Crow, 1983).

To produce a real-time image, the data which were collected and analysed by the system were constantly updated many times per second to produce a constant moving image. Major advances in computer technology and digital information systems throughout the last twenty years have permitted the development of ultrasonographic technology to follow suit (Bartrum and Crow, 1983).

During recent years, dramatic improvements have been made in the quality of the screens and focussing of transducers and each development has produced equipment with superior resolving powers (Bartrum and Crow, 1983). In addition, facilities for hard copy, such as direct video recording, polaroid or multiformat cameras and measurement systems, based on electronic calipers, have become standard features of ultrasonographic units (Bartrum and Crow, 1983; Powis and Powis, 1984). However, the resolution of any ultrasonographic unit was limited to some extent by the frequency of sound that it produced. Separate echoes could only be produced by interfaces which were more than one pulse width apart. The shortest pulse width which could be achieved was one wavelength in length (Bartrum and Crow, 1983; Powis and Powis, 1984). Therefore, equipment which utilized ultrasound with higher frequencies had inherently superior resolution (Bartrum and Crow, 1983).

As an ultrasound wave travels through the body, it has been found that its energy was progressively lost. This attenuation was due to adsorption, reflection and scattering of sound energy (Shirley et al, 1978). Attenuation rate was directly proportional to the frequency of the sound wave. Thus high frequency sound was attenuated more rapidly than low frequency sound and in order to produce a large field of imaging, lower frequency transducers were used (Shirley et al, 1978). Ultrasonographic units were supplied with amplification systems to overcome the effects of attenuation due to tissue depth but, nevertheless, the penetrating powers of sound in the higher frequency range was limited (Shirley et al, 1978; Powis and Powis, 1984). In an attempt to overcome the progressive decrease in the intensity in the sound wave and in order that differing depths of tissue could be compared, the ultrasound machine was fitted with a depth gain compensation function. Echoes were amplified in proportion to their distance from the source. The level of amplification and the point at which this function was applied to the returning echoes could be controlled by the operator (Powis and Powis, 1984) and by the late 1970's, equipment was available which could produce images of diagnostic quality over a field of penetration of up to around 200mm (Bartrum and Crow, 1983).

Two types of beam shape could be produced: sector and linear array (Bartrum and Crow, 1983; Powis and Powis, 1984). In a linear array transducer, the piezoelectric crystals were arranged such that a rectangular shaped beam was produced. This equipment had the advantage that it was less expensive to produce and maintain. However, the transducers were bulky and, therefore, harder to use in the production of abdominal images where areas with extremely large differences in acoustic impedance occurred and had to be avoided; for example, the interfaces between soft tissues and gas in the bowel (Bartrum and Crow, 1983). The initial design of sector scanners utilized several piezoelectric crystals mounted on a rotating wheel which produced a pie-shaped image. This system was more delicate and expensive but it had the advantage that only small areas of contact with the body were required to image a large area internally (Bartrum and Crow, 1983; Powis and Powis, 1984). This design was then followed by phased array transducers in which crystals were stimulated in sequence to produce a similar effect (Bartrum and Crow, 1983; Powis and Powis, 1984). These transducers were extremely expensive and did not replace the use of mechanical sector scanners in veterinary medicine (Barr, 1988).

The versatility of diagnostic ultrasonography has contributed largely to its application in a wide range of medical disciplines (Powis and Powis, 1984). The other quality of the technique which has promoted its use in medicine was its non-invasive nature and it was regarded as safe for both operator and patent (Ginther, 1986). In 1975, the following statement was issued by the American Institute of Ultrasound in Medicine : "In the low megahertz frequency range there have been (as of this date) no demonstrated significant biological effects in mammalian tissues exposed to intensities below 100 mW/cm^2. Furthermore, for ultrasonic exposure times less than 500 seconds and greater than one second, such effects have not been demonstrated even at higher intensities when the product of intensity and exposure time is less than 50 joules/cm" (American Institute of Ultrasound in Medicine, 1975).

C H A P T E R   O N E

LITERATURE REVIEW

1:1 HEPATIC IMAGING TECHNIQUES IN VETERINARY MEDICINE

Radiography has been the most widely used imaging technique for assessment of the liver in small animals (Suter, 1982). Increased or diminished size was reported as the most common abnormality detected on plain radiography in small animals (Suter, 1982). However, radiographic evaluations of liver size were subject to substantial errors and technical artifacts and the method was subjective and inexact. Nevertheless, documentation of gross alteration in size was considered to be valuable (Suter, 1982). Useful and diagnostic radiographs of the liver in large animals have not been achieved due to the bulk of the equine abdomen (Rantanen, 1985).

Generalised hepatic enlargement has been reported as a result of a variety of pathological processes including venous congestion, fatty infiltration, neoplasia, extrahepatic bile duct obstruction, early cirrhosis and nodular hyperplasia (Wrigley, 1985). Early stages of these diseases have been radiographically undetectable, in some cases, owing to the inaccuracy of survey radiography (Wrigley, 1985).

Localised liver enlargement has been appreciated in cases in which there was displacement of the adjacent organs (Wrigley, 1985). The most common cause of localised liver enlargement was neoplasia but cysts and abscesses have also resulted in radiographically-detected localised enlargement (Wrigley, 1985).

Marked reduction in liver size was considered significant, especially if combined with clinical or biochemical abnormalities of the liver. Decreased size was due to portosystemic shunts, advanced cirrhosis or chronic hepatocellular degeneration (Wrigley, 1985).

Portal vein angiography permitted the precise identification of portosystemic shunts. It has been performed intraoperatively to allow the successful localisation and ligation of congenital portosystemic shunts (Suter, 1982).

Mineralisation was the only process that has resulted in altered radiodensity in small animals. It occurred in association with gall bladder and bile duct calculi which were an uncommon clinical entity in the dog (Suter, 1982). Diffuse hepatic diseases such as fatty infiltration, cirrhosis or venous congestion did not produce detectable density changes (Wrigley, 1985).

Quantitative hepatobiliary scintigraphy has been described in the dog (Kerr and Hornof, 1986). The authors found it useful in the diagnosis of portocaval shunts and reported its potential in investigations of extrahepatic jaundice. Measurement of excretion of Techneticium 99 labelled sulphur colloids also provided information on the functional status of the hepatocyte (Kerr and Hornof, 1986). A technique for hepatobiliary nuclear scintigraphy has also been described in normal and fasting horses and this procedure showed potential for the evaluation of equine hepatobiliary disease (Hornof and Baker, 1986).

HEPATIC ULTRASONOGRAPHY.

The earliest reports of hepatic ultrasonography in man were confined to the differentiation of solid and discrete intrahepatic masses (Taylor, 1977[a]). Initial studies of the detection of hepatic metastatic disease resulted in failure rates of 53% and 39% (McCarthy, Davis, Wells, Ross and Follet, 1970). However, the introduction of grey-scale technology allowed the internal structure of organs to be assessed by displaying low level echoes (Taylor, 1977[a]). Taylor (1977[a]) concluded that grey-scale ultrasonography promised to be a useful tool in the investigation of liver disease. Since that time a large number of reports have described the ultrasonographic appearance of various hepatic diseases and the indications for hepatic ultrasonography in man have been defined. These indications included investigation of hepatomegaly, abnormal radionucleotide scans, jaundice, abdominal masses, unexplained fever, weight loss, upper abdominal pain and ascites, the identification of metastases, provision of guidance for hepatic biopsy and to aid treatment planning and monitoring (Merritt, 1980).

Ultrasonography produced highly accurate assessment of hepatic neoplasia and proved more accurate than any other investigative technique (Taylor, 1977[a]). However, the ultrasonographic appearance of malignant hepatic neoplasia was not closely associated with the histological or angiographic characteristics of the specific neoplasm involved (Green, Bree, Goldstein and Stanley, 1977; Hillman, Smith, Gammalgaard and Holm, 1979). Differentiation between malignant and benign neoplasms has been possible in children by investigating the portal vessel radicles supplying the lesion and identifying compression of the lumen and invasion of the vessel walls (Brunelle and Chaumont, 1984).

The identification of intrahepatic abscesses has been possible using ultrasonography (Taylor, 1977[a]; Callan, Filly and Marcus, 1980). However, the ultrasonographic appearance of hepatic abscess was non-specific and varied from anechoic to highly echogenic (Kuligowska, Connors and Shapiro, 1982).

Evaluation of the biliary tract and gall bladder has also been successful (Taylor, 1977[a]; Birnholz, 1979; Merritt, 1980). Hepatic vasculature has been identified and in cases of hepatic congestion due to congestive or right-sided cardiac failure, dilation of the hepatic vessels was apparent (Leopold, 1979). A significant difference in the diameter of hepatic vessels was demonstrated between normal patients and those with congestive cardiac failure (Henriksson, Hedman, Johansson and Lindstrom, 1982).

In investigation of hepatocellular disease ultrasonographic characteristics have not correlated well with pathological findings (Joseph, Dewbury and McGuire, 1979; Cohen, Siddiqui, Weetman, Provisor and Coates, 1986). Chronic hepatitis has not produced a characteristic ultrasonographic appearance (Kurtz, 1980). In contrast, acute hepatitis has produced a typical appearance of reduced overall echogenicity with increased numbers and echogenicity of the portal vessels visible (Kurtz, Rubin, Cooper, Nisenbaum, Cole-Beuglet, Medoff and Goldberg, 1980). Liver size determined ultrasonographically has also proved to be a useful indicator of acute hepatitis (Niederau and Sonnenberg, 1984).

A highly echogenic liver with increased attenuation and a heterogeneous appearance has been found in association with cirrhosis (Taylor, 1977[a]). A-mode evaluations have provided further evidence that cirrhosis may result in increased attenuation (Mountford and Wells, 1972). This finding was considered to be the result of fibrosis (Joseph et al, 1979).

Fatty change resulted in a similar increase in echogenicity but this was of a more homogeneous nature (Foster, Dewbury, Griffith and Wright, 1980; Birnholz, 1979). Heterogenicity has been described as the most characteristic feature of cirrhosis (Birnholz, 1979). However, numerous authors have concluded that increased echogenicity and attenuation may be observed in a variety of hepatic diseases including cirrhosis, fatty change, portal tract fibrosis, long-standing congestive cardiac failure and hepatitis (Joseph et al, 1979; Foster et al, 1980, Kurtz et al, 1980; Cohen, Kaude and Wright, 1981). Nevertheless, analysis of the application of ultrasonography in investigation of hepatocellular disease has produced good sensitivity (Foster et al, 1979; Joseph et al, 1979) and in one series, ultrasonographic change was the earliest indication of liver disease in 13% of cases (Joseph et al, 1979). The technique has produced poor specificity and in some cases of established cirrhosis, the echogenicity and attenuation have been normal (Joseph et al, 1979; Giorgio, Amoroso, Lettieri, Fico, Stefano, Finelli, Scala, Tarantino, Pierri and Pesce, 1986). The reasons for this were unclear (Joseph et al, 1979). However, recent work based on amplitude and frequency change analysis to provide further tissue characteristics has suggested that fatty infiltration rather than fibrosis resulted in elevation of attenuation and in advanced cirrhotic cases in which there was fibrosis without fatty infiltration, attenuation was similar to that of controls (Taylor, Riely, Hammers, Flax, Weltin, Garcia-Tsao, Conn, Kuc and Barwick, 1986).

The application of ultrasonography in the investigation of abdominal disease in domestic and exotic animals was first proposed by James et al (1975). Compound B mode ultrasonographs allowed delineation of the borders of the liver and assessment of size but visualisation of the gall bladder, blood vessels and parenchymal detail was limited (James, Osterman, Bush, Sheehan, Novak and Wright, 1976). The development of grey-scale ultrasonographic technology and its application to veterinary medicine allowed the visualisation of the internal structures of the liver and the normal ultrasonographic appearance in various species has been reported (Cartee, 1981; Nyland, Park, Lattimer, Lebel and Miller, 1981; Yamago and Too, 1984; Rantanen, 1985; Wrigley, 1985).

Detailed descriptions of the ultrasonographic appearance of hepatic diseases in domestic animals are limited in number at present but some retrospective studies have been performed comparing ultrasonographic findings with clinical, radiological and pathological findings.

The successful diagnosis of hepatic neoplasia in dogs has been reported (Cartee, 1981; Nyland et al, 1981; Nyland and Park, 1983; Nyland, 1984). Three ultrasonographic patterns were initially recognised in association with hepatic lymphosarcoma in the dog (Nyland, 1984). These were similar to those reported in humans (Ginaldi, 1980). In a series of 17 cases of canine hepatic and splenic neoplasia investigated ultrasonographically, 14 cases had hepatic involvement. A mixed echo-pattern was the most frequently encountered appearance and no pattern was considered to be specific for the tumour-type involved (Feeney, Johnston and Hardy, 1984).

Non-neoplastic masses have also been identified successfully using hepatic ultrasonography (Nyland and Park, 1983; Konde, Lebel, Park and Wrigley, 1986). The appearance of a gas-producing abscess has been reported (Konde et al, 1986). Hepatic cysts have been described and were considered an identical finding and nodular hyperplasia has resulted in multiple echogenic foci (Nyland and Park, 1983).

The hepatic and portal circulations have been examined (Nyland and Park, 1983). In right-sided cardiac failure,dilated hepatic veins were easily identified (Nyland and Park, 1983). Portal hypertension, secondary to acquired liver disease, has resulted in tortuous portal veins which were identified at the porta hepatis (Nyland and Park, 1983). Congenital intrahepatic portosystemic shunts have been diagnosed successfully using ultrasonography (Nyland and Park, 1983; Wrigley, Macy and Wykes, 1983). Intraoperative use allowed identification and subsequent ligation of a ductus venosus in a dog (Wrigley et al, 1983).

The ultrasonographic appearance of the canine biliary system and gall bladder has been described by several authors (Cartee, 1981; Nyland Gillet, 1982; Nyland and Park, 1983). The bile ducts could not be identified in the normal dog. However, following experimental ligation of the common bile duct, the dilated biliary system could be identified and be distinguished from blood vessels by the branching, tortuous appearance (Nyland and Gillet, 1982).

The authors concluded that identification of dilated bile ducts could support the diagnosis of extrahepatic jaundice (Nyland and Gillet, 1982).

Choleolithiasis has resulted in focal hyperechogenic areas in the cat (Cartee, 1981). In the dog, choleoliths could be identified as highly echogenic structures which fell to the dependent portion of the gall bladder with positional changes (Nyland and Park, 1983). Choleoliths have been identified in the bile ducts associated with recurrent colic in aged horses (Traub, Rantanen, Reed and Schecter (1982; Rantanen, 1985). Choleocystitis produced a double-rim effect due to oedema of the gall bladder wall in the dog (Nyland and Park, 1983).

1:2 SPLENIC DISEASES IN SMALL ANIMALS AND HORSES.

The functions of the spleen have been defined as filtration of the blood, formation of antibodies and production of cells (Feldman and Zinkl, 1983). Functional enlargement of the spleen could occur in response to haemolytic anaemia or infection and splenomegaly might also occur secondary to portal hypertension, extramedullary haemopoiesis or due to neoplasia (Feldman and Zinkl, 1983). Neoplasic diseases of the spleen included acute and chronic leukaemia, lymphoma, haemangioma and haemangiosarcoma (Theilen and Madewell, 1979; Feldman and Zinkl, 1983; Jubb, Kennedy and Palmer, 1985). Canine leukaemia and lymphoma were considered to be among the most frequently recognised neoplastic diseases recognised in canine clinical practice (Madewell, 1985). However, lymphosarcoma was recognised as an uncommon event in the horse. It accounted for only 0.42% and 1.3% respectively of neoplasms in two surveys of equine tumours (Sundberg, Burnstein, Page, Kirkham and Robinson, 1977; Pascoe and Summers, 1981). Equine lymphosarcoma has been classified as mediastinal, multicentric, alimentary, cutaneous and generalised forms (Theilen and Madewell, 1979). These forms could exist in combination and considerable variation occurred between individual cases (Neufeld, 1973; Theilen and Madewell, 1979). Both alimentary and generalised forms might involve the spleen (Theilen and Madewell, 1979) and solitary splenic lymphosarcoma has been reported (Jubb et al, 1985).

The bone marrow has been identified as the primary site of involvement in leukaemia and malignant cells could infiltrate lymphatic organs. Therefore, the discrimination between leukaemia and lymphosarcoma was based on the finding of malignant cells in the peripheral blood in leukaemia cases (Leifer and Matus, 1985).

Haemangiosarcoma has been defined as a malignant tumour composed of endothelial cells and it has been found more frequently in the dog than in any other species where it may affect the spleen (Brown, Patnaik and McEwen, 1985).

Splenic rupture and haematoma has occurred in association with abdominal trauma (Feldman and Zinkl, 1983;

Spier, Carlson, Nyland, Snyder and Fischer, 1986) and abscessation could occur secondary to infection of a haematoma (Spier, Carlson, Nyland, Snyder and Fischer, 1986).

The diagnosis of splenic disease has been aided by abdominal radiography in small animals (Thrall, 1977; Kealey, 1979). The spleen could usually be distinguished on radiographs of the abdomen. However, it could be demonstrated more clearly using pneumoperitonography or following intravascular injection of contrast medium (Kealey, 1979). For a definitive diagnosis of splenic disease, biopsy was considered necessary, being performed either percutaneously or through laparotomy and excision (Farrow, 1987).

Radiography of the equine spleen has not been possible (Rantanen, 1986[a]) and reports of splenic disease in the horse have been based largely on post-mortem findings with the exceptions of those in which exploratory laparotomy (Browning, 1986) or splenic ultrasonography had been performed (Spier et al, 1986).

SPLENIC ULTRASONOGRAPHY.

In man, the spleen has been a difficult organ to evaluate clinically due to its anatomical position (Taylor, 1977[b]). Ultrasonographic examination was especially important since it was highly diagnostic of certain diseases and could avoid the necessity for the patient to undergo other diagnostic procedures which were associated with greater morbidity and discomfort (Hassani and Bard, 1976). A technique for ultrasonographic estimation of the volume of the spleen has been devised which was based on performing several transverse scans at 20mm intervals (Kardel, Holm, Norby-Rasmussen and Mortensen, 1971). Using grey-scale technology, haematomata, cysts and abscessation of the spleen have been identified ultrasonographically (Hassani and Bard, 1976; Taylor, 1977b; Mittlestaedt and Partain, 1980; Lupien and Sanerbrei, 1984). Generalised splenomegaly due to systemic infection and vascular congestion have produced increased echogenicity (Hassani and Bard, 1976; Siler, Hunter, Weiss and Naber, 1980). Diffuse increase in echogenicity has also been observed in association with neoplastic processes in the spleen (Siler et al, 1980). Haemangioma of the spleen produced an ultrasonographic pattern which was predominantly composed of cystic spaces. However, the findings reflected the spectrum of solid to cystic change seen in gross specimens (Ros, Moser, Dachman, Murari and Olmsted, 1987). Efforts have been made to recognise lymphomatous involvement of the spleen in man by evaluating the echogenicity of the organ. A hypoechoic pattern has been observed in Hodgkin's disease, lymphomas and leukaemia (Brascho, 1980). However, it has been impossible to distinguish this appearance from abscesses and metastases from other malignancies (Brascho, 1980) and a hyperechoic pattern has also been observed in association with lymphoma and leukaemia (Siler et al, 1980) and, therefore, laparotomy has been advocated to reach a definite diagnosis (Brascho, 1980).

In 1976, James et al, described the normal ultrasonographic appearance of the canine spleen using compound B mode equipment (James, Sanders, Osterman, Novak and Bush, 1975). Reports of the normal ultrasonographic appearance and techniques of examination of the spleen using compound B mode and real-time grey-scale technology have subsequently appeared in the literature (James et al, 1976; Yamaga and Too, 1984; Nyland and Hager, 1985; Rawlinson and Hoffman, 1986; Rantanen, 1986), but reports of abnormalities which were detected in association with splenic disease remain sparse.

In 1983, Foss et al described the ultrasonographic findings of primary and metastatic splenic neoplasia. Ultrasonographic examination confirmed the presence of splenomegaly and illustrated the changes in tissue texture which were the result of splenic disease. These authors also concluded that the technique was easy to perform (Foss, Wrigley, Park, Konde and Lebel, 1983). Feeney, Johnston and Hardy (1984) reported the ultrasonographic findings in a series of 17 cases of hepatic and splenic neoplasia which included six cases of splenic involvement. Ultrasonographic examination provided information on tissue architecture which was not demonstrated by radiography and, therefore, ultrasonographic examination was considered a useful adjunct to radiography (Feeney, Johnston and Hardy, 1984).

Splenic haematoma in the horse has been described and it produced an image of areas of anechoic fluid surrounded by an echogenic wall (Spier et al, 1986). Splenic abscess in the dog has been located ultrasonographically and resulted in a hypoechoic area with a thick, echogenic wall (Konde, Lebel, Park and Wrigley, 1986).

1:3 ULTRASONOGRAPHIC ESTIMATION OF OVINE FOETAL NUMBERS.

The efficiency of management of a ewe flock could be improved by early detection of non-pregnant ewes and determination of foetal numbers. Barren ewes could be sold to avoid unnecessary feeding. Pregnant ewes could be divided into groups according to foetal number and fed accordingly. This could decrease the incidence of overgrown single lambs and accompanying losses due to dystocia and prevent undernourishment of ewes and lambs in multiple pregnancies. Thus birth weight of twins could be increased with a reduction incidence of pregnancy toxaemia. Extra attention at lambing could be provided for the multiple bearing group (White and Russel, 1984).

The absolute nutritional requirement of ewes during pregnancy was dependent on several factors in addition to foetal numbers. Body score, stage of gestation, live weight of the ewe and type of grazing all influenced energy requirement. Tables for nutritional requirements were generally calculated in experimental situations rather than on commercial farms and so the allowance required for climate and locomotion was difficult to assess (Russel, 1985). These factors must also be taken into account when deciding feeding regimes based on foetal numbers (Russel, 1985). However, a study by Parker and Waterhouse (1986) indicated that the overall benefit of scanning in a hill flock where the incidence of twinning was low, was at least 1 kg extra liveweight weaned per ewe. Similarly, in the upland or lowground situation, identification of barren ewes and reduction in lamb and ewe mortality resulted in considerable savings (Russel, 1985).

A wide range of methods of pregnancy diagnosis in the ewe has been reviewed by Richardson (1972), who suggested that there was not a simple, accurate and inexpensive method available. With the development of B mode ultrasonic scanning this situation has changed. Lindahl (1976) reported 84% accuracy of single and multiple detection with a composite scanning technique. White, Russel and Fowler (1984) carried out a trial on 1120 ewes to evaluate real-time ultrasonic scanning in the U.K. They reported 99% accuracy of determination of foetal number for an experienced operator and improvement in the ability of an inexperienced operator to determine foetal numbers from 69% to 93% in a period of five days (White, Russel and Fowler, 1984). This trial found that the technique of real-time ultrasonic scanning reported in Australia could be applied equally successfully in the U.K. (Fowler and Wilkins, 1980; Fowler and Wilkins, 1982; White, Russel and Fowler, 1984).

1:4 ULTRASONOGRAPHY OF THE PREGNANT BITCH AND QUEEN.

The same ultrasonographic technique may be applied to the bitch and the queen (Mailhac, Chaffeux, Legrand, Carlier and Heitz, 1980; Bondestam, Alitalo and Karkkainen, 1980; Bondestam, Karkkainen, Alitalo and Forss, 1984; Inaba, Matsui, Shimizu and Imari, 1984; Inaba, Nakajima, Matsui and Imari, 1983; Shille and Gontarek, 1985). In determination of foetal numbers it has been found to compare well with conventional methods of pregnancy diagnosis such as palpation and radiography which was limited to use following the onset of mineralisation of the skull after the forty-second day of gestation (Toal, Walker and Henry, 1986).

1:5 ULTRASONOGRAPHIC ASSESSMENT OF FOETAL GROWTH RATE.

In 1961, the Expert Committee on Maternal and Child Health of the World Health Organisation recommended that infants weighing less than 2,500g at birth be designated "low birth weight" rather than premature (World Health Organisation, 1961). It has been estimated that one third of low birth weight infants were in fact full term (Bard, 1978). These growth-retarded babies were subjected to numerous problems and for this reason it was considered imperative that intrauterine growth retardation (IUGR) was diagnosed in utero (DeVore and Hobbins, 1979). Clinical evaluation of I.U.G.R. by palpation was unsuccessful (Hobbins, Winsberg and Berkowitz, 1983).

Ultrasonographic assessment of foetal growth by measurement of biparietal diameter was first proposed in 1969 (Willocks, Donald, Campbell and Dunsmore, 1967) and with technological advances ultrasonographic screening became considered to be vital in the diagnosis of I.U.G.R. (DeVore and Hobbins, 1979).

Ultrasonographic assessment of intrauterine contents has provided the ability to measure structures that were related to body size (Hobbins et al, 1983). The parameters which could be measured were biparietal diameter, head circumference, abdominal circumference and total intrauterine volume (DeVore and Hobbins, 1979; Hobbins et al, 1983).

White, Russel, Wright and Whyte (1985) designed an ultrasonographic technique to estimate the gestational age in cattle and were able to establish equations for estimation of age based on measurement of various anatomical parameters. Similar equations for growth rates in other domestic species have not been developed.

ASSESSMENT OF GROWTH RATE IN THE OVINE FOETUS.

In the past, most studies of growth of the ovine foetus have been limited to post-mortem examinations.

Green and Winters (1945) published an extensive study on prenatal development of the sheep. Evans and Sack (1973) published the results of a study on foetuses comprising the Cornell Collection. Growth curves and chronological data of external features were presented.

An in utero technique for measurement of crown-rump length was described by Mellor and Mathieson (1979) and a similar technique for measurement of foetal girth was described by Mellor and Murray (1982). Both of these techniques required surgical placement of monofilament nylon measuring devices. Taylor, Doore, Robinson and Clewlaw (1983) described a method of measuring foetal skull size using ultrasonic transducers placed on either side of the foetal skull. Growth was monitored by measuring the time taken for an ultrasonic signal to pass from one transducer to the other. However, like the techniques described by Mellor and Mathieson (1979) and Mellor and Murray (1982), it also required surgical intervention.

1:6 DIAGNOSTIC TECHNIQUES IN CANINE PROSTATIC DISEASE.

Prostatic disease has been described as one of the commoner clinical entities seen in male dogs presented in a clinical practice (Hornbuckle, MacCoy, Allan and Gunther, 1978). Eight types of prostatic disease have been recognised: hyperplasia, metaplasia, prostatitis, neoplasia, cyst formation, abscesses, calculi and atrophy (Allen, Noakes and Renton, 1984). Benign prostatic hyperplasia (B.P.H.) was seen in 60% of all dogs over five years of age (Johnson and Archibald, 1974). B.P.H. was often asymptomatic but if there was gross enlargement it could contribute to problems with defaecation and the potential for prostatic and urinary tract infection was increased (Hornbuckle et al, 1978).

Prostatitis could be either acute or chronic and was associated with hyperplasia or metaplasia. Both haematological and ascending urinary tract infection were reported. Prostatic neoplasia occurred most frequently in older dogs - prostatic adenocarcinomas being the most common neoplasm affecting the gland (Allen et al, 1984).

Prostatic cysts have been classified in four categories: prostatic retention cysts; multiple cysts associated with B.P.H.; cyst formation associated with squamous metaplasia and paraprostatic cysts. Prostatic retention cysts occurred following obstruction of the prostatic duct whereas paraprostatic cysts were not in communication with the prostate (Hoffer, Dykes and Greiner, 1977).

Prostatic abscesses might result from infection of retention cysts, paraprostatic cysts, metaplasia or coalescences of multiple suppurative foci which were associated with acute prostatitis. Paraprostatic cysts could only become infected by the haematogenous route

(Hoffer et al, 1977).

Prostatic calculi have seldom been reported but they have been described as arising either within the gland or within the urinary tract. In these cases radiography was useful in reaching the diagnosis (Allen et al, 1984). Prostatic atrophy has been described in aged dogs. However, it was not associated with clinical signs (Allen et al, 1984).

Conventional diagnostic techniques which have been applied to canine disease include plain radiography and retrograde urethrograms (Feeney, Johnston, Klausner, Perman, Leininger and Tomlinson 1987[a]), bacterial culture and cytology of semen, urine and prostatic washings (Barsanti, Shotts, Prasse and Crowell, 1980; Ling, Branam, Ruby and Johnson, 1983; Barsanti and Finco, 1984) and percutaneous biopsy techniques (Barsanti et al, 1980).

PROSTATIC ULTRASONOGRAPHY.

Transabdominal, transurethral and transrectal techniques of ultrasonography have been described in man for investigation of prostatic disease (Gammalgaard and Holm, 1980; Greenberg, Neiman, Bradt, Falkowski and Carter, 1981). Initially only the size and shape of the gland could be analysed but the advent of grey-scale technology has allowed internal structure of the gland to be assessed (Harada, 1984). Transabdominal scanning, using the full urinary bladder as an acoustic window proved to be the simplest of the three methods. It required no specialised equipment other than a general purpose ultrasonographic unit (Greenberg et al, 1981). Radially rotating transducers have been designed for introduction into the urethra or rectum. For use within the urethra the transducer was placed coaxially within an endoscope but rectal scanners could be guided by hand (Peeling and Griffiths, 1984). These methods produced superior resolution in imaging the prostate tissue although detail of the central portion of the gland could be distorted with a urethral transducer (Peeling and Griffiths, 1984). In addition, urethral scanning required a general anaesthetic thus infringing the concept of the technique being non-invasive (Peeling and Griffiths, 1984).

The more conventional method of investigation of the human prostate gland had been by digital examination which was easy to perform and required no additional materials. In order to be of value, ultrasonography had to provide evidence of impalpable disease and be of use in localisation and staging of neoplasia and in monitoring of treatment (Peeling and Griffiths, 1984). In a study of sonographic findings of patients with suspected and unsuspected prostatic disease, Fritzche, Axford, Ching, Rosenquist and Moore (1983) found that the sensitivity for diagnosis of prostatic neoplasia was 90% and the specificity was 60%. The authors considered this a useful technique but cautioned that further criteria needed to be developed for differentiating prostatic carcinoma from non-neoplastic conditions such as prostatitis and post-operative fibrosis in man.

The veterinary literature has been found to contain relatively few reports of the applications of ultrasonography to the diagnosis of canine prostatic disease. A technique for transabdominal sonographic evaluation of the canine prostate was first described by Cartee and Rowles (1983). In this study, the normal ultrasonographic anatomy of the gland was described and compared to the observations made in prostates affected by cystic hyperplasia, benign hyperplasia and neoplasia. Differentiations of cystic and solid enlargement by ultrasonography was effective and the ease of examination and safety of the technique offered an opportunity to monitor treatment.

The ultrasonographic appearance of canine prostatitis and prostatic abscessation has been described (Foss, Wrigley, Park, Konde and Lebel, 1984). In conjunction with other techniques, ultrasonography was judged by the authors to be useful in reaching a diagnosis. However, these reports were based on very limited case numbers. Feeney, Johnston and Klauser (1985) also described the ultrasonographic appearance of benign, inflammatory and neoplastic diseases of the prostate. They stated that ultrasonography was a sensitive but not necessarily specific means of evaluation of the prostate. This agreed with findings in human prostatic disease

(Fritzche et al, 1983). A retrospective study of thirty cases of prostatic disease and the associated ultrasonographic appearance has been reported. It was concluded that ultrasonography should be applied in cases demonstrating radiographic evidence of prostatic enlargement to further elucidate the morphology of this enlargement (Feeney, Johnston, Klausner, Perman, Leininger and Tomlinson, 1987[b]).

C H A P T E R T W O

MATERIALS

AND

METHODS

2:1 HEPATIC ULTRASONOGRAPHY.

The small animals were prepared for ultrasonographic examination by clipping the hair from the ventral abdomen using surgical clippers. Echolucent gel was applied to the skin to facilitate acoustic contact. The animals were placed either in dorsal recumbency or allowed to stand. No sedation was required for the dogs but the cats resented clipping and, therefore, deep sedation or general anaesthesia was required. Horses were prepared by clipping an area around the seventh and eighth intercostal spaces on the left ventral body wall and an area from the 11th to the 17th intercostal space on the right dorsal body wall. No sedation was required.

Cats and dogs were examined using a 5mHz sector transducer and ultrasonographic unit. Larger dogs were examined using both 5 and 3mHz sector transducers. Horses were examined using a 3.5mHz curved linear array transducer and a 3.5mHz sector transducer.

2:1A Four normal dogs, two normal cats and six normal horses were examined to establish the technique and normal findings of hepatic ultrasonographic examinations.

2:1B Thirty cases were selected for hepatic ultrasonography on the basis of clinical, biochemical and haematological findings. The following parameters were evaluated: echogenicity relative to other abdominal organs; evenness of echogenicity; size; shape; smoothness of margins; appearance of the hepatic vasculative; appearance of the biliary system; presence of localised areas of abnormality.

2:2 SPLENIC ULTRASONOGRAPHY.

The small animals were prepared for ultrasonographic examination by clipping the hair from the left cranial abdomen wall. Echolucent gel was applied to the skin to facilitate acoustic contact. The animals were either placed in dorsal recumbency or allowed to stand. No sedation was required for the dogs but the cats required deep sedation.

Horses were prepared by clipping an area ventral to the lung field on the left flank from the eighth intracostal space to caudal to the last rib. The ultrasonographic equipment which was used is detailed in Section 2:1.

2:2A Four normal dogs, two normal cats and six normal horses were examined to establish the technique and normal findings of splenic ultrasonographic examination.

2:2B Twenty one cases were selected for splenic ultrasonography on the basis of clinical, biochemical and haematological findings. The following parameters were evaluated during ultrasonographic examination of the spleen: echogenicity relative to other abdominal organs; evenness of echogenicity; size; shape; smoothness of margin; presence of localised areas of abnormality.

2:3 ASSESSMENT OF THE ACCURACY OF ULTRASONOGRAPHIC DETERMINATION OF OVINE FOETAL NUMBERS BY INEXPERIENCED AND EXPERIENCED OPERATORS AT VARIOUS STAGES OF GESTATION.

A group of 50 greyface ewes was used for the study. The reproductive cycles of the ewes were synchronised using progesterone impregnated vaginal sponges (Veramix, Upjohn). Immediately prior to mating, the ovulation rate was determined by laparoscopy. The mating was carried out with the ewes split into groups of 12. A tup, fitted with a colour marked keel, was introduced to each group for three days. The ewes were closely observed and the day on which colour marking first appeared was recorded. The day of gestation for each ewe was calculated on the basis of these dates. Fourteen days later the tups were again introduced to the ewes to ensure all the ewes which returned to service were covered.

ULTRASONOGRAPHIC EXAMINATION TECHNIQUE.

The equipment used was a real-time B mode ultrasonographic unit with a 3.5 mHz linear array transducer (Vetscan, Dynamic Imaging). The ventral abdomen was clipped and vegetable oil was applied as a coupling medium. The ewes were turned over and supported in dorsal recumbency by a cradle designed for this purpose.

A sweep of the abdomen from the left hand side was made commencing at the umbilical level, extending caudally to the pelvic brim, across to the right hand side and then running cranially to ensure the limits of both horns were examined. By building up a mental three-dimensional image, care was taken not to identify the same foetus twice from different angles, thus mistaking it for two separate foetuses. Where possible, twin foetuses were both viewed on the same screen to confirm their existence. This technique was described by White and Russel (1984).

METHODS OF CALCULATION OF ACCURACY OF DETERMINATION OF OVINE FOETAL NUMBER.

Tables were constructed to display the results of prediction of accuracy which were obtained at each examination time by both individual operators and for their composite results. The method by which the data were inserted is described in Table 1. The ewes were divided into two groups:

Group One : Thirty five ewes which were not marked on re-introduction of the tup were assumed to have held to the first service. This group was examined ultrasonographically on day 42-43; day 57-58; day 79-80 and day 106-107 of gestation.

Group Two : Fifteen ewes which were marked again following re-introduction of the tup were examined on three occasions: day 42-43, day 58 and day 80 of gestation. These ewes were not examined on the occasion at which Group One was first examined because at this date they were at day 21 of gestation and the handling and turning of the ewe, which

TABLE 1. METHOD OF ARRANGEMENT OF THE DATA FOR THE CALCULATION OF THE ACCURACY OF ESTIMATION OF OVINE FOETAL NUMBERS.

		LAMBING NUMBER				
		0	1	2	3	4
SCANNING	0	X	U	U	U	U
LITTER	1	O	X	U	U	U
SIZE	2	O	O	X	U	U
	3	O	O	O	X	U
	4	O	O	O	O	X

	BARREN,	SINGLE,	MULTIPLE
BARREN	X	U	U
SINGLE	O	X	U
MULTIPLE	O	O	X

X = correct, U = under-estimation

O = over-estimation

was necessary, was considered to be a potential cause of embryonic mortality.

Two methods of analysis were applied to the data. The calculations were performed by a computer which was made available by the West of Scotland College of Agriculture.

METHOD ONE:

The following formulae were applied:

Scan result; Correct = $\dfrac{\text{number predicted correctly}}{\text{number predicted correctly plus number predicted wrongly}}$.

Scan result; Over-estimation = $\dfrac{\text{number of over-estimations}}{\text{number predicted correctly plus number predicted wrongly}}$.

Scan result; Under-estimation = $\dfrac{\text{number of under-estimations}}{\text{number predicted correctly plus number predicted wrongly}}$.

METHOD TWO:

The following formulae were applied:

Scan result; Correct = $\dfrac{\text{total number of correct examinations}}{\text{total number of ewes examined}}$.

Scan result; Under-estimation = $\dfrac{\text{total number of under-estimations}}{\text{total number of ewes examined}}$.

Scan result; Over-estimation = $\dfrac{\text{total number of over-estimations}}{\text{total number of ewes examined}}$.

2:4 ASSESSMENT OF THE ACCURACY OF ULTRASONOGRAPHIC DETERMINATION OF CANINE AND FELINE PREGNANCY AND FOETAL NUMBERS.

Thirty six bitches and four queens were examined with a B mode real-time scanner using a 5 mHz sector transducer. Prior to examination, the hair of the ventral abdomen of the bitches was removed. The cats' fur was found to mix well with echolucent gel and so clipping, which was poorly tolerated by cats, was not necessaty. The bitches were placed in dorsal recumbency and the abdominal cavity was examined using both longitudinal and transverse scans. The examination was begun at the pelvic brim. The bladder was identified first and the entire abdomen examined by moving the transducer cranially to the level of the liver. Cats could be restrained most effectively by being held in an upright position close to the chest of an assistant.

The stage of gestation ranged from day 23 of gestation onwards. The estimated number of foetuses was compared with the number born. Information was obtained by contacting the owners after the predicted whelping date. Accuracy in detection of foetal numbers was compared with litter size and gestation stage of examination.

2:5 ULTRASONOGRAPHIC DETERMINATION OF THE INTRAUTERINE GROWTH RATE OF THE OVINE FOETUS.

The group of fifty greyface ewes which were used for this study and the timings of examinations are described in Section 2:3. Measurements were made at each ultrasonographic examination and similar parameters were received at birth. The data collected for twin and single foetuses were compared at each recorded day of gestation and at birth to establish if there were significant differences in the mean size of these populations of foetuses.

ULTRASONOGRAPHIC EXAMINATION TECHNIQUES.

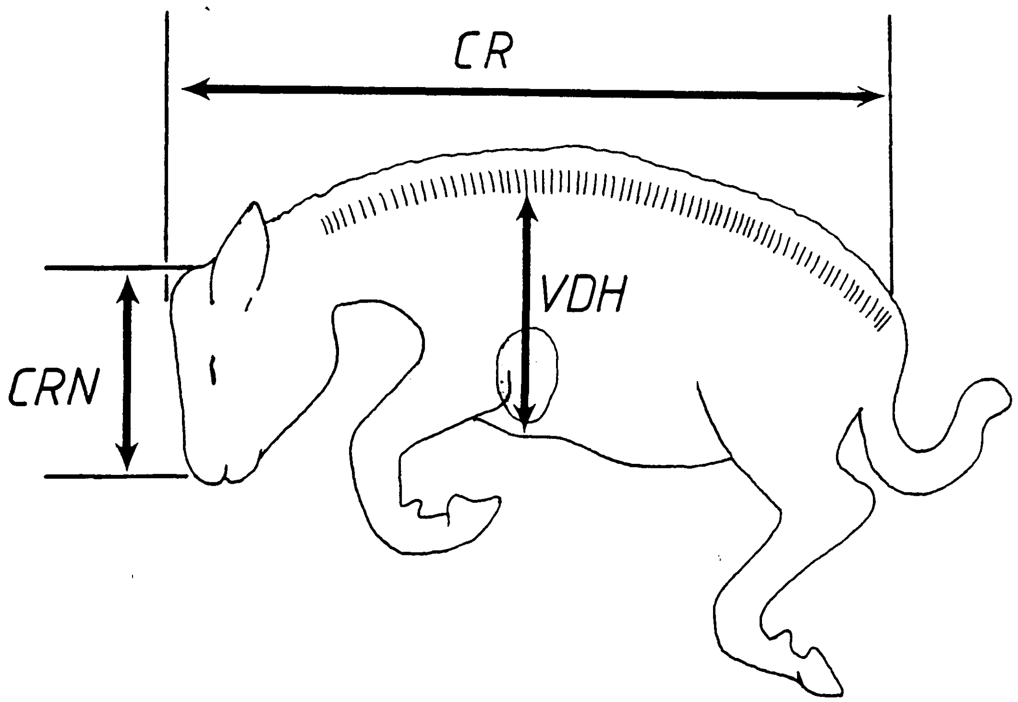
The ewes were prepared and examined in the same way as described in Section 2:3. Assessment of the foetal growth rate was carried out by measuring the following parameters : crown-rump length (C.R.); biparietal diameter (B.P.); transthoracic diameter (T.T.); cross sectional abdominal diameter (X.A.); crown to rostral nasal bone length (C.N.); ventrodorsal thoracic height (V.D.H.) as indicated (Figs. 1, 2). The measurements were made from the screen using calipers and applying a correction factor of 2. To standardise measurements, the T.T. and V.D.H. measurements were made at the level of the heart. The X.A. measurements were made at the level of the liver and the widest point of the parietal bones was used.

STATISTICAL ANALYSIS.

The mean values of B.P. and T.T. at each recorded day of gestation for twin and single foetuses were compared using a Students T. test. The Barserrani correction factor was applied and, therefore, a probability level of 0.00625 was considered to be significant.

MATHEMATICAL ANALYSIS.

The V.D.H., C.N. and X.A. measurements were discarded because insufficient data were recorded. The mean values of each of the remaining parameters at each recorded



VDH = Ventrodorsal at heart level.
CRN = Crown to rostral nasal bone length.
CR = Crown rump.

Fig. 1 Anatomical positions at which ovine foetal measurements were made.

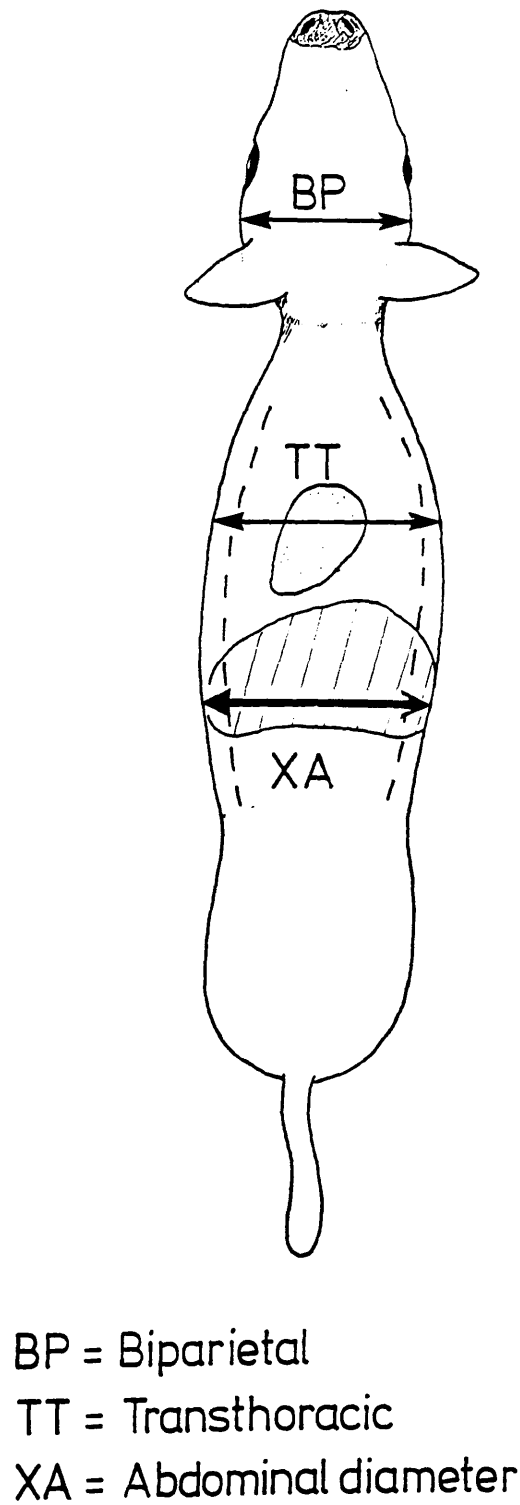


Fig. 2. Anatomical positions at which ovine foetal measurements were made.

day of gestation and various arithmetical functions of these values were plotted against the gestational age. The data for C.R. were not analysed further. Linear regression and correlation coefficients were calculated for logarithims of the biparietal and transthoracic diameters and ninety five per cent confidence values were established. The following two methods of predicting age from foetal size were applied.

METHOD THREE:

A graphical technique was applied to the curve of the regression of Y on X (Fig. 3).

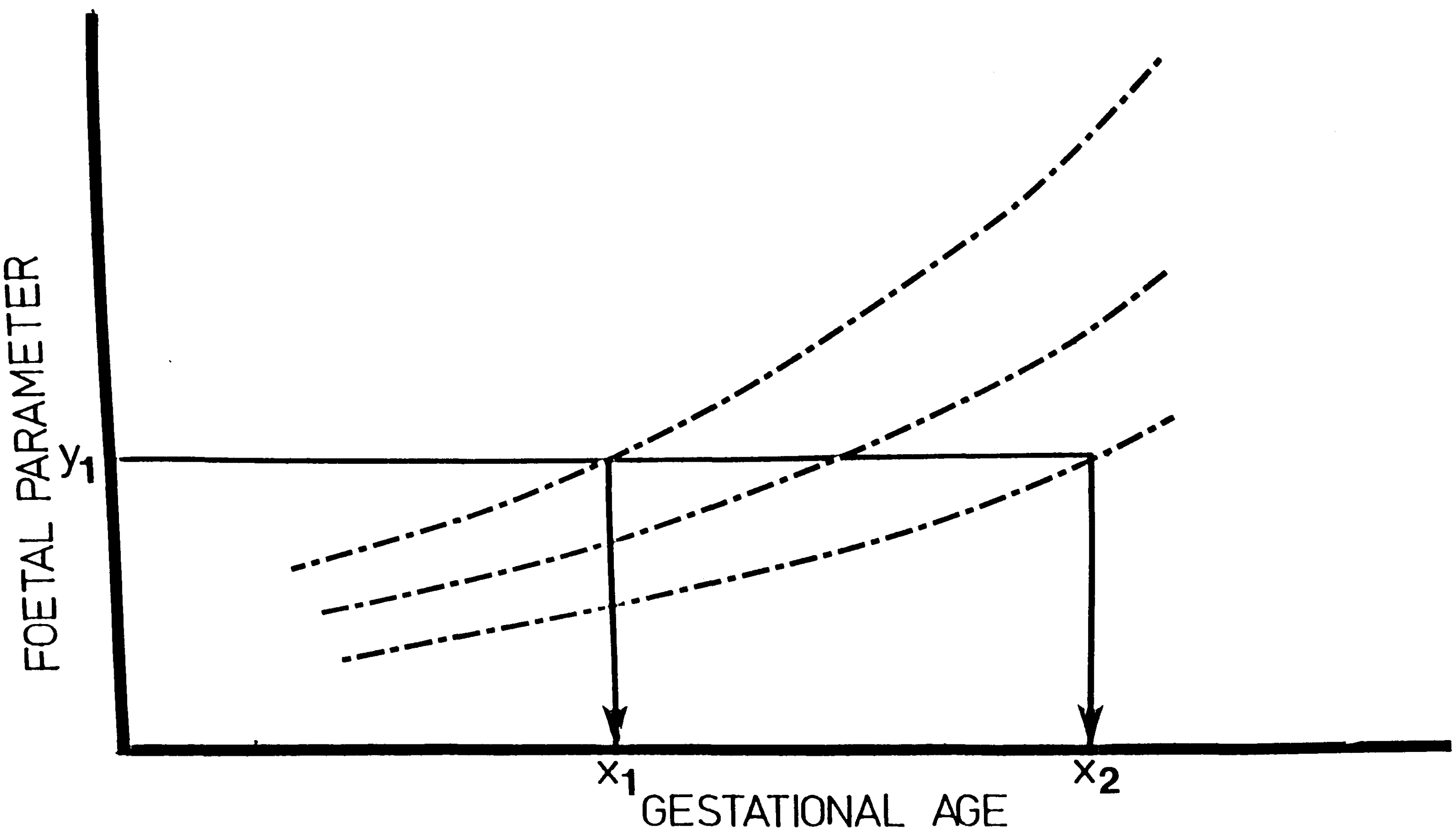
METHOD FOUR:

Formulae were developed for estimation of gestational age based on the regression analysis of X on log Y, where X was gestational age and Y was the measured foetal parameter.

2:6 PROSTATIC ULTRASONOGRAPHY.

Prior to examination, the dogs were placed in dorsal recumbency and the hair was clipped from the caudo-ventral abdomen before echolucent gel was applied to facilitate acoustic contact.

2:6A The normal prostate glands of three live dogs and one canine cadaver were examined ultrasonographically. The prostates from the cadaver and one of the dogs which was euthanased for an unrelated medical condition were removed and examined in a waterbath. The animals were



Where the foetal parameter is y , Gestational age range is x_1 to x_2

Fig. 3. The geometric method for estimation of ovine gestational age (Method Three)

examined using 3 and 5 mHz sector transducers. In addition, one animal was examined with a 5 mHz linear array transducer.

2:6B Nine clinical cases were selected for prostatic ultrasonography on the basis of clinical signs of prostatic disease and radiological evidence of prostatic enlargement or a caudal abdominal mass. In seven cases surgical or post-mortem examinations were performed to confirm the diagnosis made on the basis of clinical, radiological, laboratory and ultrasonographic findings. The following parameters were evaluated ultrasonographically : size of the prostate gland; echogenicity relative to other abdominal organs; uniformity of echogenicity throughout the gland; smoothness of contour of the gland; symmetry and shape of the gland; presence of periprostatic lesions. The animals were examined using 3 and 5 mHz sector transducers.

C H A P T E R   T H R E E

RESULTS

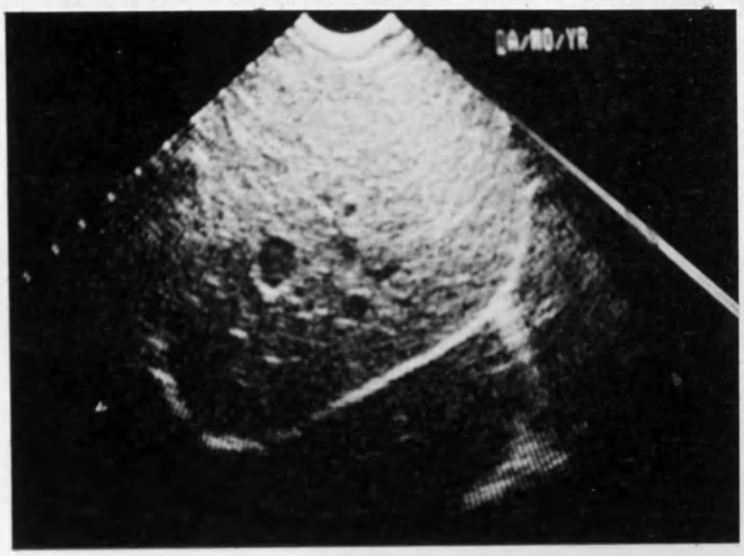
3:1A HEPATIC ULTRASONOGRAPHY.

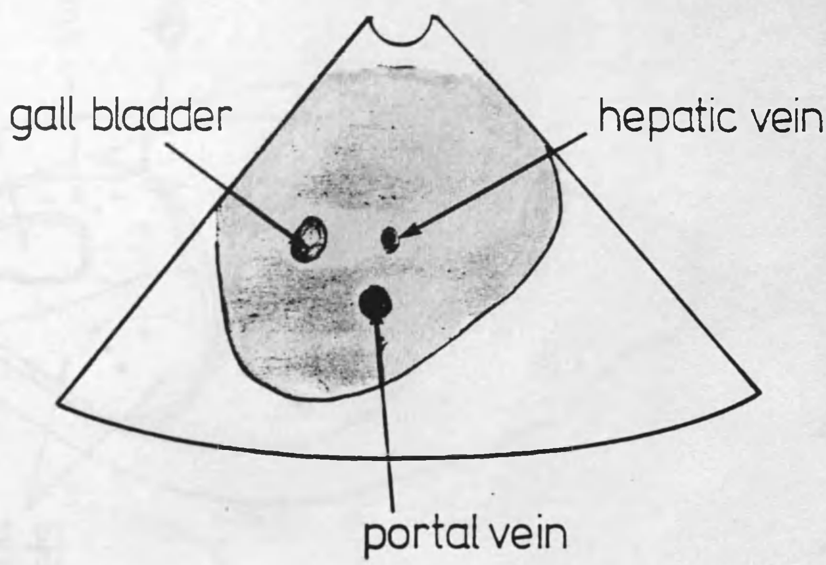
In the four normal dogs, the liver was easy to locate in a cranial abdominal position. Transverse scans were made by placing the transducer in a substernal position and swinging it from caudal to cranial. Longitudinal scans were made by swinging the transducer from left to right. Oblique scans were made from the 10th, 11th and 12th intercostal spaces. A similar technique was performed on the two cats successfully.

In the horse, suitable acoustic windows for imaging the liver were limited. The more ventral portion of the left lobe could be identified from the seventh and eighth intercostal spaces. On the right side the caudal portions of the liver could be located in the 14th, 15th, 16th and 17th intercostal spaces. During expiration larger areas could be identified as the lung moved cranially to expose the underlying liver.

The diaphragm was represented by a strongly echogenic line in small animals and was less echogenic when observed in horses in the left ventral position. In all species, the liver had an even granularity and was more echogenic than the kidneys and less echogenic than the spleen. Portal vessels had brightly echogenic walls and no walls were observed around the hepatic vessels (Figs. 4, 5, 6). In the small animals, the caudal vena cava could be identified lying to the right of midline and the hepatic vessels could

Fig. 4 An ultrasonograph of normal canine liver.
The echogenicity is even and the gall bladder, hepatic and portal vessels can be distinguished.





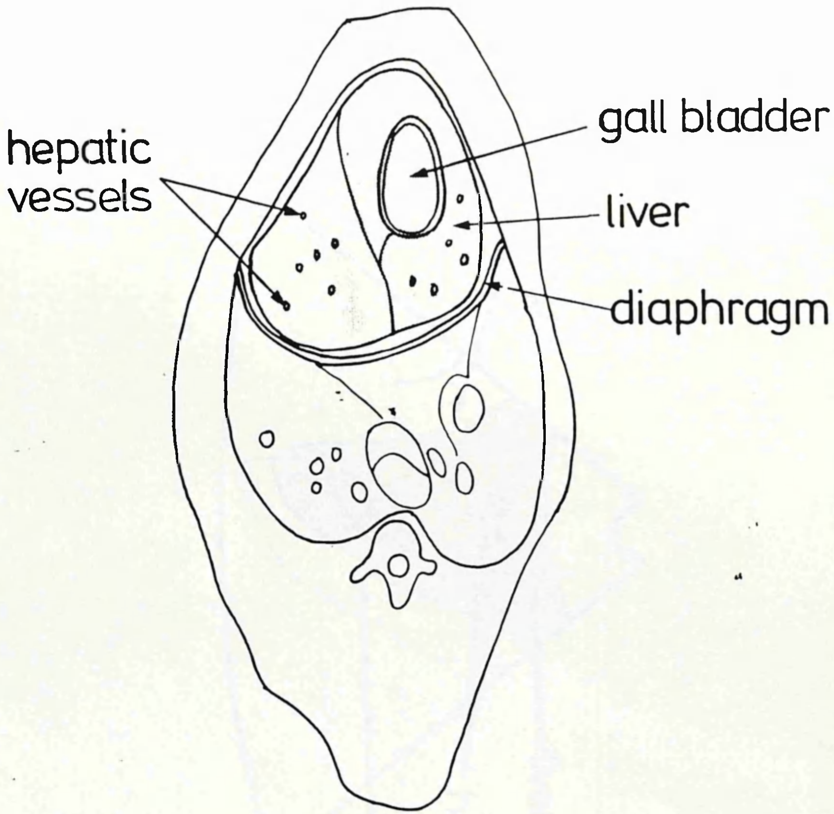
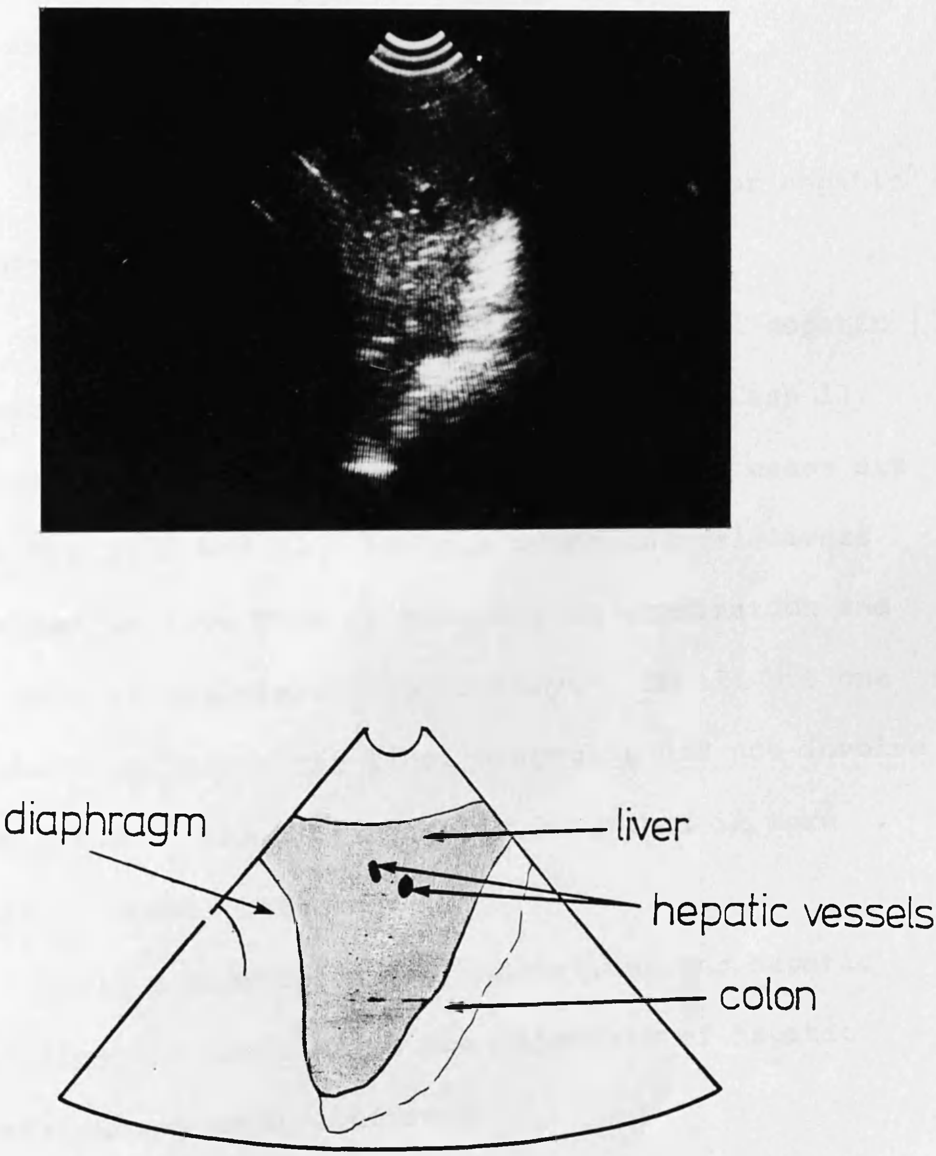


Fig. 5 An oblique section of the canine cranial abdomen made in the same plane as the preceding ultrasonograph. The positions of the liver, gall bladder and hepatic vasculature are demonstrated.

Fig. 6 An ultrasonograph of normal equine liver. The liver lies between the diaphragm and the colon. Hepatic vessels are visible.



be seen running into it. In the horses, the caudal vena cava was difficult to identify and could be located in only two cases.

The gall bladder, in the small animals, was of variable size and was represented by a round or oval anechoic area with distal enhancement. The bile ducts were not observed.

3:1B HEPATIC ULTRASONOGRAPHY.

27 dogs and three cats were selected for hepatic ultrasonography.

18 cases were considered to have normal hepatic ultrasonographic findings with the exception of Case 13. The clinical indications and diagnoses for these cases are listed in Tables 2 and 3. In this group, normal livers were examined in five dogs at post-mortem examination and in three dogs at exploratory laparotomy. In all but one of the remaining cases, the final diagnosis did not involve hepatic disease. The final case is described in more detail below (Case Thirteen).

Table 4 summarises the indications for hepatic ultrasonography in cases which the diagnosis of hepatic disease was subsequently confirmed.

Table 5 summarises the ultrasonographic findings and final diagnosis in the eight cases of diffuse hepatic disease which were included in the study.

Table 6 summarises the ultrasonographic findings

TABLE 3 : IDENTIFICATION AND DIAGNOSIS IN CASES WHICH DEMONSTRATED NORMAL HEPATIC ULTRASONOGRAPHIC FINDINGS

Case Number	Breed	Age (Years)	Sex	Diagnosis
13	German Shepherd	9	M	Lymphoblastic leukaemia
18	German Shepherd	11	M	Paraprostatic cyst
19	Pointer	2	M	Paraprostatic cyst
20	German Shepherd	4	M	Anal gland tumour
21	German Shepherd	9	M	Prostatic adenocarcinoma
26	Old English Sheepdog	12	F	Thyroid carcinoma
27	Cross	10	F/S	Myositis
28	Labrador	10	M	Preputial trauma
29	German Shepherd	7	M	Osteosarcoma
30	German Shepherd	3	M	Pancreatic insufficiency
31	Collie	3	M	Pituitary tumour
32	Labrador	5	F/S	Chronic renal failure
33	German Shepherd	2	F	Megaoesphagus
34	Labrador	6	M	Ruptured bladder
35	Springer Spaniel	5	M	No diagnosis made
36	Cocker Spaniel	11	M	Pharyngeal paralysis
37	Labrador	6 mths	F	Incontinence
38	Collie	7	M	Myaesthenia gravis

M = male; F = female; F/S = female neutered

TABLE 2 : SUMMARY OF THE INDICATIONS FOR HEPATIC ULTRASONOGRAPHY IN CASES WHICH HAD NO HEPATIC ABNORMALITY

Case No.	Routine Abdominal Exam.*	Non-specific Clinical Signs	Increase in Radiographic Hepatic Size	Possible Hepatic Metastases	Biochemical Evidence of Hepatic Disease
18	1				
19	1				
20	1			1	
21	1			1	
26				1	
27		1	1		
28	1				
29		1		1	
30	1				
31		1			
32	1				
33		1			
34		1			1
35		1			
36	1				
37	1				
38	1				
TOTAL	10	6	1	4	1

* Routine abdominal examination indicates that there was not specific indication for hepatic ultrasonography but the examination was performed routinely during the examination of the other abdominal organs.

TABLE 4 : SUMMARY OF THE INDICATIONS FOR HEPATIC ULTRASONOGRAPHY IN THIRTEEN CASES WITH HEPATIC DISEASE

Case No	Clinical signs referrable to hepatic dysfunction	Non-specific clinical signs	Bio-chemical evidence of hepatic disease	Palpable mass	Possible metastases	Loss of visceral detail on radio-graphy	Increase in radio-graphic hepatic size	Decrease in radio-graphic hepatic size	Radio-graphic evidence abdominal mass
1		1			1				
2		1		1	1				1
3		1							
4		1		1	1				1
5		1				1			
6	1		1			1			
7	1							1	
8	1		1						
9		1					1		
10		1					1		
11		1				1			
12		1							
13		1	1						
TOTAL	3	10	3	2	3	3	2	1	2

TABLE 5 : THE ULTRASONOGRAPHIC FINDINGS AND DIAGNOSIS IN EIGHT CASES OF DIFFUSE HEPATIC DISEASE

Ultrasonographic Findings	Case No.	Diagnosis
Decreased hepatic size, normal echogenicity	7	Portocaval Shunt
Decreased hepatic size, dilation of portal vessels	8	Portocaval Shunt
Decreased hepatic size, mixed echogenicity	6	Cirrhosis
Increased hepatic size, normal echogenicity	9, 10, 11	Fatty infiltration, none reached, venous congestion
Increased hepatic size, reduced echogenicity	12	Myeloid Leukaemia
Normal hepatic size and echogenicity	13	Lymphoid Leukaemia

TABLE 6 : SUMMARY OF THE ULTRASONOGRAPHIC FINDINGS AND DIAGNOSIS IN CASES OF LOCALISED HEPATIC DISEASE

Case No.	Ultrasonographic Findings	Diagnosis
1	Multiple hyperechogenic areas	Fatty change
2	Single, hyperechogenic mass	Hepatic carcinoma
3	Anechoic areas with distal enhancement and overall heterogeneous echogenicity	Cystic and microcystic degeneration
4	Multiple hyperechogenic areas	Metastases
5	Localised area of increased echogenicity and free fluid	Peritonitis, amyloidosis and hepatic adhesions

in the remaining five cases in which localised lesions were identified ultrasonographically.

Case reports were prepared for each case of liver disease including clinical, laboratory, radiographic and ultrasonographic findings and the diagnosis and pathological findings were appropriate. For the purposes of conciseness, only those details which were considered to have been useful in reaching or confirming the diagnosis have been included and some ancillary data have been omitted.

Table 7 summarises the importance of the ultrasonographic findings in reaching the final diagnosis in the 13 cases of hepatic disease in this study.

3:2A SPLENIC ULTRASONOGRAPHY.

In the four normal dogs, the spleen was identified on the left dorsal flank overlying the kidney. It was traced ventrally to the midline. The location of the tail of the spleen varied from lying immediately caudal to the liver to lying in the mid-ventral abdomen. Longitudinal, transverse and oblique scans could be performed. The medial border of the spleen was smooth and produced a bright linear echo. Vessels could be seen running into the spleen but none were identified within its substance. The echogenicity was greater than that of the liver and kidney and was even throughout the organ (Figs. 7, 8).

In the two cats, using a 5 mHz sector transducer, it was difficult to identify the spleen. An echolucent gel

TABLE 7 : SUMMARY OF THE USEFULNESS OF THE INFORMATION PROVIDED BY HEPATIC ULTRASONOGRAPHY IN REACHING THE DIAGNOSIS IN 13 CASES OF HEPATIC DISEASE

Usefulness of Ultrasonographic Information	Case Numbers	Total	(%)
Confirmed clinical and/or radiographic evidence	2, 5, 7, 8, 9, 10, 11, 12	8	(50)
Additional diagnostic information	2, 4, 5, 6, 7	5	(31)
Insignificant	1, 3	2	(12)
False negative	13	1	(6)

Fig. 7 An ultrasonograph of normal canine spleen. The echogenicity of the spleen is greater than that of the underlying left kidney.

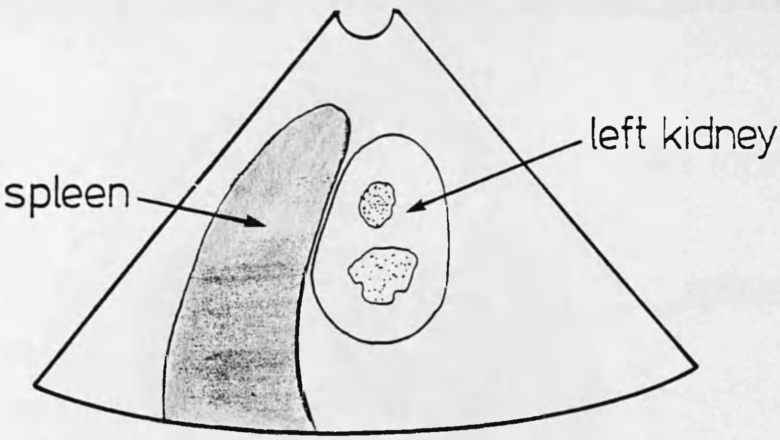
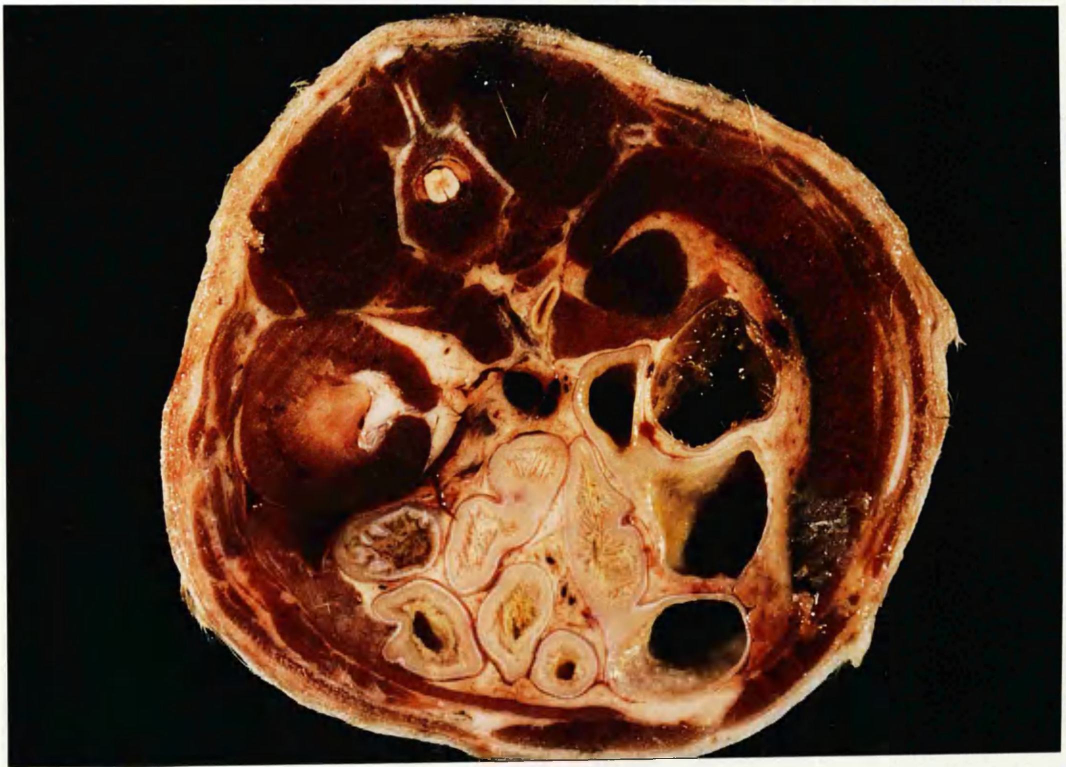
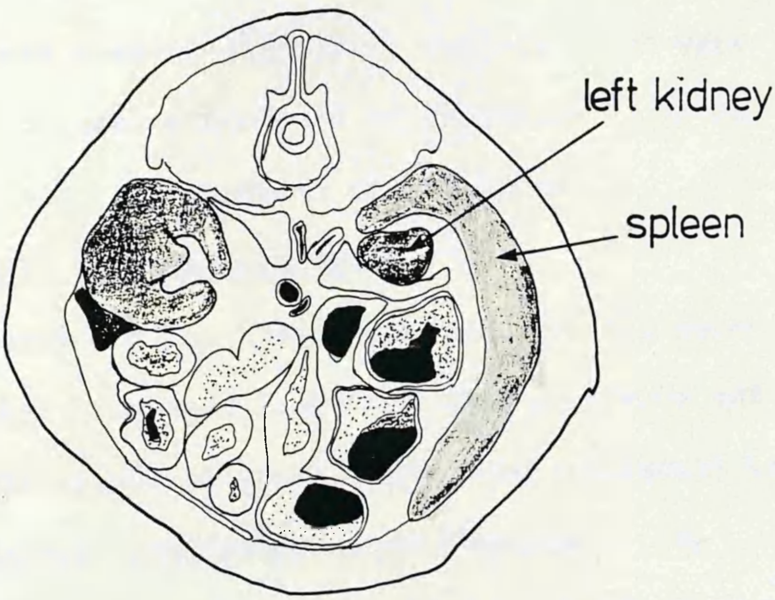


Fig. 8 A transverse section of the canine cranial abdomen. This section was made in the same plane as the preceding ultrasonograph and demonstrates the position of the spleen and the left kidney.





block was used to provide a space between the skin and the transducer but, nevertheless, it could not be imaged with confidence.

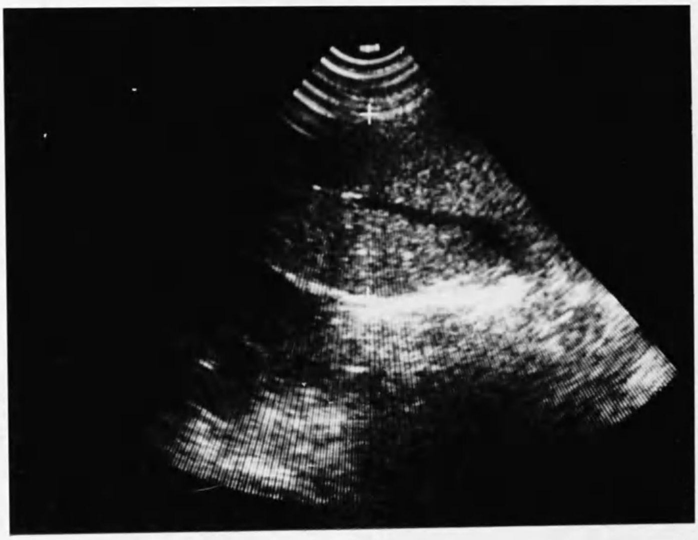
The equine spleen had a triangular shape (Fig. 9) and could be located in the sublumbar fossa where it overlay the left kidney. It was then traced cranially, ventral to the lung margin. In the cranial abdomen, the spleen lay medial to the liver. The majority of the organ lay beneath the ribs and, therefore, at each intercostal space the transducer had to be moved cranially and caudally in an arc in order to image the parts beneath the ribs. The more dorsal position lay beneath the lung field and, therefore, could not be imaged. Ventral to the spleen, in the mid-abdomen, lay hyperechoic areas with acoustic shadowing representing the colon. The echogenicity of the equine spleen was similar to that of the dog (Fig. 10). It was more echogenic than the liver and the kidney and the echogenicity was even throughout. Vessels which were anechoic with no echoes produced by the walls could be identified within the substance of the spleen.

3:2B SPLENIC ULTRASONOGRAPHY.

20 dogs and one horse were selected for splenic ultrasonography. Table 8 lists the identification and the final diagnosis in the 16 cases which were considered to have normal splenic ultrasonographic findings. The indications for splenic ultrasonography in these cases are

Fig. 9 The equine spleen which is a triangular organ.

Fig. 10 An ultrasonograph of normal equine spleen made from the sublumbar fossa. The echogenicity is even throughout. The capsule is hyperechoic and a blood vessel is apparent.



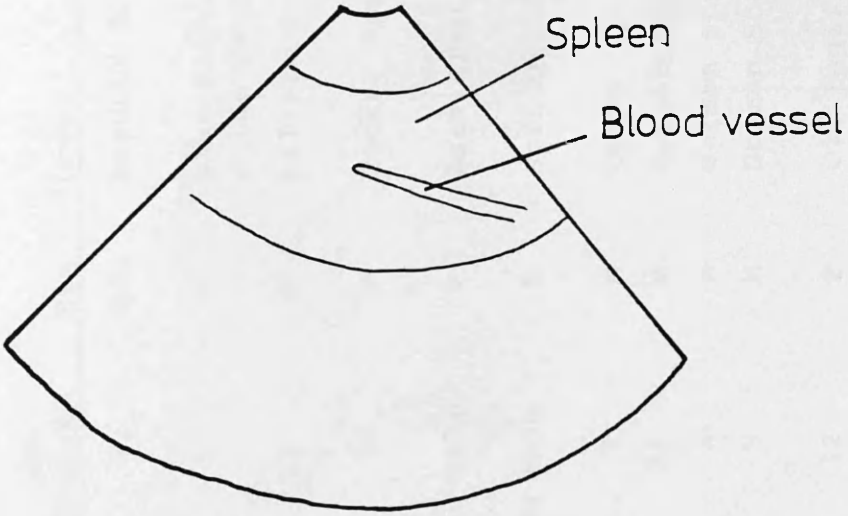


TABLE 8 : SUMMARY OF THE INDICATIONS FOR SPLENIC ULTRASONOGRAPHY AND THE FINAL DIAGNOSIS IN 16 CASES WHICH HAD NORMAL SPLENIC ULTRASONOGRAPHIC FINDINGS

Case No.	Age (Years)	Sex	*Breed	Indication for Splenic Ultrasonography	Diagnosis
1	9	F/S	Bassett Hound	Possible metastases	Gastric carcinoma, no metastases
2	5	M	West Highland White Terrier	Radiographic cranial abdominal mass	Hepatic neoplasia
3	13	F	Maltese Terrier	Non-specific signs, routine abdominal exam+	Hepatic cysts
6	9	F	Cocker Spaniel	Hepatic dysfunction, routine abdominal exam	Hepatic cirrhosis
7	18 mths	F	Lasa Apso	Hepatic dysfunction, routine abdominal exam	Portosystemic shunt
8	14 mths	M	Springer Spaniel	Hepatic dysfunction, routine abdominal exam	Portosystemic shunt
9	3	M	Cairn	Routine abdominal exam	Diabetes mellitus
18	11	M	German Shepherd	Routine abdominal exam	Paraprostatic cyst
20	4	M	German Shepherd	Routine abdominal exam	Anal gland tumour
21	9	M	German Shepherd	Possible metastases	Prostatic adeno-carcinoma
26	12	F	Old English Sheepdog	Possible metastases	Thyroid carcinoma, no metastases
27	10	F/S	Cross	Non-specific routine abdominal examination	Myositis

TABLE 8 (Cont'd)

Case No.	Age (Years)	Sex	*Breed	Indication for Splenic Ultrasonography	Diagnosis
35	5	M	Springer Spaniel	Anorexia, halitosis, routine abdominal exam	No diagnosis
36	11	M	Cocker Spaniel	Routine abdominal exam	Pharyngeal paralysis
38	6 mths	F	Labrador	Routine abdominal exam	Incontinence
39	9	M	Shetland Collie	Non-specific, routine abdominal examination	Pancreatitis

* M = Male, F = Female, F/S = Female, spayed

\+ Routine abdominal exam indicates that there was no specific indication for splenic ultrasonography but the examination was performed routinely during the examination of the other abdominal organs.

summarised in Table 9. In 13 of these cases, the examination was performed during the examination of other abdominal organs.

Table 10 summarises the ultrasonographic findings and diagnosis in the four cases of splenic disease included in this study. Case reports were prepared for each case of splenic disease which included clinical, laboratory, radiographic and ultrasonographic findings and the diagnosis and pathological findings where appropriate. For the purpose of conciseness, only those details which were considered to have been useful in reaching or confirming the diagnosis in each case have been included and some ancillary data have been omitted.

3:3 ASSESSMENT OF ACCURACY OF ULTRASONOGRAPHIC DETERMINATION OF OVINE FOETAL NUMBERS BY INEXPERIENCED AND EXPERIENCED OPERATORS AT VARIOUS STAGES OF GESTATION.

The accuracy of detection of pregnancy and determination of foetal numbers by both operators at different stages of gestation is presented in Tables 11 to 16. The accuracy of detection of pregnancy and determination of foetal number through gestation of the inexperienced and experienced operator is presented in Tables 17 and 18, respectively. The composite result of every scan made in this study is presented in Table 19. For comparison, the scanning accuracy achieved by the West of Scotland Agricultural College for the season 1985-86 is presented

TABLE 9 : SUMMARY OF THE INDICATIONS FOR SPLENIC ULTRASONOGRAPHY IN 19 DOGS AND ONE HORSE

Splenic Ultrasonography	Case No.	Radiographic or Palpable abdominal Mass	Possible Metastases	Radiographic Splenomegal	Routine* Abdominal Examination
Normal	1		1		
	2	1			
	3				1
	6				1
	7				1
	8				1
	9				1
	18				1
	20				1
	21		1		
	26		1		
	27				1
	35				1
	36				1
	38				1
	39				1
Abnormal	13		1	1	
	14	1			
	15	1			
	16	1			
TOTAL (+)		4 (3)	4 (1)	1 (1)	12 (0)

+ Number in which splenic ultrasonography was abnormal

* Routine abdominal examination indicates that there was not a specific indication for splenic ultrasonography but the examination was performed routinely during the examination of the other abdominal organs.

TABLE 10 : SUMMARY OF ULTRASONOGRAPHIC FINDINGS IN FOUR CASES OF SPLENIC DISEASE

Ultrasonographic Findings	Case No.	Diagnosis
Diffuse reduction in echogenicity with localised anechoic areas	13	Lymphoblastic leukaemia
Localised multiple anechoic areas surrounded by hyperechoic septae	14, 15	Splenic haemangiosarcoma
Localised mass composed of hyperechoic foci with anechoic areas	16	Splenic lymphosarcoma

TABLE 11 : THE ACCURACY OF DETERMINATION OF OVINE FOETAL NUMBERS BY THE INEXPERIENCED OPERATOR AT DAYS 40-43 OF GESTATION

		Lambing Number 0	1	2	3	4	Total
	0						
Scanning	1		7	9			16
Litter	2		4	18	2		24
Size	3		1	3			4
	4						
	Total		12	30	2		44

Proportion where:	Method One					Method Two
Scan correct	None	0.33	0.50	0	None	0.57
Scan was under	None	0.43	0.31	0.33	None	0.25
Scan was over	None	0.24	0.19	0.67	None	0.18

	Barren	Single	Multiple	
Scan correct	None	0.33	0.62	0.68
Scan was under	None	0.43	0.24	0.20
Scan was over	None	0.24	0.14	0.11

TABLE 12 : THE ACCURACY OF DETERMINATION OF OVINE FOETAL NUMBERS BY THE INEXPERIENCED OPERATOR AT DAYS 57-62 OF GESTATION

		Lambing Number					
		0	1	2	3	4	Total
	0						
Scanning	1		8	5			13
Litter	2			18			18
Size	3			1	1		2
	4						
	Total		8	24	1		33

Proportion where:	Method One					Method Two
Scan correct	None	0.62	0.75	0.50	None	0.82
Scan was under	None	0.33	0.21	0.00	None	0.15
Scan was over	None	0.00	0.04	0.50	None	0.03
	Barren	Single	Multiple			
Scan correct	None	0.62	0.80			0,85
Scan was under	None	0.38	0.20			0.15
Scan was over	None	0.00	0.00			0.00

TABLE 13 : THE ACCURACY OF DETERMINATION OF OVINE FOETAL NUMBERS BY THE EXPERIENCED OPERATOR AT DAYS 57-62 OF GESTATION

		Lambing Number					
		0	1	2	3	4	Total
	0						
Scanning	1		4				4
Litter	2			7			7
Size	3				1		1
	4						
	Total		4	7	1		12

Proportion where:	Method One					Method Two
Scan correct	None	1.00	1.00	1.00	None	1.00
Scan was under	None	0.00	0.00	0.00	None	0.00
Scan was over	None	0.00	0.00	0.00	None	0.00

	Barren	Single	Multiple	
Scan correct	None	1.00	1.00	1.00
Scan was under	None	0.00	0.00	0.00
Scan was over	None	0.00	0.00	0.00

TABLE 14 : **THE ACCURACY OF DETERMINATION OF OVINE FOETAL NUMBERS BY BOTH OPERATORS**

AT DAYS 57 — 62 OF GESTATION

		Lambing Number					
		0	1	2	3	4	Total
	0						
Scanning	1		12	5			17
Litter	2			25			25
Size	3			1	2		3
	4						
	Total		12	31	2		

Proportion where:	Method One					Method Two
Scan correct	None	0.70	0.80	0.66	None	0.86
Scan was under	None	0.29	0.16	0.00	None	0.11
Scan was over	None	0.00	0.03	0.33	None	0.02
	Barren	Single	Multiple			
Scan correct	None	0.70	0.82			0.86
Scan was under	None	0.29	0.15			0.11
Scan was over	None	0.00	0.03			0.02

TABLE 15 : THE ACCURACY OF DETERMINATION OF OVINE FOETAL NUMBER BY THE EXPERIENCED OPERATOR AT DAYS 78 — 83 OF GESTATION

		Lambing Number					
		0	1	2	3	4	Total
	0						
Scanning	1		10	1			11
Litter	2		2	25	1		28
Size	3			5	1		6
	4						
	Total						

Proportion where:	Method One					Method Two
Scan correct	None	0.77	0.74	0.14	None	0.80
Scan was under	None	0.08	0.06	0.14	None	0.04
Scan was over	None	0.15	0.21	0.71	None	0.16
	Barren	Single	Multiple			
Scan correct	None	0.77	0.91			0.93
Scan was under	None	0.08	0.03			0.02
Scan was over	None	0.15	0.06			0.04

TABLE 16 : THE ACCURACY OF DETERMINATION OF FOETAL OVINE NUMBER BY THE EXPERIENCED OPERATOR AT DAYS 106 — 107 OF GESTATION

		Lambing Number					
		0	1	2	3	4	Total
	0						
Scanning	1		8		1		9
Litter	2			24			24
Size	3						
	4						
	Total		8	24	1		33

Proportion where:		Method One				Method Two
Scan correct	None	0.89	1.00	0.00	None	0.91
Scan was under	None	0.11	0.00	1.00	None	0.08
Scan was over	None	0.00	0.00	0.00	None	0.00

	Barren	Single	Multiple	
Scan correct	None	0.89	0.96	0.97
Scan was under	None	0.11	0.04	0.03
Scan was over	None	0.00	0.00	0.00

TABLE 17 : THE ACCURACY OF DETERMINATION OF OVINE FOETAL NUMBERS BY THE INEXPERIENCED OPERATOR FROM DAYS 40 — 107 OF GESTATION

		Lambing Number					
		0	1	2	3	4	Total
	0						
Scanning	1		15	14			29
Litter	2		4	36	2		42
Size	3		1	4	1		6
	4						
	Total		20	54	3		77

Proportion where:	Method One					Method Two
Scan correct	None	0.44	0.60	0.13	None	0.68
Scan was under	None	0.41	0.27	0.25	None	0.21
Scan was over	None	0.15	0.13	0.63	None	0.12
	Barren	Single	Multiple			
Scan correct	None	0.44	0.69			0.75
Scan was under	None	0.41	0.23			0.18
Scan was over	None	0.15	0.08			0.06

TABLE 18 : THE ACCURACY OF DETERMINATION OF OVINE FOETAL NUMBER BY THE EXPERIENCED OPERATOR FROM DAYS 40 — 107 OF GESTATION

		Lambing Number					
		0	1	2	3	4	Total
	0						
Scanning	1		22	1	1		24
Litter	2		2	56	1		59
Size	3			5	2		7
	4						
	Total		24	62	4		90
Proportion shere:		Method One					Method Two
Scan correct		None	0.85	0.86	0.22	None	0.89
Scan was under		None	0.08	0.03	0.22	None	0.03
Scan was over		None	0.08	0.11	0.56	None	0.08
		Barren	Single	Multiple			
Scan correct		None	0.85	0.94			0.96
Scan was under		None	0.08	0.03			0.02
Scan was over		None	0.08	0.03			0.02

TABLE 19 : THE ACCURACY OF DETERMINATION OF OVINE FOETAL NUMBERS BY THE INEXPERIENCED AND EXPERIENCED OPERATORS FROM DAYS 40 — 107 OF GESTATION

		Lambing Number					
		0	1	2	3	4	Total
	0						
Scanning	1		37	15	1		53
Litter	2		5	92	3		100
Size	3		1	9	3		13
	4						
	Total		43	116	7		166
Proportion where:			Method One				Method Two
Scan correct		None	0.63	0.74	0.18	None	0.80
Scan was under		None	0.27	0.15	0.24	None	0.11
Scan was over		None	0.10	0.11	0.59	None	0.89
		Barren	Single	Multiple			
Scan correct		None	0.63	0.83			0.87
Scan was under		None	0.27	0.12			0.10
Scan was over		None	0.10	0.05			0.04

in Table 20.

The above results are also presented graphically and are grouped as follows; variations in operator efficiency in overall accuracy, single, twin, triplet and multiple detection (Figs. 11-15); variations in relation to gestation age in overall accuracy, single, twin, triplet and multiple detection accuracy (Figs. 16-20).

3:4 ASSESSMENT OF THE SENSITIVITY OF ULTRASONOGRAPHIC DETERMINATION OF CANINE AND FELINE PREGNANCY AND FOETAL NUMBERS.

Seventeen of the 36 bitches and one of the four cats were found to be non-pregnant. The earliest correct diagnosis was made at day 23 of gestation. At that stage only the amniotic sac and foetal mass were visible. By day 29 pulsating umbilical vessels were apparent (Fig. 21). The earliest recorded detection of a beating foetal heart was at day 33 although in three bitches scanned at day 34, 35 (Fig. 22) and 36 respectively, this could not be discerned. From day 39 onwards this finding was consistent. In later gestation details of foetal skulls, individual limbs and abdominal organs could be distinguished (Fig. 23).

The average number of foetuses estimated ultrasonographically was 4.08. The actual number born was 5.434. The total number of accurate estimations of foetal numbers was seven out of 23 pregnancies (30.49%). Under-estimations were made in 14 cases (60.8%) and over-

TABLE 20 : <u>THE ACCURACY OF DETERMINATION OF OVINE FOETAL NUMBERS BY THE WEST OF SCOTLAND AGRICULTURAL COLLEGE FOR THE SEASON 1985-86</u>

		Lambing Number					
		0	1	2	3	4	Total
	0	141	3	2	1		147
Scanning	1	18	1,006	48	2		1,074
Litter	2	2	59	885	159	8	1,113
Size	3	1		34	120	10	165
	4						
	Total	162	1,068	969	282	18	2,499
Proportion where:		Method One					Method Two
Scan correct		0.84	0.89	0.74	0.37	0.00	0.86
Scan was under		0.04	0.05	0.18	0.53	1.00	0.09
Scan was over		0.13	0.07	0.08	0.11	0.00	0.05
		Barren	Single	Multiple			
Scan correct		0.84	0.89	0.91			0.95
Scan was under		0.04	0.05	0.04			0.02
Scan was over		0.13	0.07	0.05			0.03

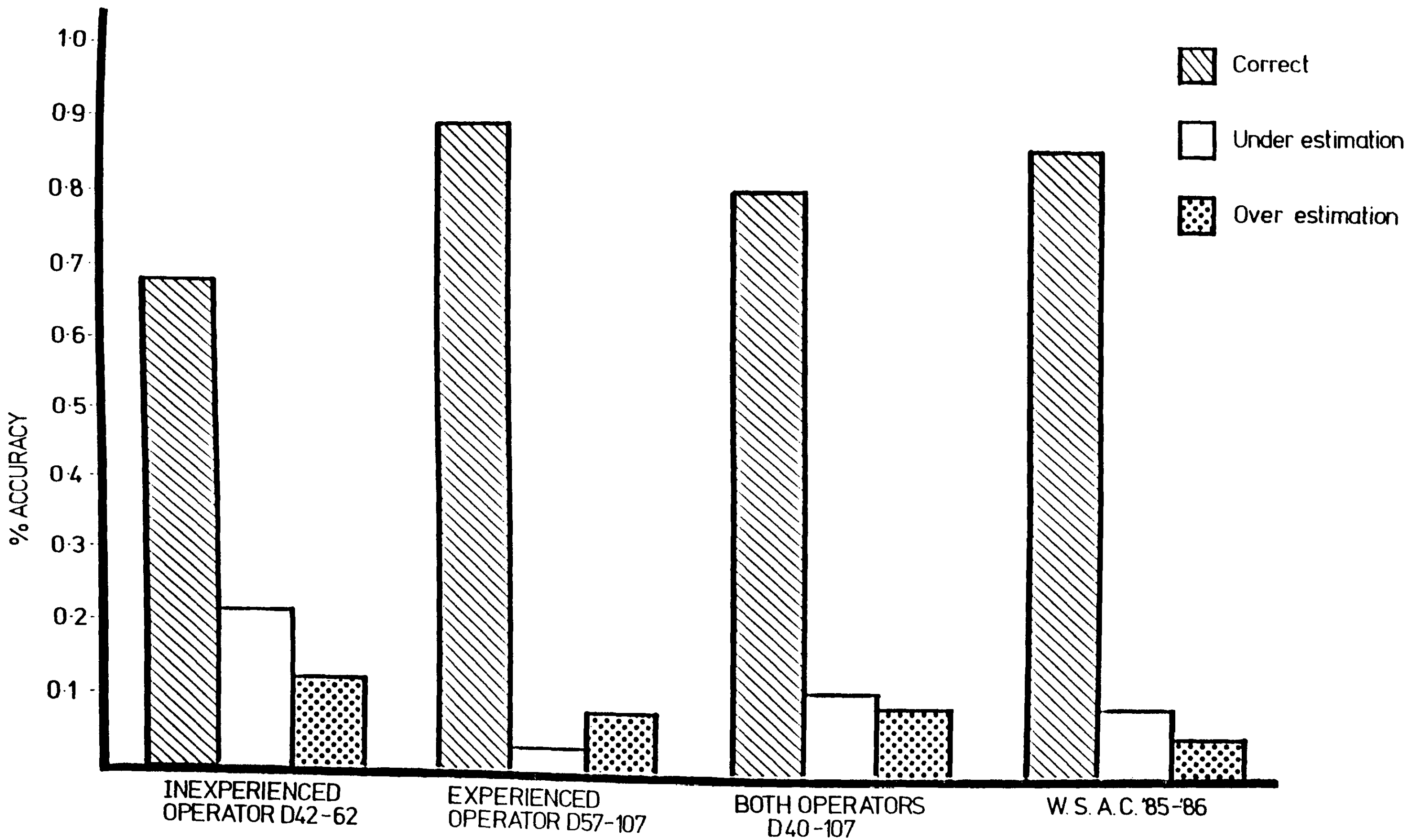


Fig. 11 The overall accuracy of ultrasonographic estimation of ovine foetal numbers by an inexperienced and experienced operator and results obtained by the West of Scotland Agricultural College (W.S.A.C.) during the season 1985-1986.

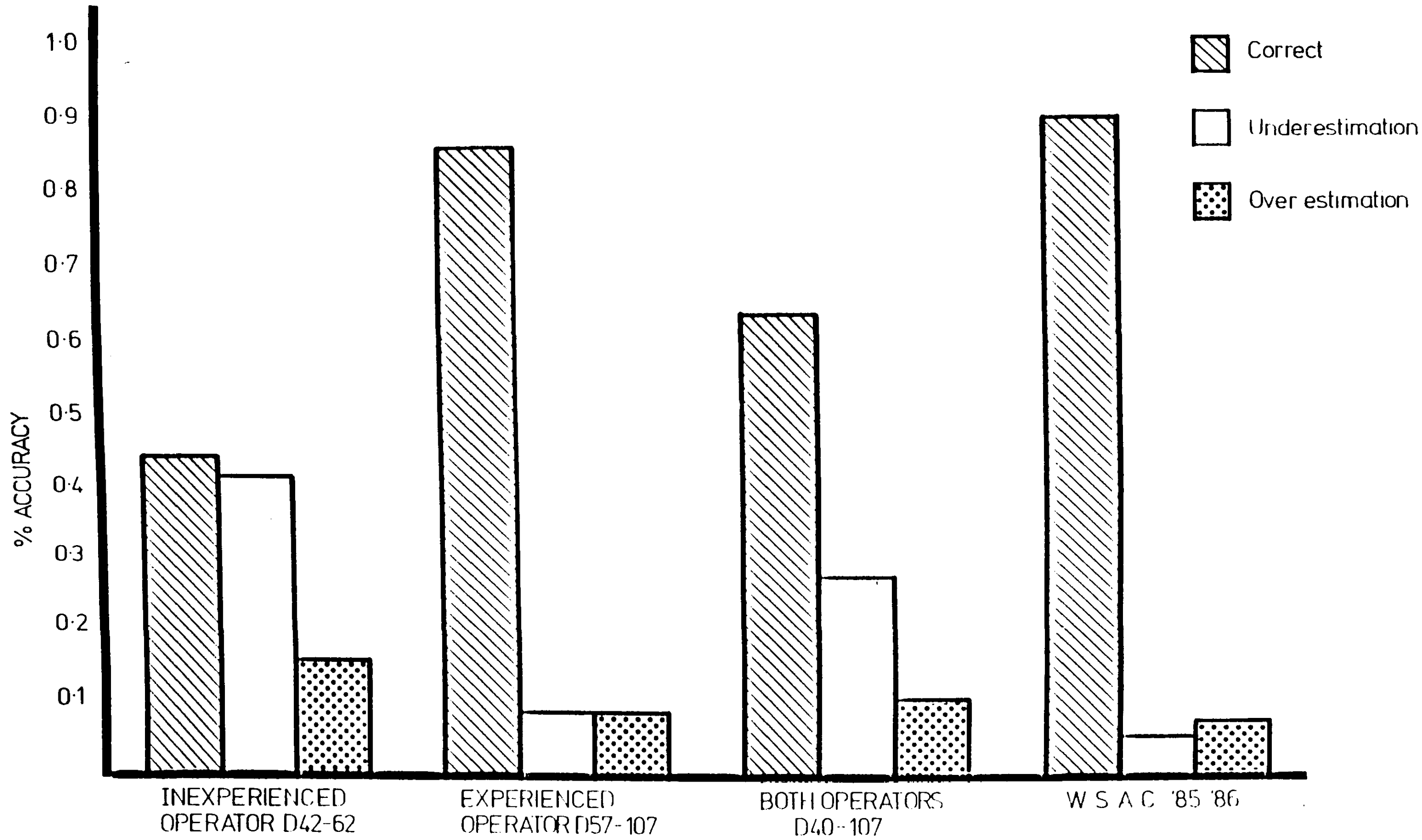


Fig. 12 The accuracy of ultrasonographic estimation of single ovine foetuses by an inexperienced and an experienced operator and the results obtained by the West of Scotland Agricultural College (W.S.A.C.) during the season 1985-1986.

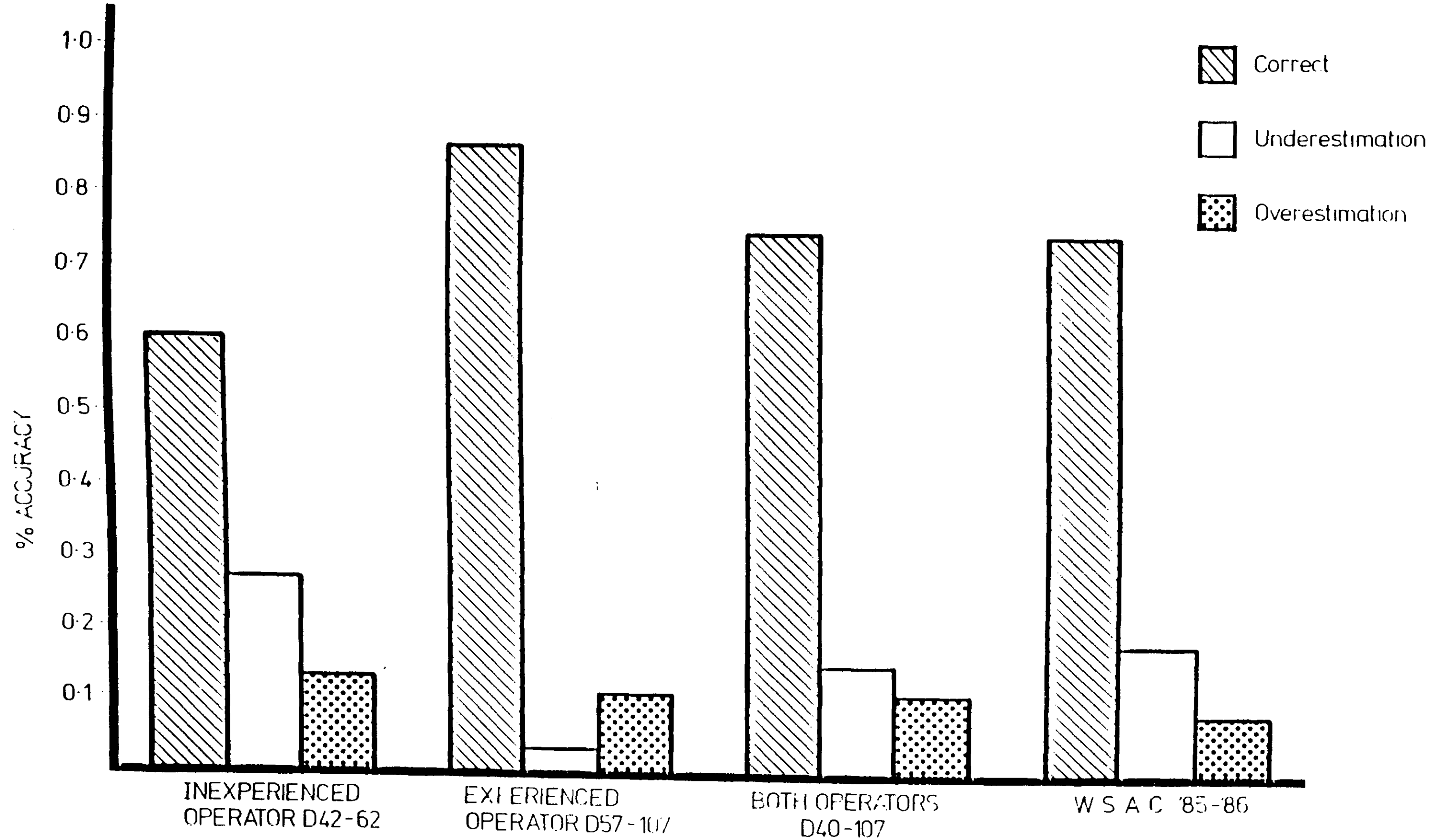


Fig. 13 The accuracy of ultrasonographic estimation of twin ovine foetuses by an inexperienced and experienced operator and the results obtained by the West of Scotland Agricultural College (W.S.A.C.) during the season 1985-1986.

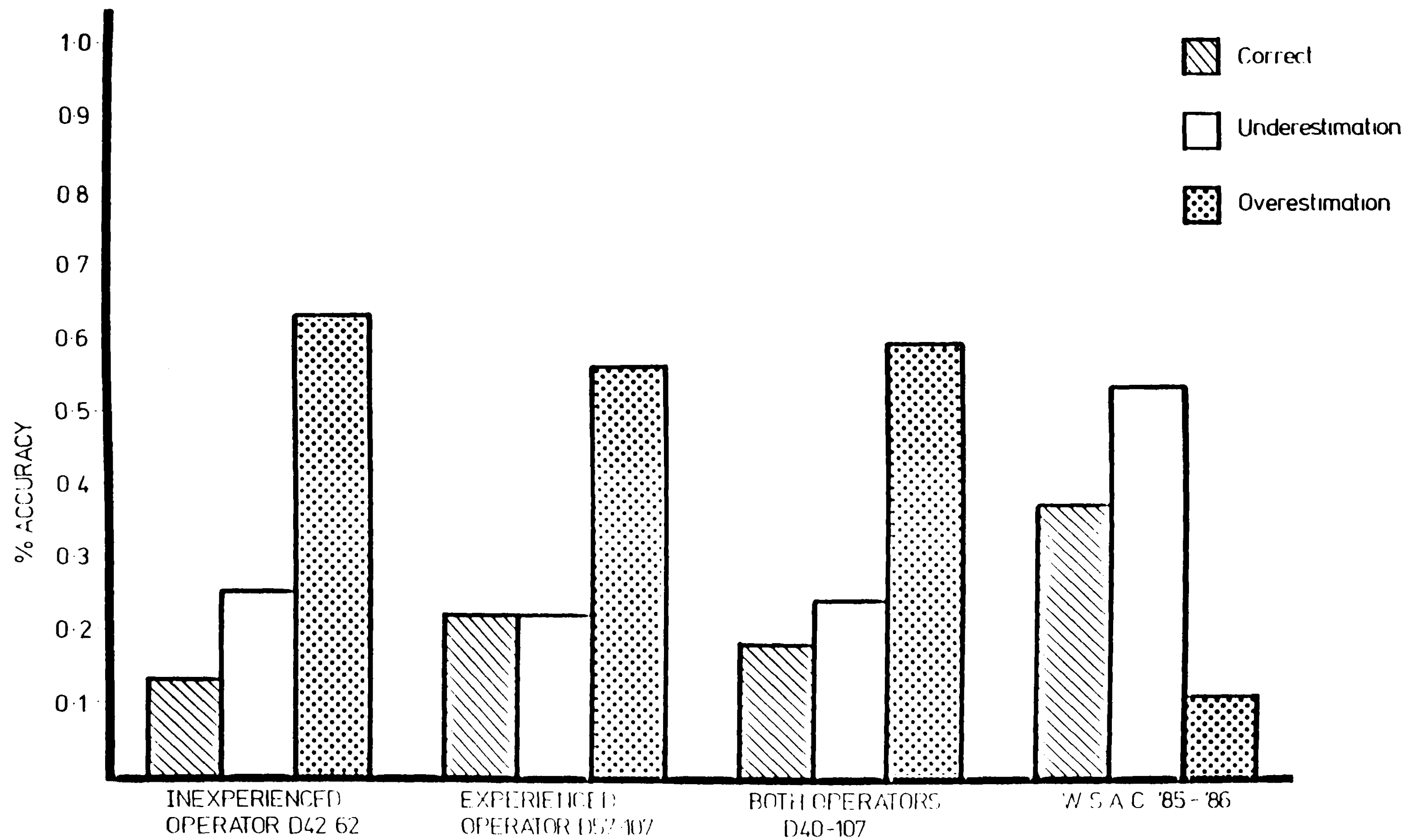


Fig. 14 The accuracy of ultrasonographic estimation of triplet ovine foetuses by an inexperienced and an experienced operator and the results obtained by the West of Scotland Agricultural College (W.S.A.C.) during the season 1985-1986.

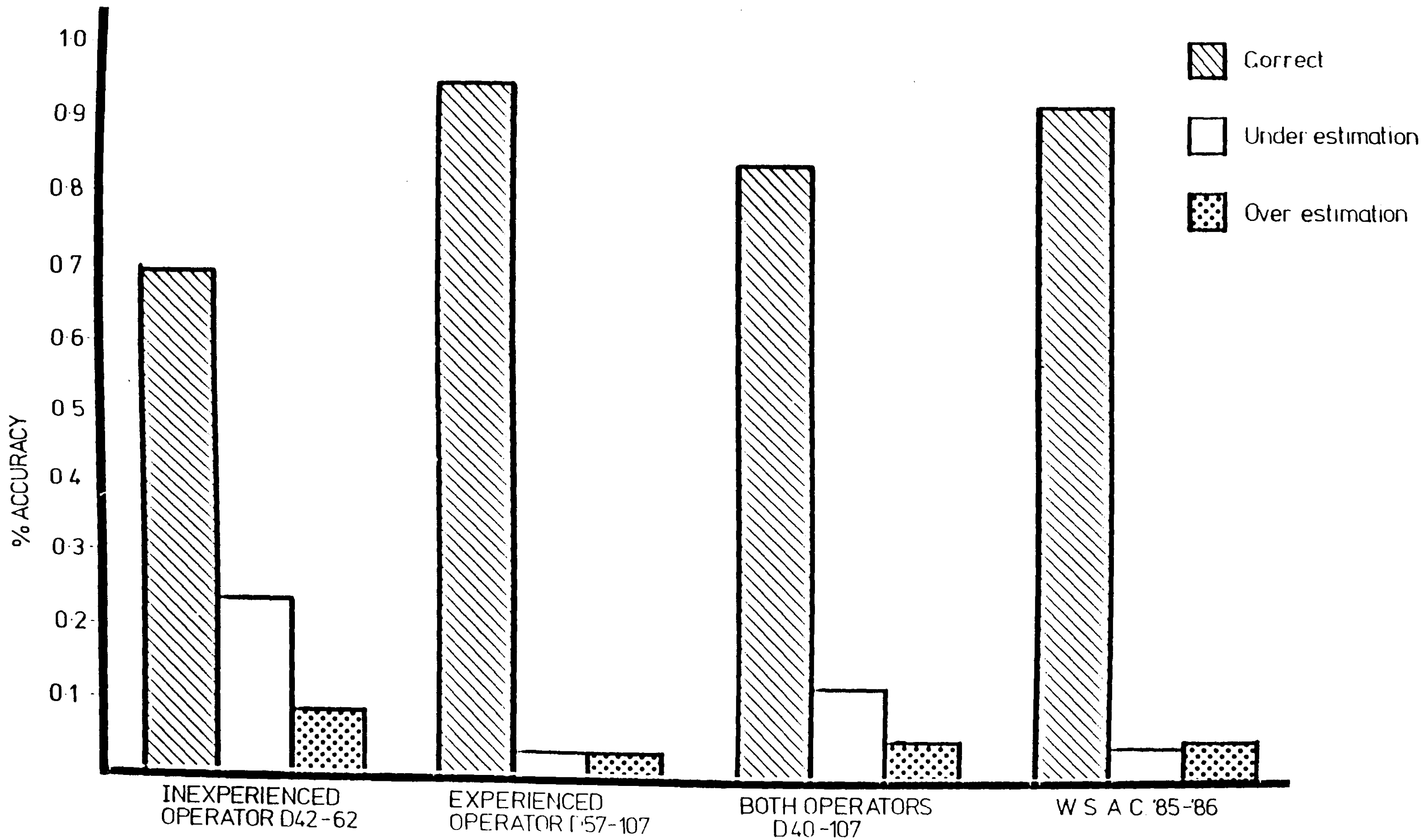


Fig. 15 The accuracy of ultrasonographic estimation of multiple ovine foetuses by an inexperienced and an experienced operator and the results obtained by the West of Scotland Agricultural College (W.S.A.C.) during the season 1985-1986.

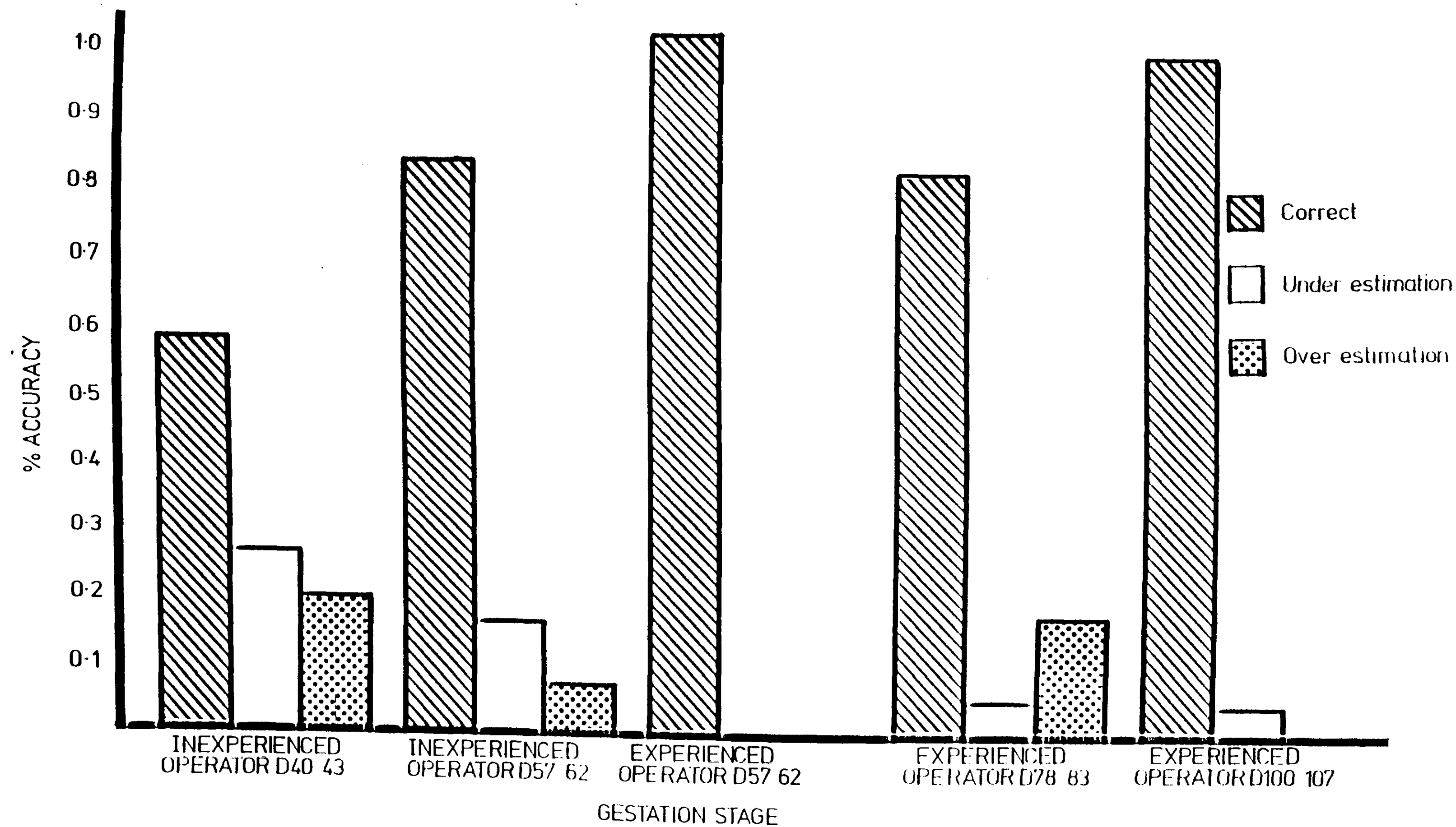


Fig. 16 The overall accuracy of ultrasonographic estimation of ovine foetal numbers at various stages of gestation.

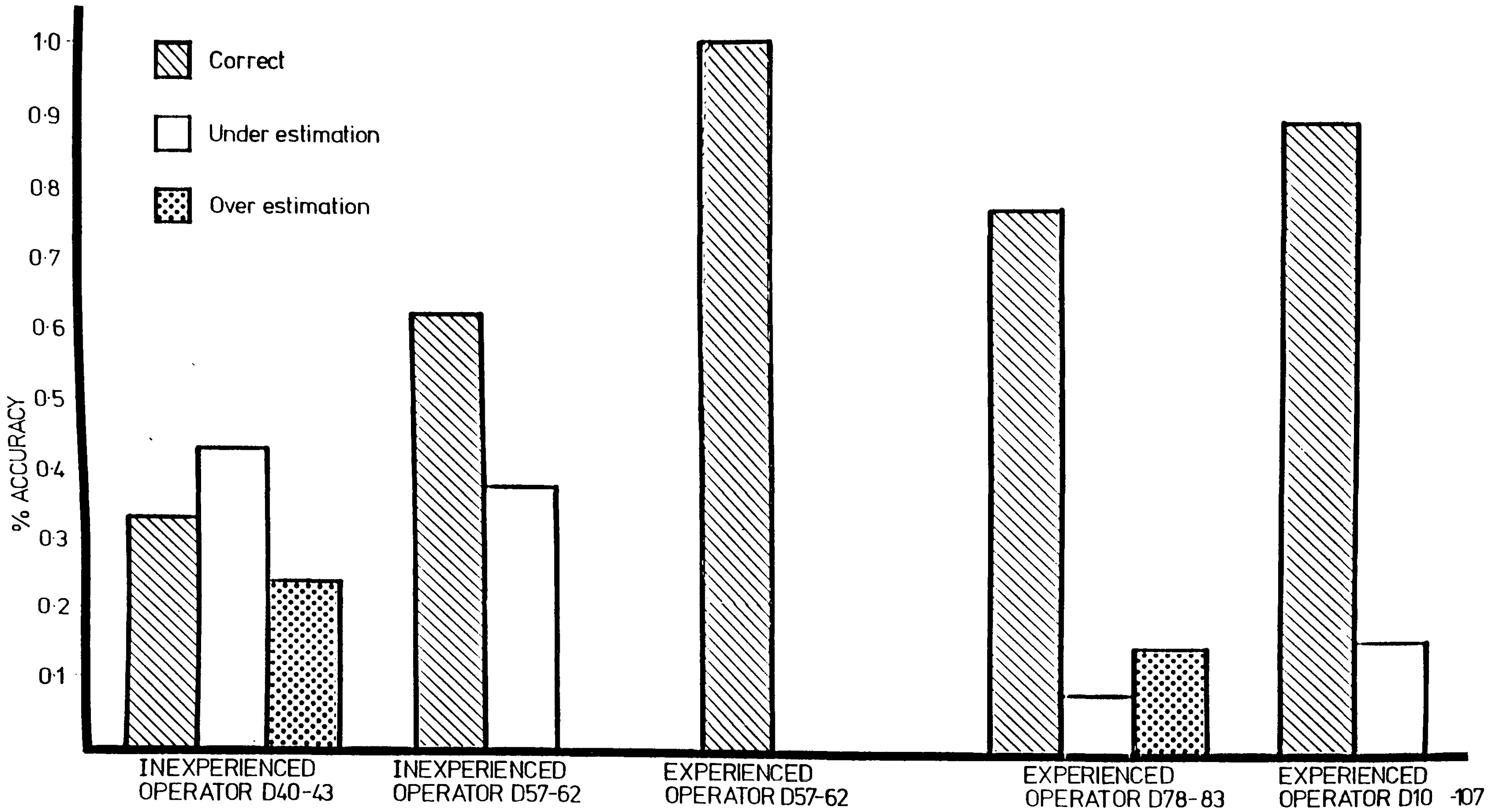


Fig. 17 The accuracy of ultrasonographic estimation of single ovine foetuses at various stages of gestation.

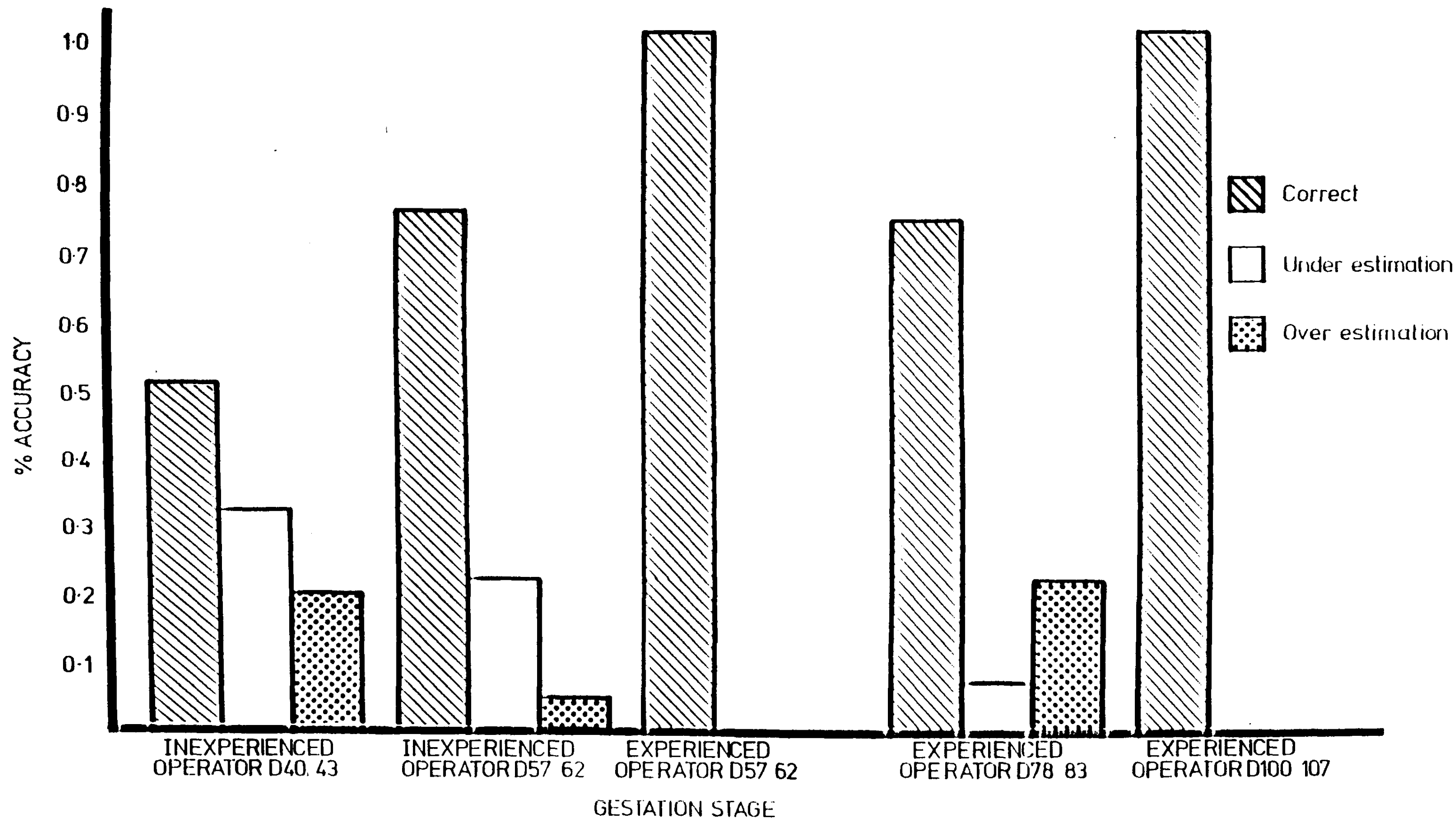


Fig. 18 The accuracy of ultrasonographic estimation of twin ovine foetuses at various stages of gestation.

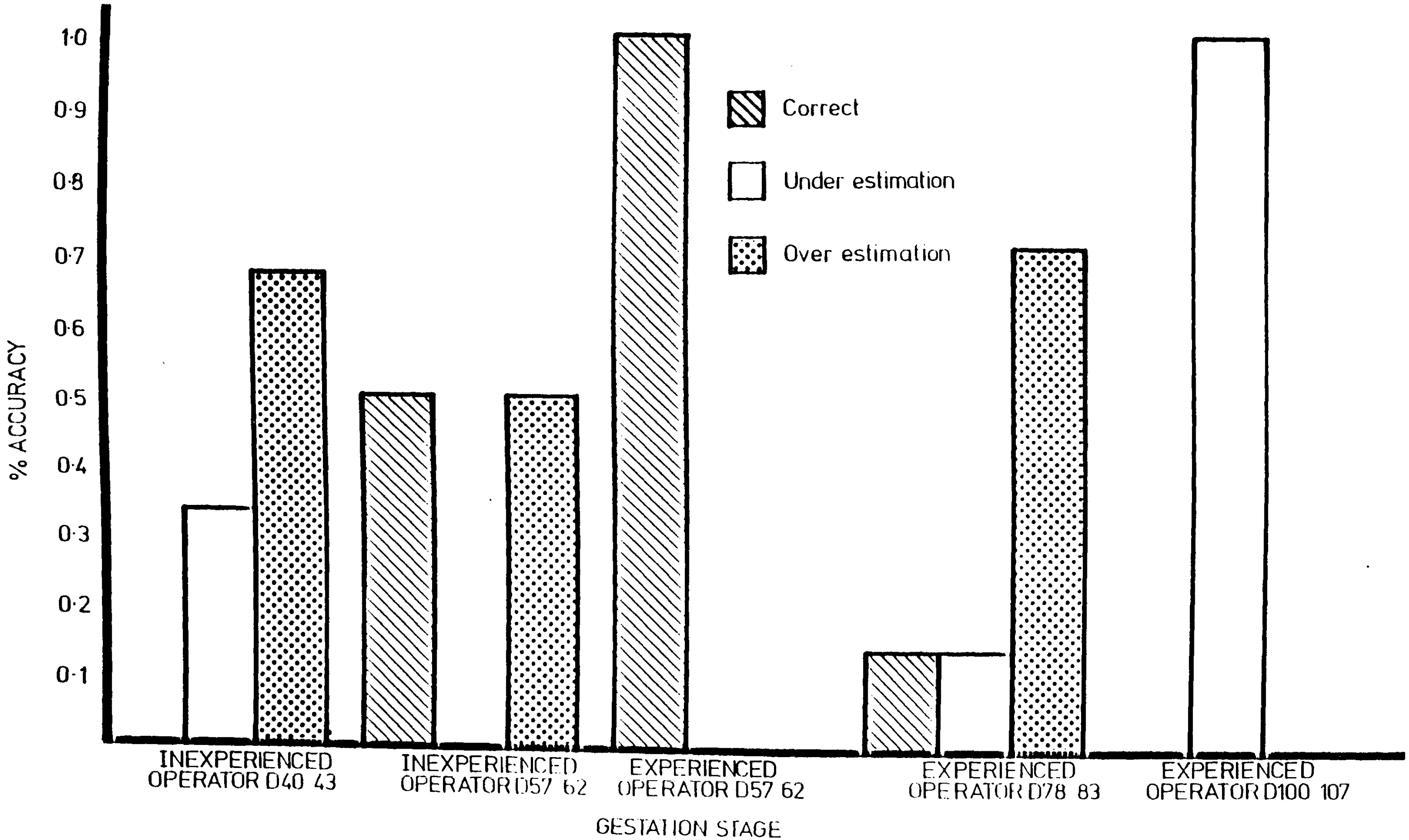


Fig. 19 The accuracy of ultrasonographic estimation of triplet ovine foetuses at various stages of gestation.

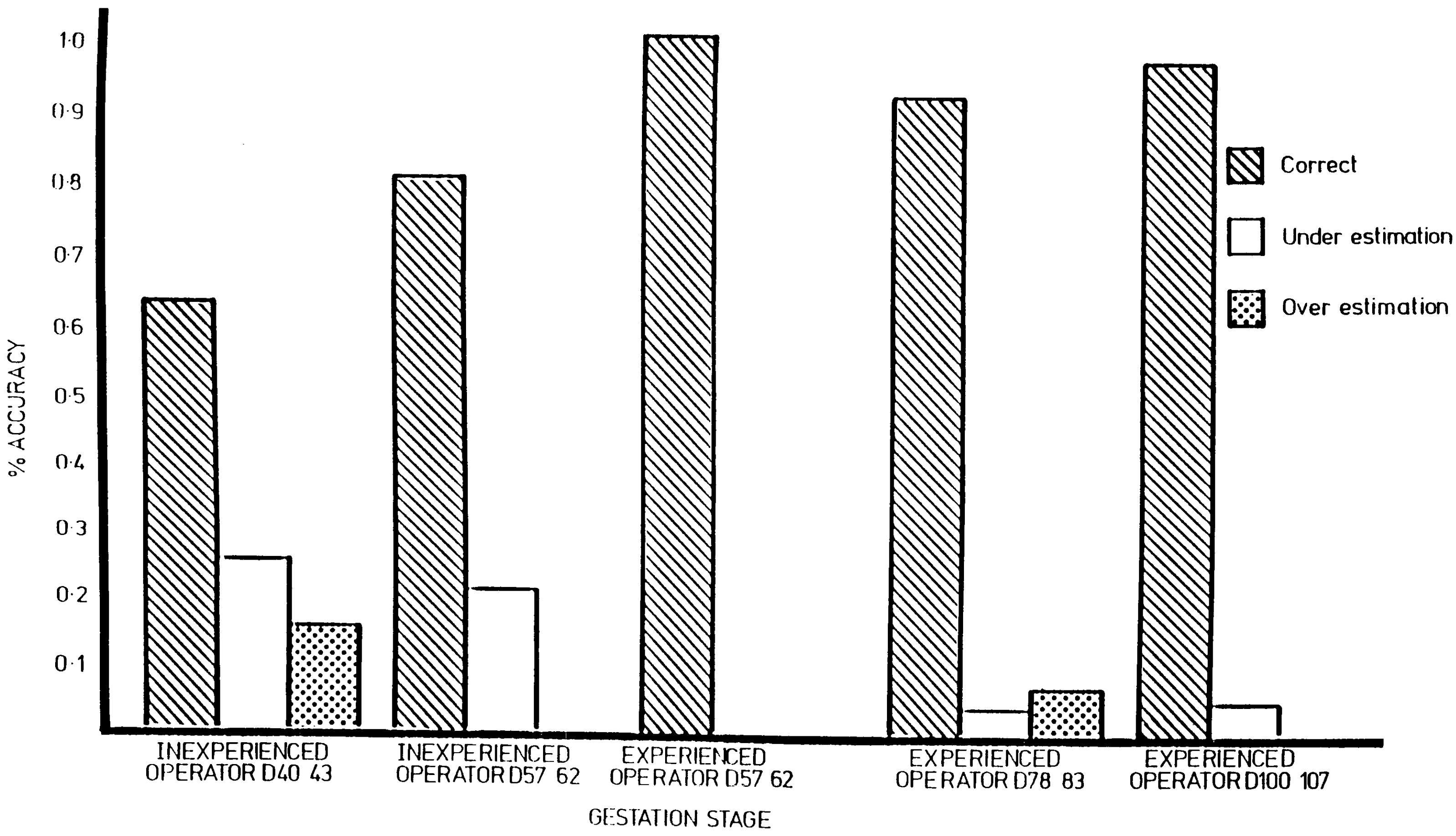
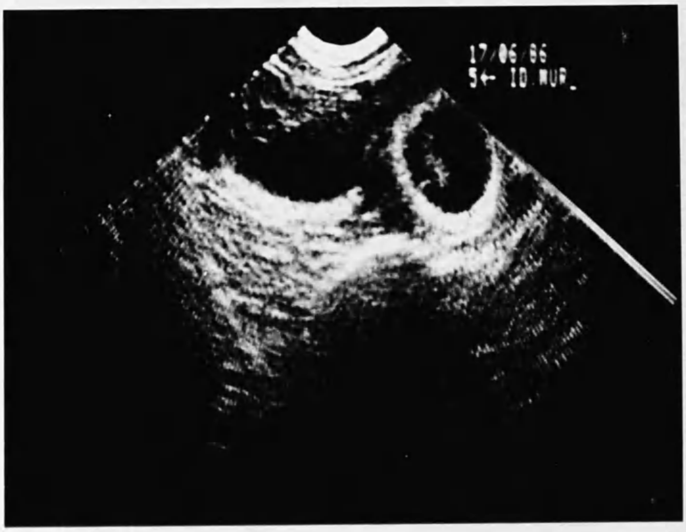


Fig. 20 The accuracy of ultrasonographic estimation of multiple ovine foetuses at various stages of gestation.

Fig. 21 An ultrasonograph of a canine foetus on the twenty-ninth day of gestation. The foetal mass lies within the amniotic vesicle and the placenta produces a distinct echogenic rim.



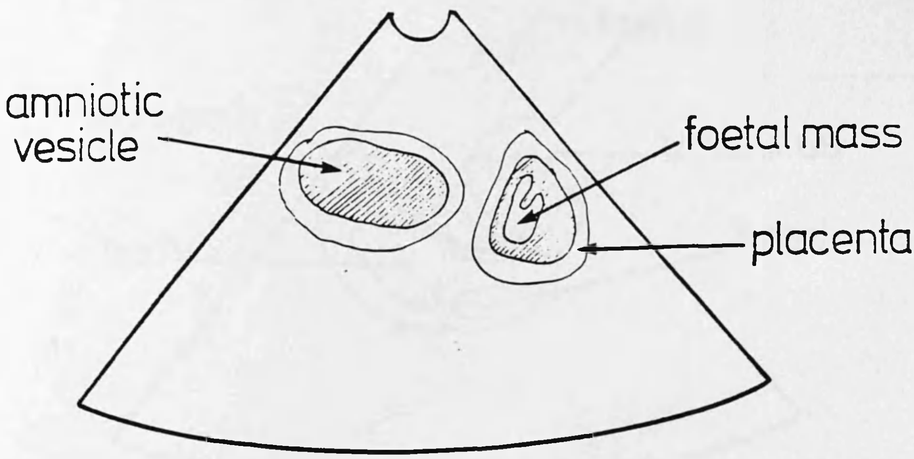
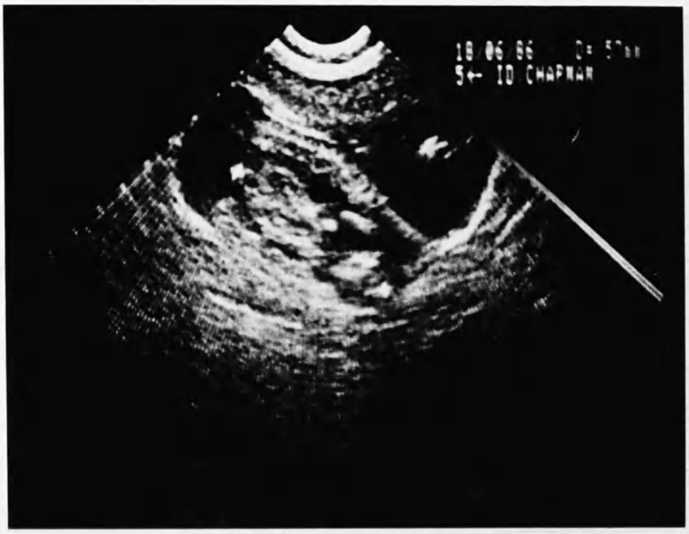


Fig. 22 An ultrasonograph of a canine foetus at the thirty-fifth day of gestation. The head, body and forelimb of the foetus and umbilical cord of another are apparent.



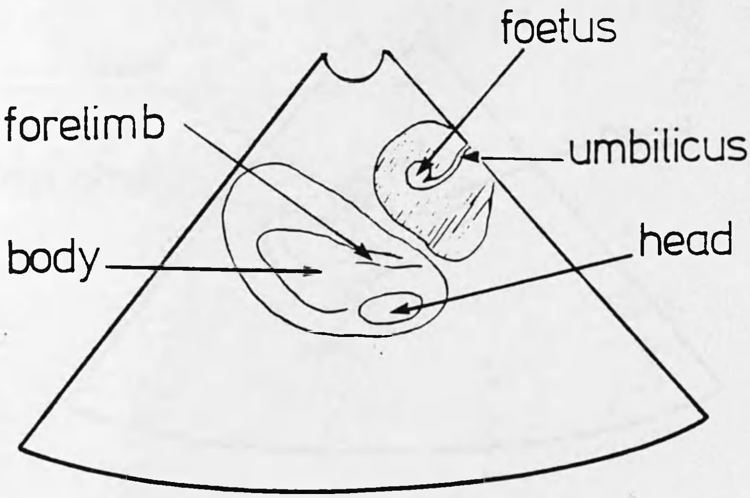
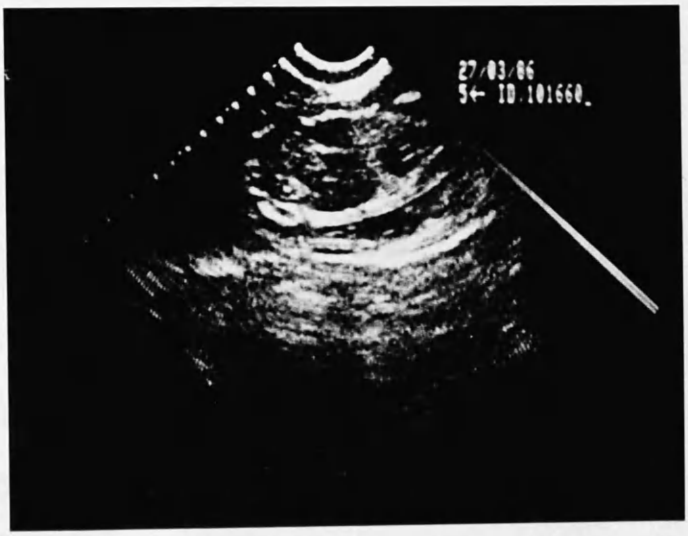
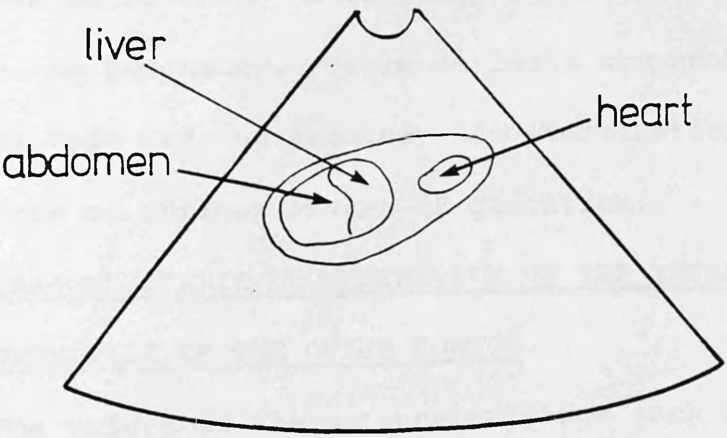


Fig. 23 An ultrasonograph of a canine foetus on the forty-ninth day of gestation. The thorax and abdomen are demonstrated. Within the thorax, the heart is evident and the liver is represented by a hypoechoic area within the abdomen.





estimations in two cases (8.69%). The feline foetus had a similar appearance to the canine foetus (Fig. 24).

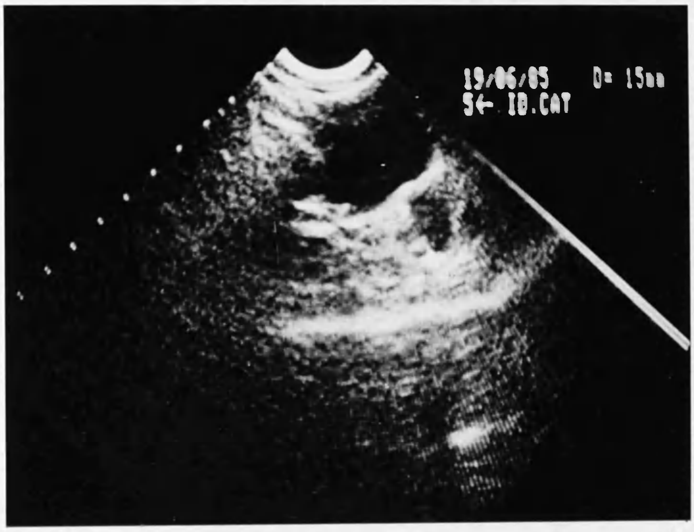
Figure 25 illustrates the incidence of each degree of error in the estimation of foetal number and the frequencies of accurate, over and under-estimations are demonstrated in Figure 26. The incidence of each degree of error relative to gestation stage is illustrated in Figure 27.

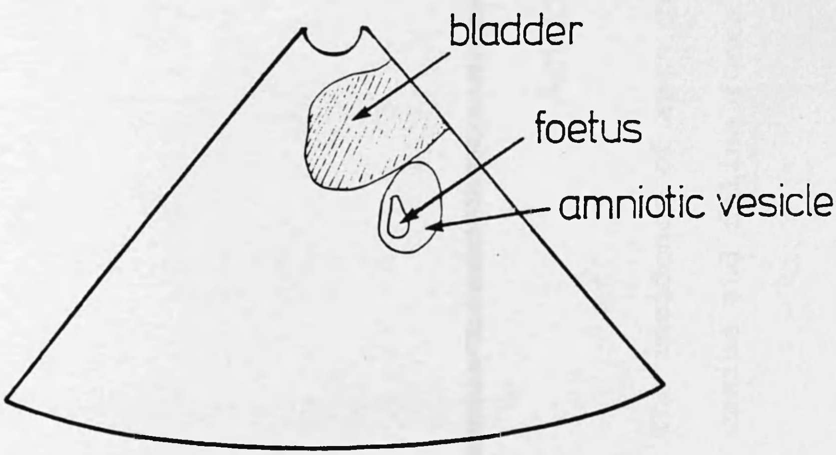
Table 21 lists the number of foetuses estimated ultrasonographically, the actual number born and the gestation stage at which the examination was made in each case. Table 22 lists the frequency of each litter size at birth and the sensitivity of ultrasonographic determination of each litter size and Table 23 indicates the accuracies of ultrasonographic determination of small, medium and large litters in 20 cases of canine pregnancy and three cases of feline pregnancy. Table 24 lists the number of examinations made and the accuracy of determination of foetal numbers at various stages of gestation.

3:5 ULTRASONOGRAPHIC DETERMINATION OF THE INTRAUTERINE GROWTH RATE OF THE OVINE FOETUS.

The values of the measurements for each foetus at various gestational ages and at birth are listed in Appendix 1. Appendices 2 and 3 record the date used for developing linear regressions for the logarithms of transthoracic and biparietal diameters.

Fig. 24 An ultrasonograph of a feline foetus on the twenty-third day of gestation. The bladder is represented by an anechoic area dorsal to which an amniotic vesicle is evident.





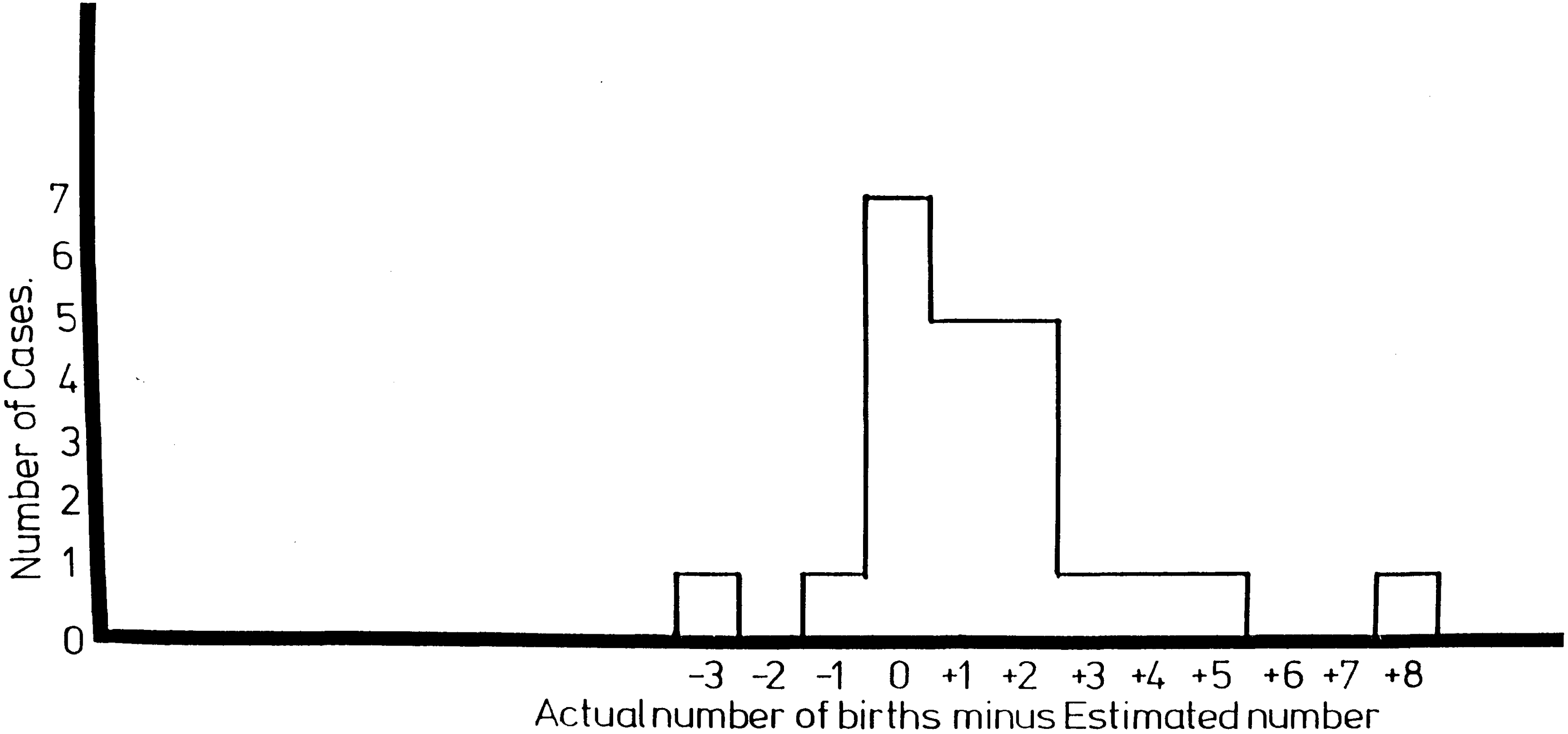


Fig. 25 The incidence of each degree of error in ultrasonographic estimation of canine and feline foetal number in 20 dogs and three cats.

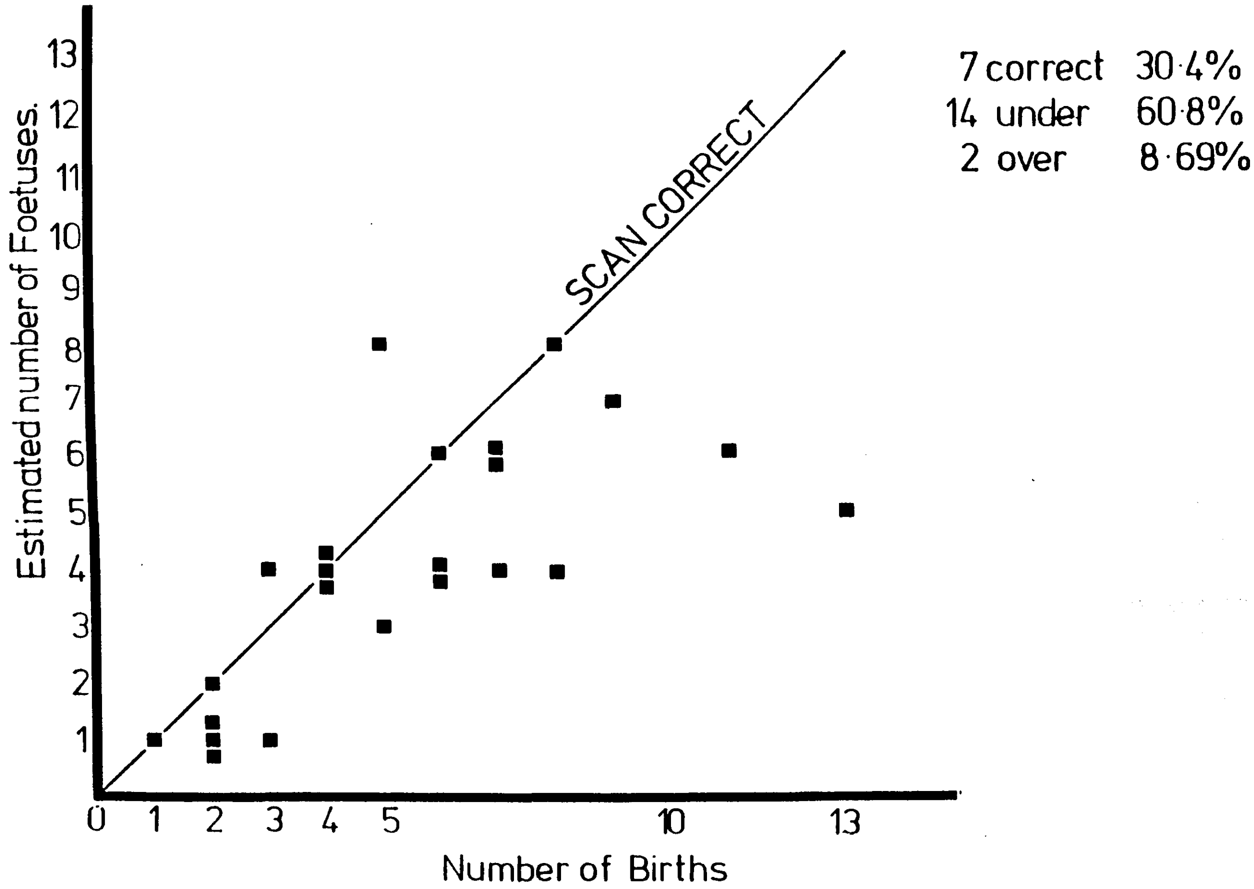


Fig. 26 The ultrasonographic estimation and actual litter size at birth of 20 canine pregnancies and three feline pregnancies.

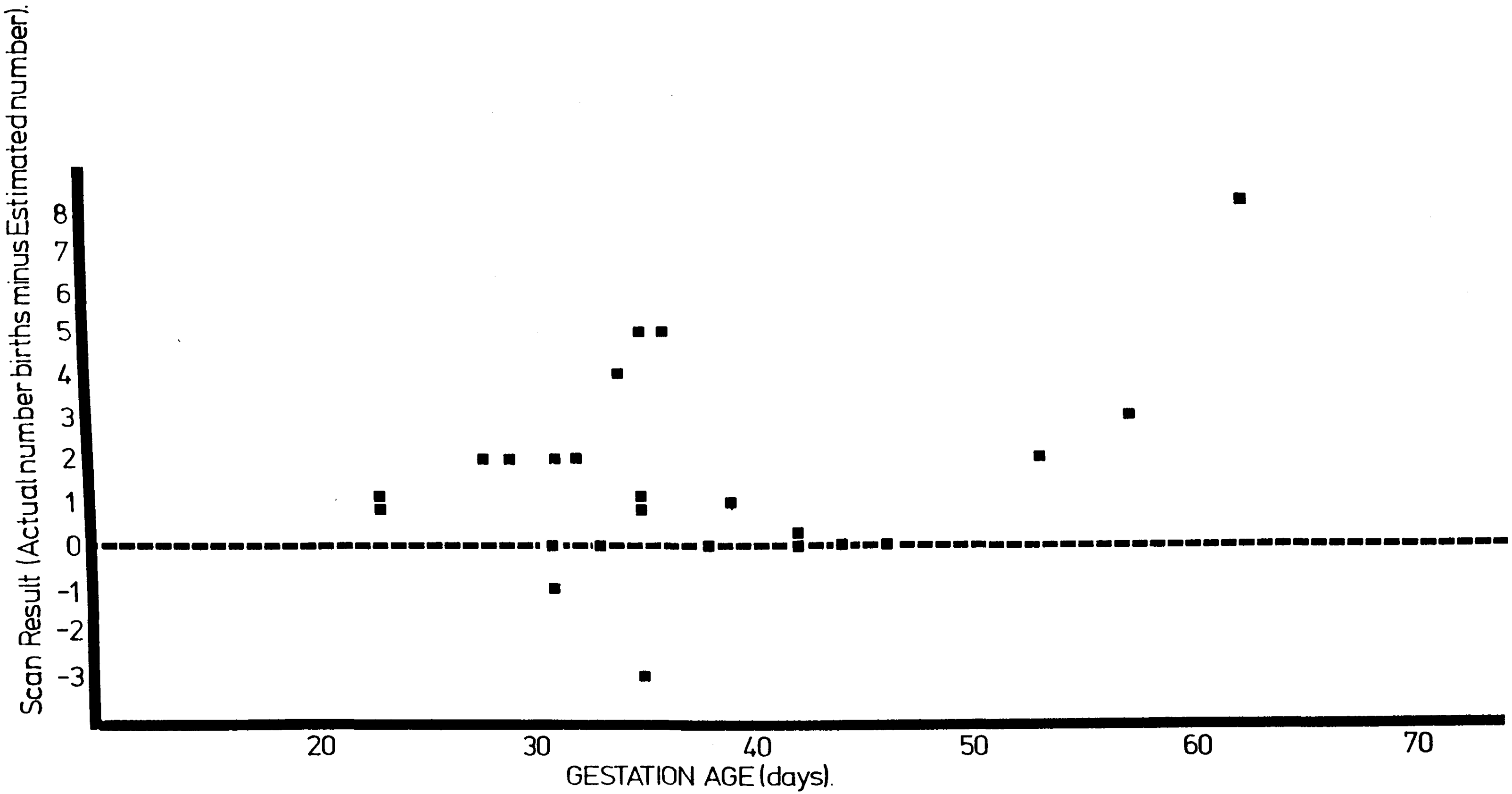


Fig. 27 The frequency of each degree of error in ultrasonographic estimation of canine and feline foetal number at various stages of gestation.

TABLE 21 : THE ESTIMATED AND ACTUAL FOETAL NUMBER IN 20 CASES OF CANINE PREGNANCY AND THREE CASES OF FELINE PREGNANCY

Case No.	Day of Gestation	Estimated No. of Foetuses	Actual Litter Size at Birth
BITCHES			
1	29	1	3
2	35	6	7
3	32	7	9
4	28	4	6
5	31	3	5
6	39	6	7
7	57	4	7
8	62	5	13
9	35	8	5
10	44	8	8
11	31	2	2
12	31	4	3
13	46	1	1
14	33	6	6
15	53	4	6
16	23	1	2
17	42	4	4
18	38	4	4
19	36	6	11
20	34	4	8
CATS			
1	23	1	2
2	42	4	4
3	35	1	2

TABLE 22 : A SUMMARY OF THE FREQUENCY AND SENSITIVITY OF DETECTION OF EACH LITTER SIZE IN 20 CASES OF CANINE PREGNANCY AND THREE CASES OF FELINE PREGNANCY

Litter Size	Frequency of Occurrence	Frequency of Correct Estimation	Sensitivity (%)		
1	1	1	100		
2	4	1	25		
3	2	0	0	41	
4	3	3	100		
5	2	0	0		
6	3	1	33		
7	3	0	0		30.4%
8	2	1	50		
9	1	0	0	18	
10	0	0	0		
11	1	0	0		
12	0	0	0		
13	1	0	0		

TABLE 23 : THE SENSITIVITY OF ESTIMATION OF LITTER SIZE WHICH WAS ACHIEVED, SMALL, MEDIUM AND LARGE LITTERS IN 20 CASES OF CANINE PREGNANCY AND THREE CASES OF FELINE PREGNANCY

	No. of Bitches	No of Correct Estimations	(%)
SMALL (1-3 births)	7	2	28
MEDIUM (4-8 births)	13	5	38
LARGE (over 8 births)	3	0	0

TABLE 24 : THE NUMBER OF EXAMINATIONS MADE AND SENSITIVITY OF DETERMINATION OF FOETAL NUMBER AT VARIOUS STAGES OF GESTATION IN 20 CASES OF CANINE PREGNANCY AND THREE CASES OF FELINE PREGNANCY

Stage of Gestation (Days)	No. of Bitches	No. of Correct Estimations	Sensitivity (%)
23 - 29	4	0	0
30 - 36	10	2	20
37 - 43	4	3	75
44	4	0	0

The mean values of crown-rump length, transthoracic and biparietal diameters and the total number of measurements made at each gestation age selected are summarised in Table 25. This information is also presented graphically. Figure 28 illustrates the relationship between crown-rump length and gestation stage. Figure 29 illustrates the relationship between biparietal diameter and gestation stage. Figure 30 illustrates the relationship between transthoracic diameter and gestation stage. Logarithmic curves are the mean biparietal diameter and mean transthoracic diameter are demonstrated (Figs. 31, 32).

The regressions of transthoracic diameter and biparietal diameter, with formulae, the correlation coefficients and the 0.95 confidence limits are presented in Figures 33 and 34.

METHOD THREE:

Foetal age can be estimated by extrapolating from the y axis to the x axis. However, the width of the confidence bands is such that in making an estimate a very wide age range is produced.

METHOD FOUR:

Equations for estimating foetal age from foetal measurements which were developed are :

Transthoracic diameter

$$x \text{ (days)} = 101.95 \log y - 78.92 \; (\pm 21.48)$$

TABLE 25 : THE MEAN VALUE OF THE TRANSTHORACIC DIAMETER, CROWN-RUMP LENGTH AND BIPARIETAL DIAMETERS AT AROUND DAYS 40, 60, 80 AND 105 OF GESTATION AND AT BIRTH, OF ALL THE FOETUSES INCLUDED IN THIS STUDY

TRANSTHORACIC

DAY	40	60	80	105	B
n		16	65	42	70
MEAN		29	39.90	51.76	91.57

CROWN RUMP

DAY	40	60	80	105	B
n	29	10			70
MEAN	32.8	78			423.57

BIPARIETAL

DAY	40	60	80	105	B
n	1	11	31	30	70
MEAN	26	29.45	36.2	47.66	76.7

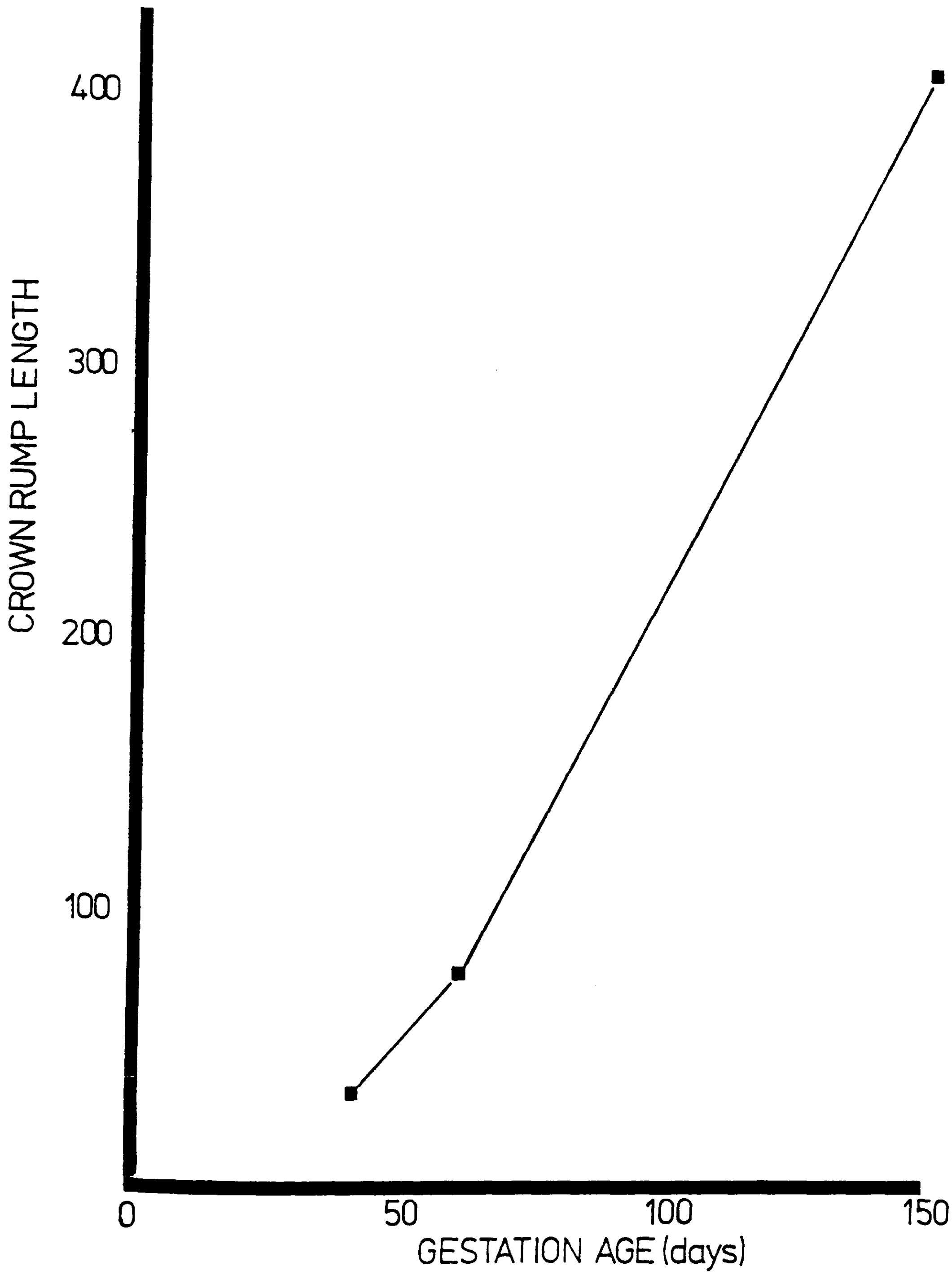
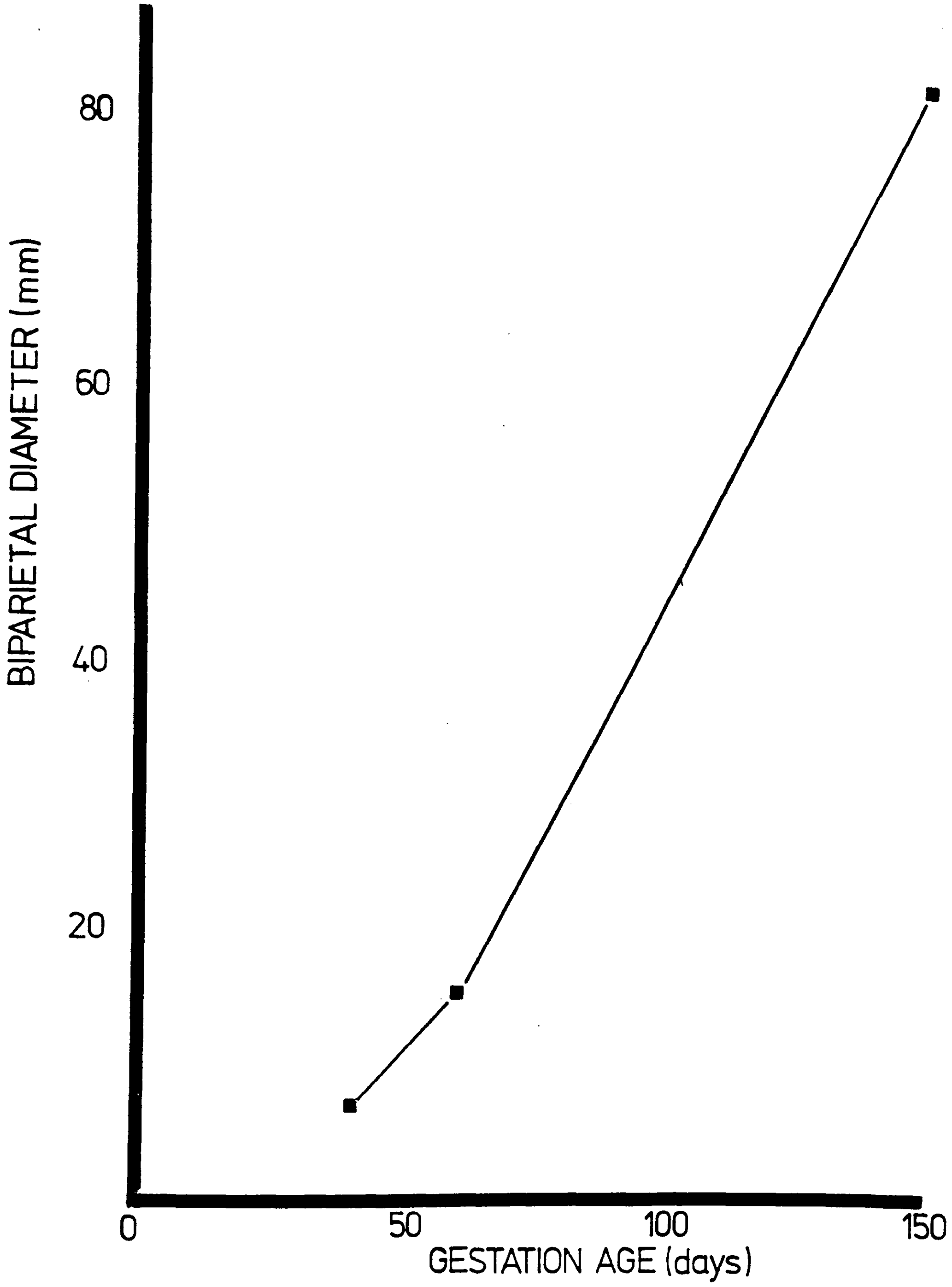


Fig. 28 The relationship between the mean crown-rump length and the gestational age in the foetuses of a group of 50 ewes.



Fir. 29 The relationship between the mean biparietal diameter and the gestational age in the foetuses of a group of 50 ewes.

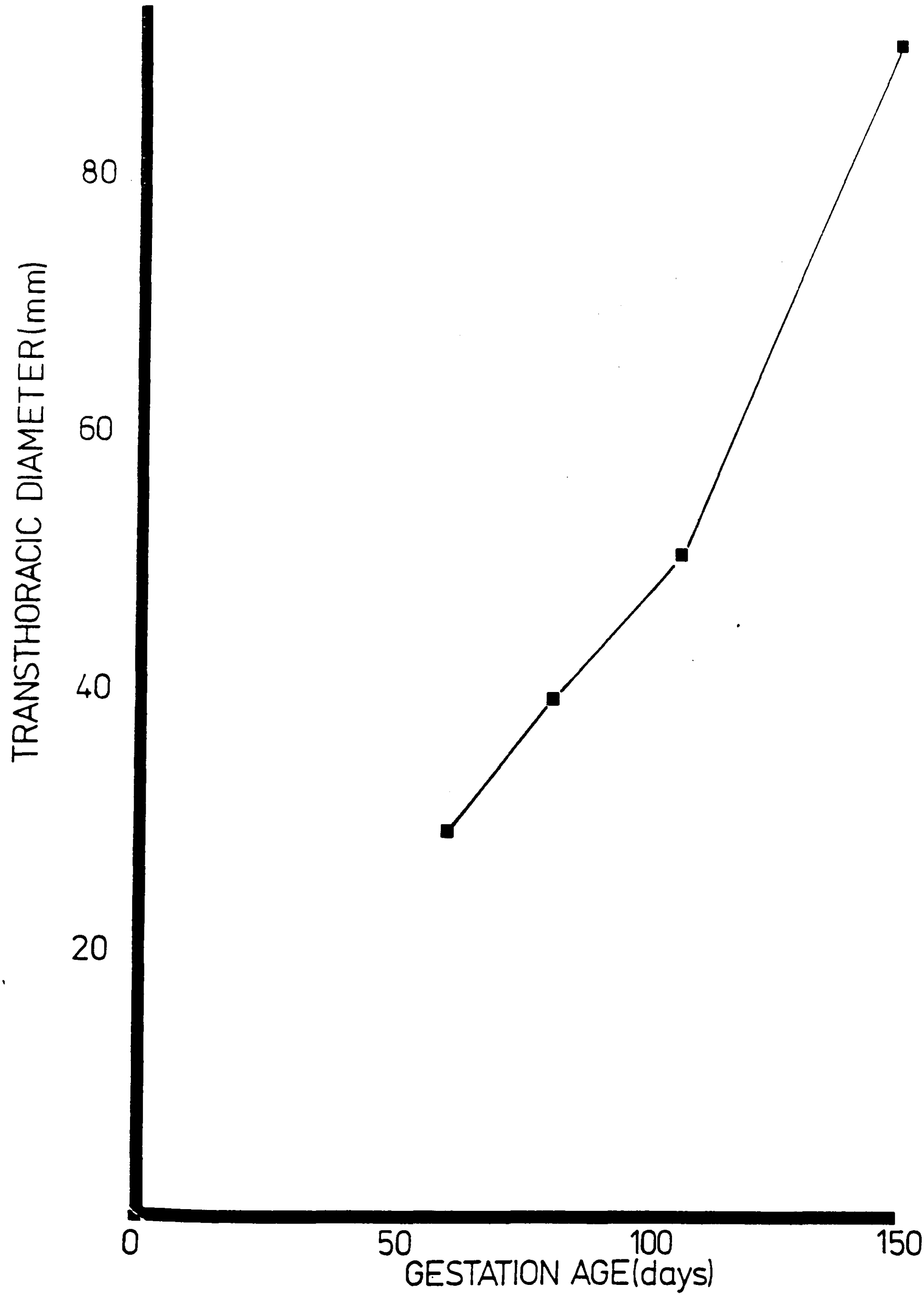


Fig. 30 The relationship between the mean transthoracic diameter and the gestational age in the foetuses of a group of 50 ewes.

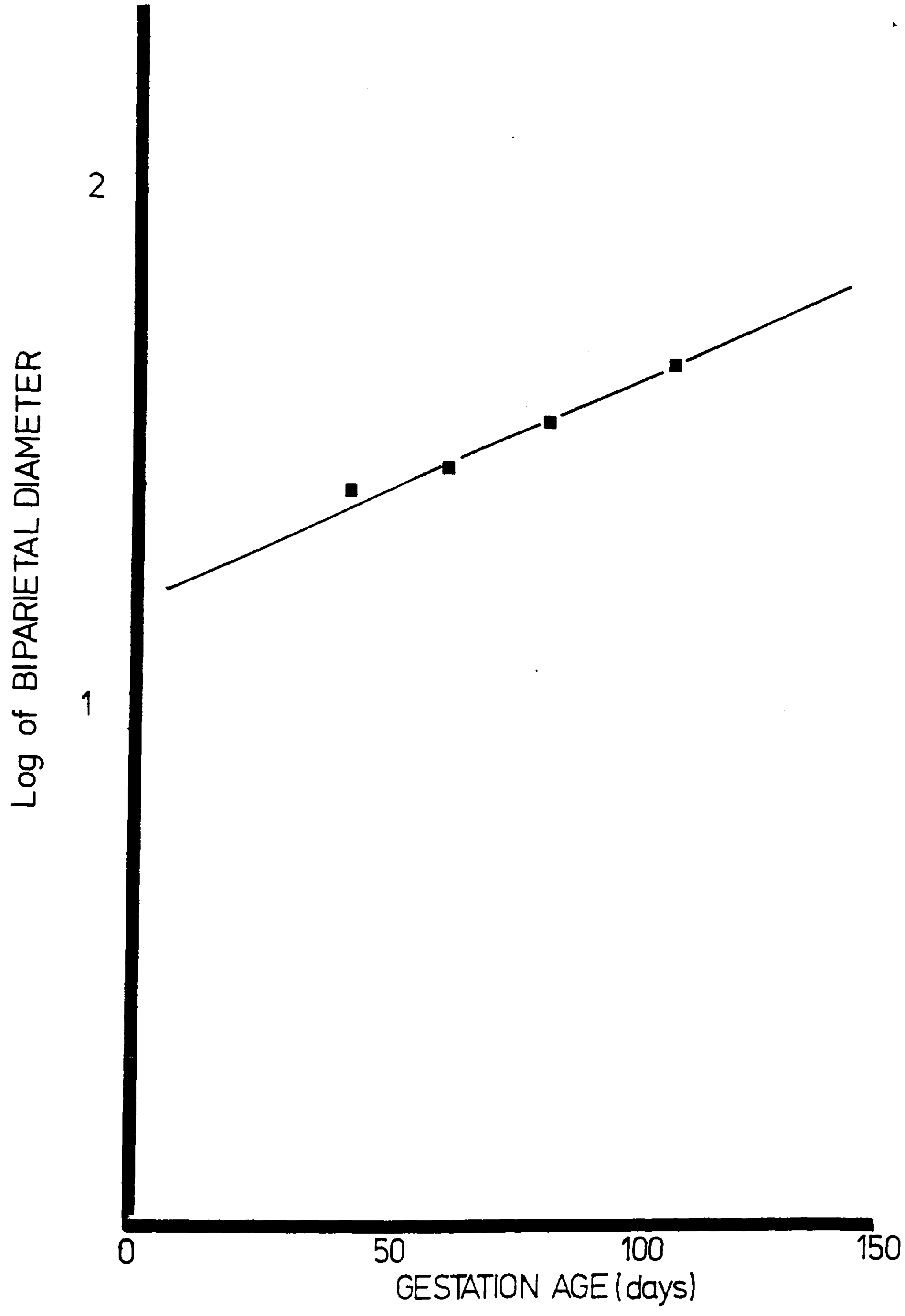


Fig. 31 The relationship between the logarithm of the mean biparietal diameter and the gestational age in the foetuses of a group of 50 ewes.

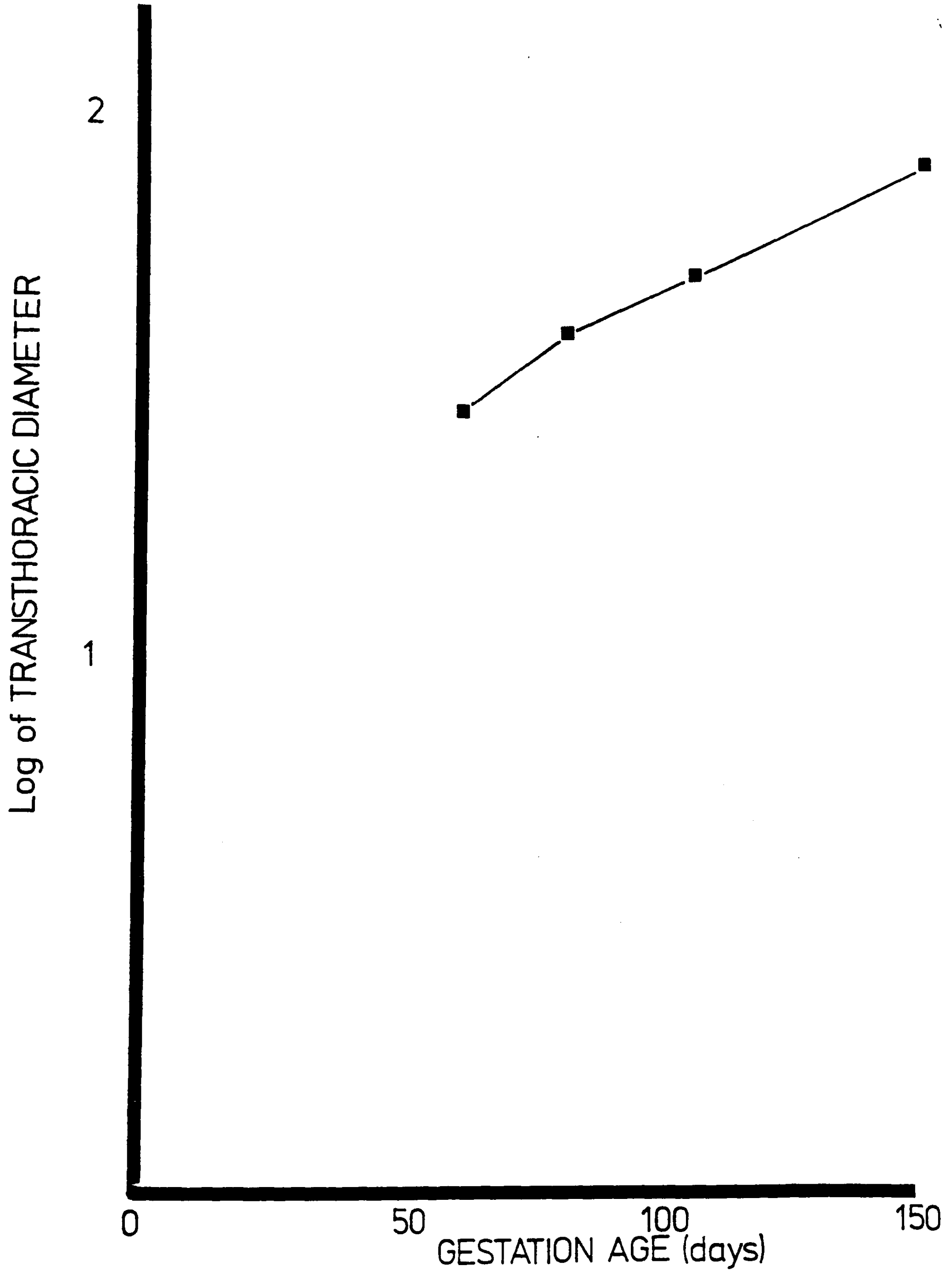


Fig. 32 The relationship between the logarithm of the mean transthoracic diameter and the gestational age in the foetuses of a group of 50 ewes.

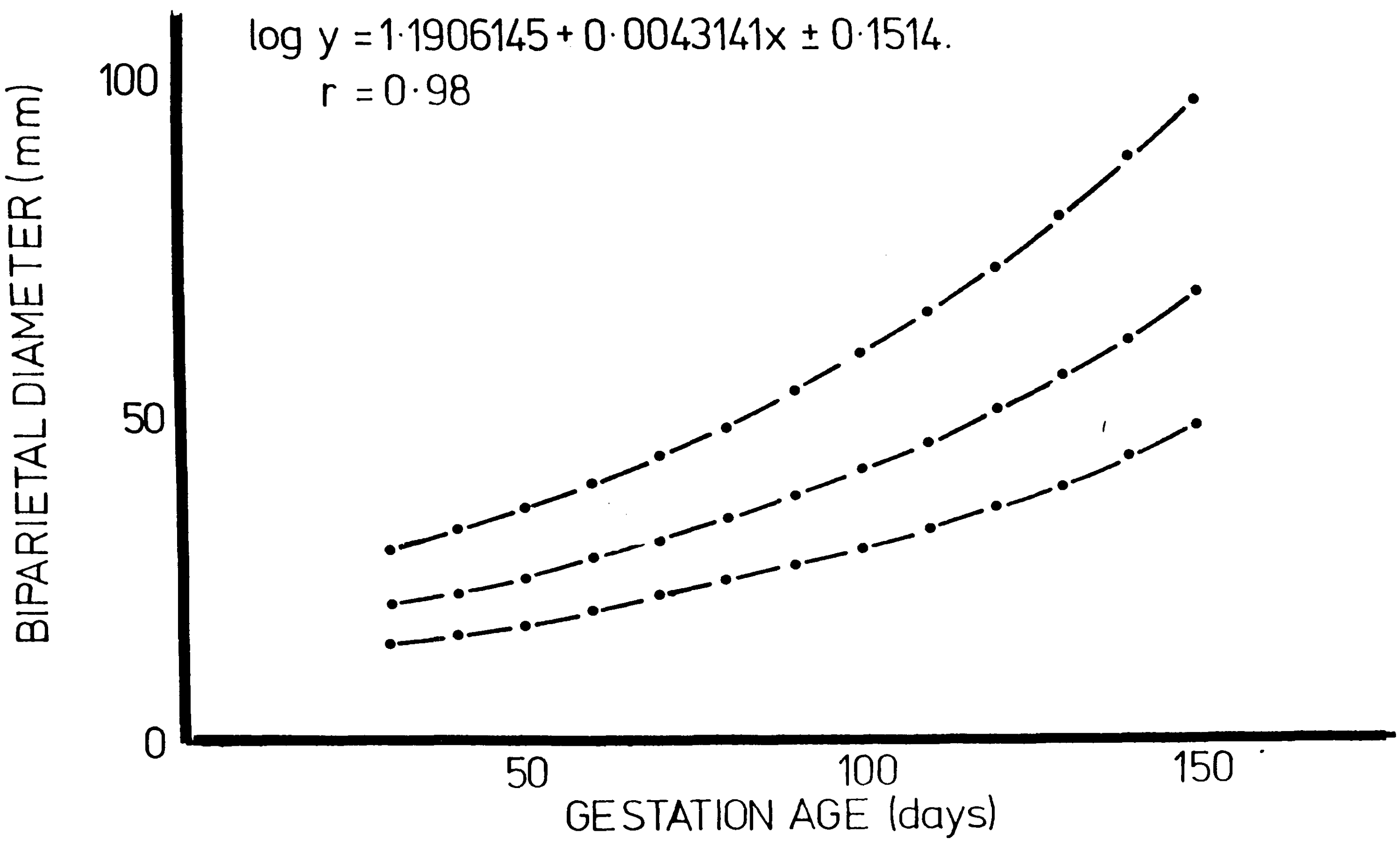


Fig. 33 The regression of the biparietal diameter on the gestational age in the foetuses of a group of 50 ewes with 0.95 confidence intervals, the formula of the curve and the coefficient of correlation

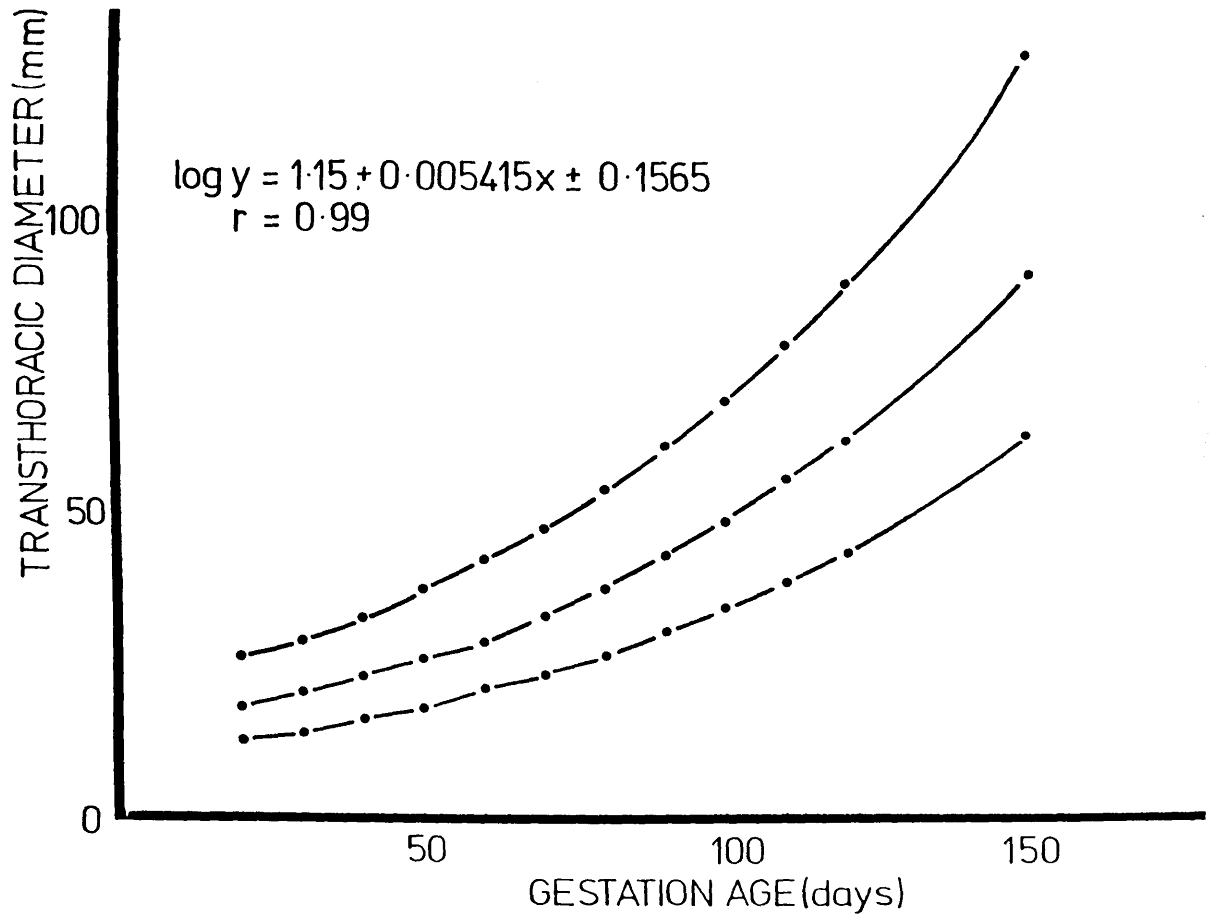


Fig. 34. The regression of the transthoracic diameter on the gestational age in the foetuses of a group of 50 ewes with 0.95 confidence intervals, the formula of the curve and the coefficient of correlation.

Biparietal diameter

$$x \text{ (days)} = 125.474 \log y - 109.242 \; (\pm 12.48294)$$

Application of the Student's T test to the mean values of transthoracic diameter and biparietal diameter for single and twin foetuses indicated that there was no significant difference in the mean size throughout gestation or at birth (Tables 26 and 27).

3:6A PROSTATIC ULTRASONOGRAPHY.

The bladder served as a useful landmark. It was identified as an anechoic structure and was traced to its neck where the prostate could be located lying at the pelvic brim. In all four normal glands examined within the pelvic cavity and in the two glands re-examined ultrasonographically at post-mortem, the prostate had a uniform echogenicity. It was slightly more echogenic than the spleen with an even granularity throughout its substance. The urethra could be traced running through the gland. The longitudinal and transverse diameters of the prostate were in the range 25-30mm. The dogs ranged in weight from 28 to 40kg. The gland appeared symmetrical in shape with a smooth contour and echogenic specular echoes were produced by the capsule when the sound beam was orientated at right angles to the gland. The tissues surrounding the prostate were generally more echogenic than the gland and lacked its even granular appearance. The pelvic brim was identified as an echogenic

TABLE 26 : THE SIGNIFICANCE OF DIFFERENCES IN TRANSTHORACIC DIAMETER BETWEEN SINGLE AND TWIN FOETUSES INCLUDED IN THIS STUDY

		60	80	105	BIRTH
SINGLES	No. of measurements	3	9	7	11
	Mean	26	42.222	46.28	96.3636
	S.E.	0.942	1.897	4.168	5.1859
TWINS	No.	7	52	29	53.172
	Mean	29.428	40.192	2.08	91.320
	S.E.	1.322	0.933	0.1	1.86855
	Probability	< 0.1 >0.05	> 0.1	>0.1	>0.1

S.E. = Standard Error.

A probability of greater than 0.006 indicates an insignificant result.

TABLE 27 : THE SIGNIFICANCE OF DIFFERENCES IN BIPARIETAL DIAMETER BETWEEN SINGLE AND TWIN FOETUSES

		60	80	105	BIRTH
SINGLES	No. of measurements		4	7	11
	Mean		33	42.28	81.8181
	S.E.		1.658	75	2.821
TWINS			26	22	53
			37.230	44.09	76.226
			1.439	72	1.257979
	Probability		< 0.1 > 0.05	> 0.1	< 0.1 > 0.05

S.E. = Standard Error

A probability of greater than 0.006 indicates an insignificant result.

contour causing acoustic shadowing. The colon also caused acoustic shadowing and could be identified lying dorsal to the prostate.

The sector transducer was required to identify the gland easily. The linear array transducer produced a rectangular sound beam which was difficult to orientate such that the beam avoided the acoustic shadowing caused by the pelvis which obscured the bulk of the gland.

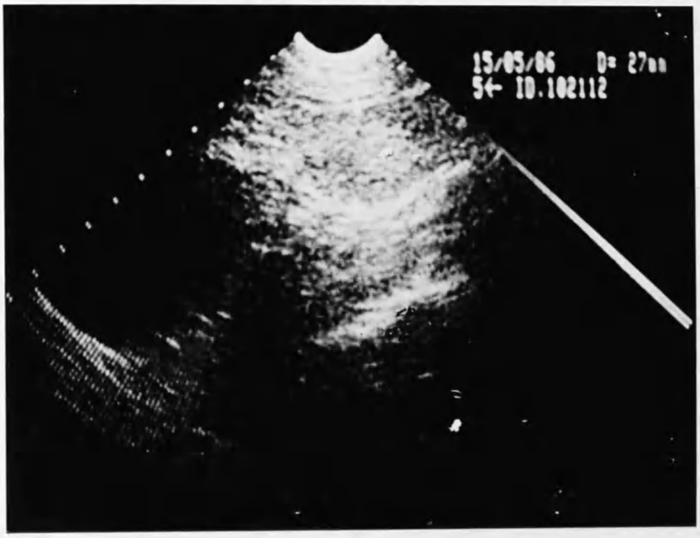
Figure 35 is an example of the normal ultrasonographic anatomy of the caudal abdominal and pelvic area.

3:6B <u>PROSTATIC ULTRASONOGRAPHY</u>.

Nine cases were selected for prostatic ultrasonography. With the exception of Case 17, the cases had clinical signs which could indicate prostatic disease. Cases 17, 18, 19, 20 and 21 had clinical and radiographic evidence of a caudal abdominal mass. Cases 22, 23, 24 and 25 had clinical and radiographic evidence of prostatic enlargement. Table 28 summarises the ultrasonographic findings and final diagnosis in these nine cases.

A case report was prepared for each individual summarising the clinical signs, radiographic and laboratory findings and describing the ultrasonographic abnormalities.

Fig. 35 An ultrasonograph of the normal canine prostate. The bladder is anechoic and the prostate gland has an even echogenicity. A hypoechoic contour with acoustic shadowing represents the colon.



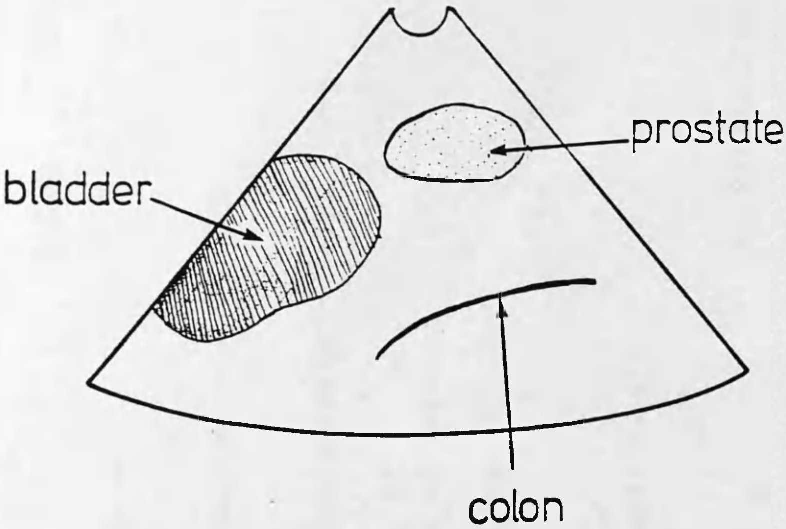


TABLE 28 : THE ULTRASONOGRAPHIC FINDINGS IN NINE CASES OF PROSTATIC AND PERIPROSTATIC DISEASE

	B.P.H.	Prostatic Adenocardinoma	Paraprostatic Cyst	Anal Sac Tumour
Increased Size	2/2	3/3	0/3	1/1
Diffuse Altered Echogenicity	2/2	3/3	0/3	0/1
Focal Altered Echogenicity	+1/2	*1/3	+1/3	0/1
Disruption of Smoothness of Contour	0/2	0/3	0/3	0/1
Disruption of Symmetry	1/2	1/3	0/3	0/1
Presence of Periprostatic Lesions	0/2	0/3	3/3	1/1

* Mineralisation + Prostatic Retention Cyst

3:7 CASE REPORTS

CASE ONE

A nine year-old female neutered Bassett Hound.

Presenting Signs: The dog displayed progressive anorexia of three months duration, melaena and vomiting.

Clinical and Endoscopic Findings: The dog was anorexic and she vomited frequently which was unrelated to feeding. The findings on endoscopic examination were suggestive of gastric carcinoma.

Radiographic Findings: Fluoroscopic examination demonstrated that the lumen of the stomach was reduced in size. A lateral abdominal radiograph was unremarkable.

Ultrasonographic Findings: The liver was examined to determine whether there were hepatic metastases. In both the left and right lobes of the liver, multiple hyperechogenic areas with ill-defined borders were identified (Fig. 36). These ranged in size from seven to 20mm in diameter. The portal vein and caudal vena cava were identified and were unremarkable. The kidneys and spleen had normal sizes and positions.

Diagnosis: Gastric carcinoma with ultrasonographically demonstrated hepatic metastases.

Confirmation of the Diagnosis: A post-mortem examination was performed and the presence of a gastric carcinoma was confirmed. Nodules were found scattered throughout the liver (Fig. 37). On histological examination, these were found to be nodules of fatty change and were not neoplastic.

Fig. 36 A hepatic ultrasonograph with numerous hyperechoic foci (Case 1, fatty change).

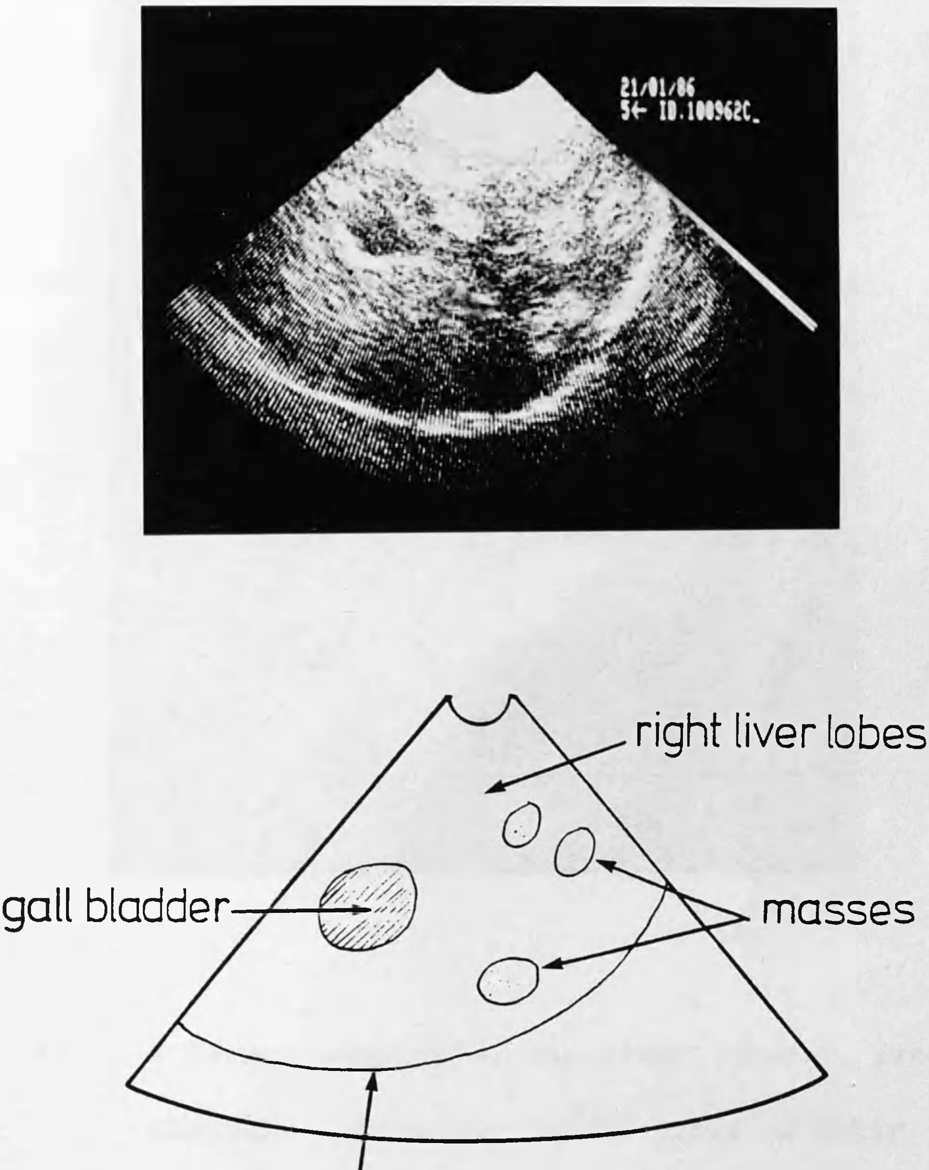


Fig. 37 A frozen section of the liver (Case 1, fatty change). Numerous yellow areas of fatty change are apparent.

CASE TWO

A five year-old male West Highland White Terrier.

Presenting Signs: The dog demonstrated dullness and vomiting for two weeks prior to admission.

Clinical Findings: A mass was palpable in the cranial abdomen.

Radiographic Findings: A lateral abdominal radiograph demonstrated a soft tissue density in the cranioventral abdomen which displaced the small intestinal loops caudodorsally. The borders of the spleen could not be distinguished. A ventrodorsal abdominal radiograph demonstrated a soft tissue density which lay at the right-hand side of the abdomen and displaced the intestine. The left kidney was normal in size and position but the right kidney could not be distinguished clearly.

Ultrasonographic Findings: The left lobes of the liver had normal echogenicity and granularity. The area immediately to the right of the gall bladder was hypoechogenic (Fig. 38) and had reduced granularity. This area extended caudally to the most caudal third of the abdomen. The spleen was of normal size and echogenicity and the mass did not adhere to it (Fig. 39). The left kidney appeared normal as did the bladder. The right kidney lay immediately deep to the mass, but the capsule appeared smooth and intact (Fig. 40). The decreased attenuating properties of the tissue which overlay the right kidney enhanced the detail which was

Fig. 38 A hepatic ultrasonograph with a localised hypoechoic area (Case 2, hepatic carcinoma).

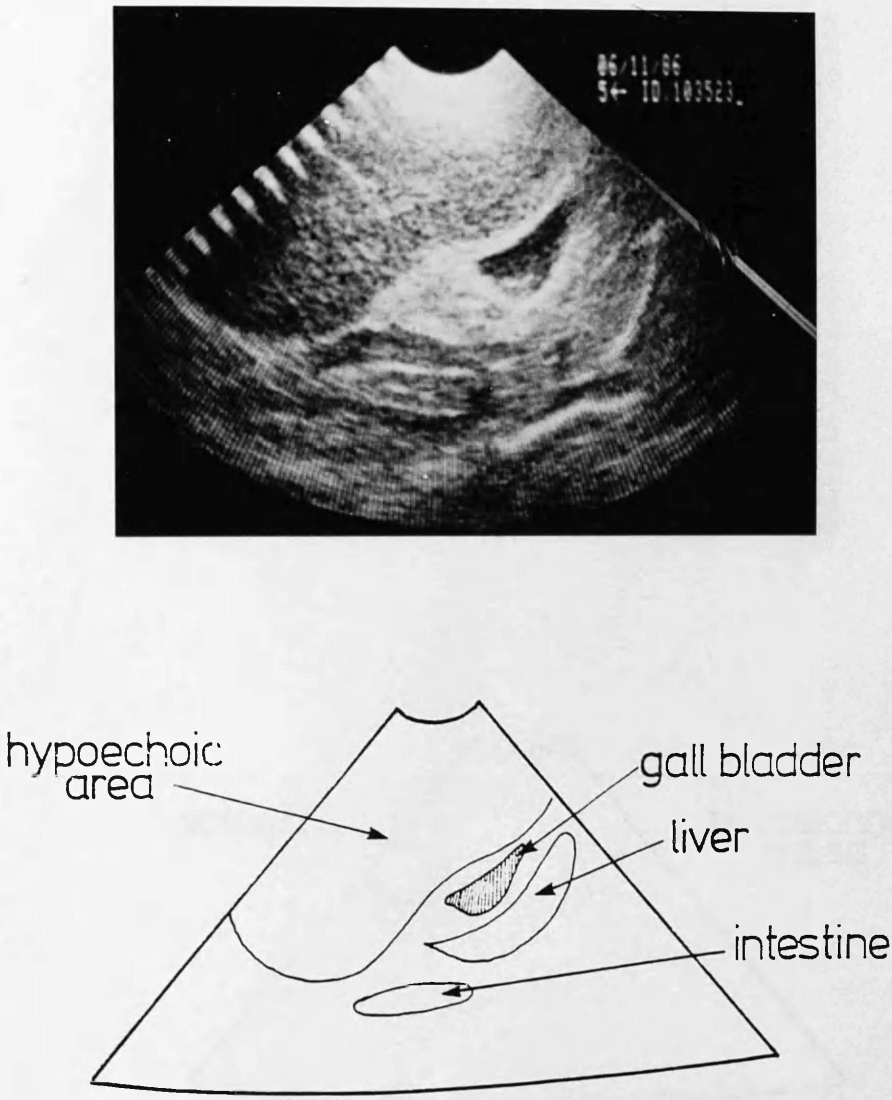


Fig. 39 An ultrasonograph of the left cranial abdomen (Case 2, hepatic carcinoma). The spleen is apparent and a hypoechoic area of abnormal tissue lies distinct from it.

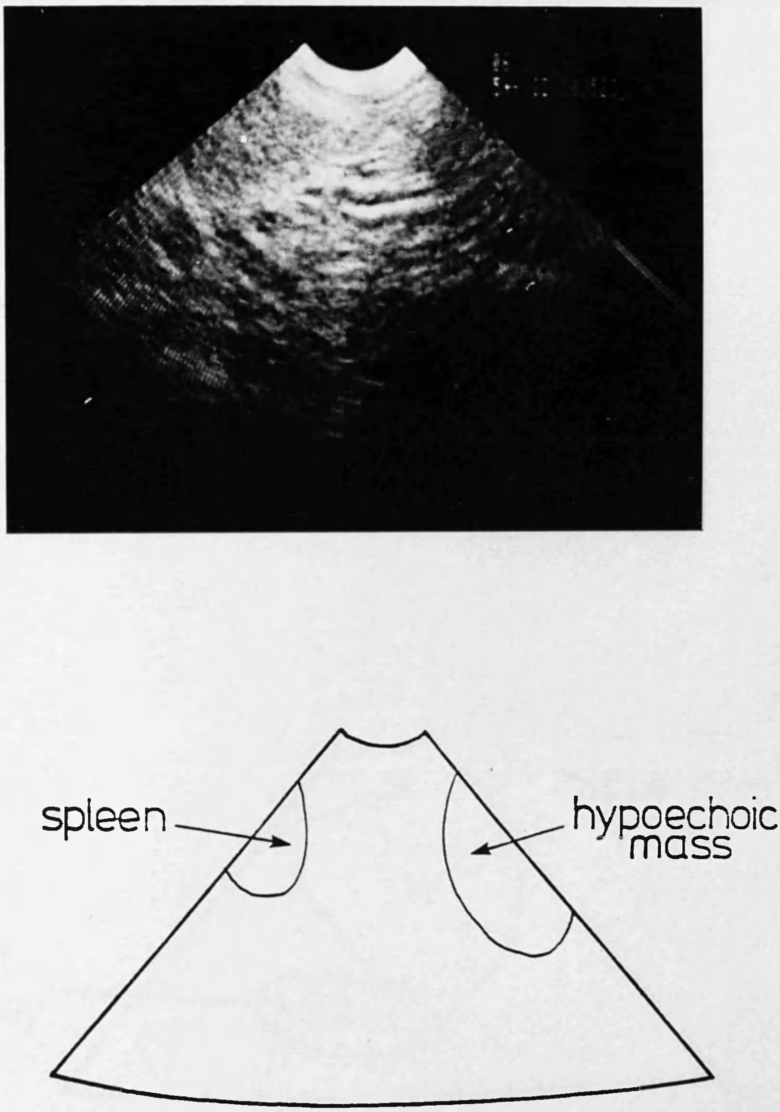
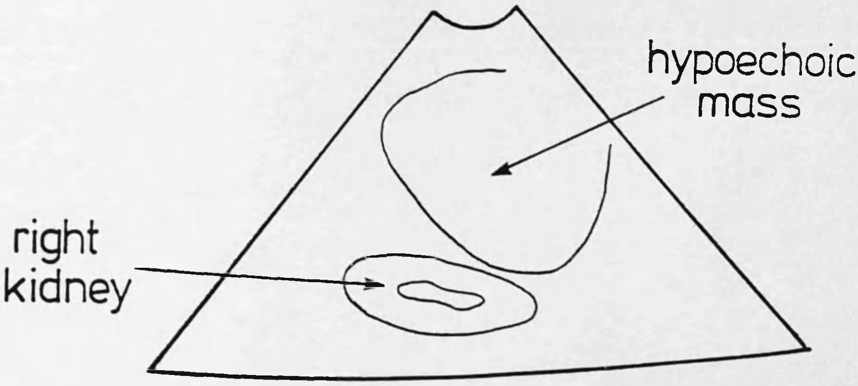


Fig. 40 An ultrasonograph of the right cranial abdomen (Case 2, hepatic carcinoma). A hypoechoic mass lies over the right kidney but the renal capsule is intact.



visible in the cranial abdomen. The right adrenal gland, the renal artery and the aorta could all be readily identified using the abnormal tissue as an acoustic window.

Diagnosis: Hepatocellular carcinoma located in the right lobes of the liver.

Confirmation of the Diagnosis: An exploratory laparotomy was performed and this diagnosis was confirmed. The neoplasm was firmly attached to the gall bladder and was, therefore, inoperable. A biopsy of the tumour indicated that it was poorly differentiated but highly malignant. The animal recovered from anaesthesia uneventfully and returned home with palliative treatment but died following a sudden relapse three months later.

CASE THREE

A thirteen year-old female neutered Maltese Terrier.

Presenting Signs: The dog had demonstrated intermittent diarrhoea for several weeks.

Clinical and Laboratory Findings: No significant abnormalities were detected on clinical examination. Biochemical and haematological parameters were normal. The faeces were of normal colour and consistency during hospitalisation.

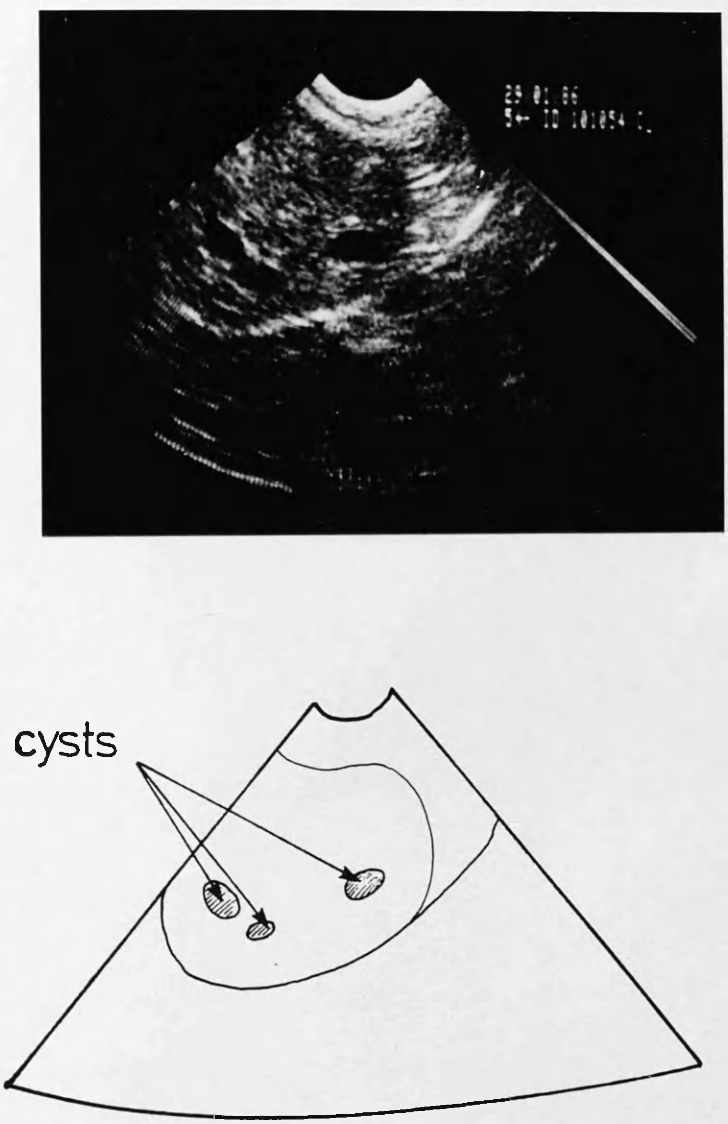
Radiographic Findings: Lateral and dorsoventral abdominal radiographs were unremarkable.

Ultrasonographic Findings: The liver had a mottled echogenicity throughout its entire substance. Three anechoic areas were identified: two were located in the right liver lobes and one in the left lateral lobe (Fig. 41). These areas caused slight acoustic enhancement and they measured approximately 10mm in diameter. They were considered to be cystic lesions due to their ultrasonographic characteristics.

Diagnosis: No diagnosis was reached which could account for the clinical signs.

Confirmation of the Diagnosis: An exploratory laparotomy was performed to evaluate the liver and to take biopsies of the gastrointestinal tract. Three cysts were located in the liver in the positions indicated ultrasonographically. Examination of a hepatic biopsy demonstrated hepatic

Fig. 41 A hepatic ultrasonograph with anechoic foci (Case 3, hepatic cysts). These foci within the liver represent degenerative cystic lesions.



degeneration with the formation of microcysts. The animal was discharged when no clinical signs had been observed during a two week hospitalisation period.

CASE FOUR

A seven year-old female neutered Domestic long-haired Cat.

Presenting Signs: The cat had been dull and anorexic for three weeks prior to admission.

Clinical Findings: The cat was extremely dull, thin and exhibited tachycardia. Nodules were palpable in the hind limbs and a mass was palpable in the cranial abdomen. The right pupil was considerably smaller than the left one.

Radiographic Findings: Lateral and dorsoventral thoracic radiographs demonstrated consolidation of the right apical lung lobe and the presence of a discrete soft tissue opacity in the dorsal thorax to the right of midline and extending from the heart base to the diaphragm. A lateral abdominal radiograph demonstrated an ill-defined hepatic margin. Caudal to the liver, there was an area of increased opacity in the cranioventral abdomen which represented an ill-defined soft tissue mass.

Ultrasonographic Findings: The liver contained numerous hyperechogenic masses which were scattered throughout its substance. These areas did not have distinct borders and were irregularly shaped. The detail of the rest of the abdominal organs could not be distinguished clearly.

Diagnosis: Widespread neoplastic masses.

Confirmation of the Diagnosis: On post-mortem examination, nodules were found in the muscles of the hind limb, the nuchal crest and the right orbit. There were multiple nodules in the liver and one in each of the spleen, a mesenteric lymph node, the stomach and the caudal lung. The diagnosis of metastatic carcinomas of unknown primary origin was made.

CASE FIVE

A two year-old female Border Collie.

Presenting Signs: The bitch presented with anorexia and weight loss of three weeks duration.

Clinical Findings: The bitch was pyrexic, vomited frequently and had abdominal distension. A laparotomy had been performed prior to admission at which several litres of pus were reported to have been drained from the abdomen.

Radiographic Findings: A lateral abdominal radiograph demonstrated poor visceral detail due to the presence of free fluid in the abdomen.

Ultrasonographic Findings: The right area of the liver appeared normal. In the left medial lobes, an area of increased echogenicity was identified. No distinct edge could be identified in this area of the liver. The intestines in the ventral abdomen were outlined by free fluid.

Diagnosis: Peritonitis.

Confirmation of the Diagnosis: On post-mortem examination, a purulent peritonitis was confirmed. The middle lobe of the liver was adherent to the diaphragm and stomach. The rest of the liver had a marked reticular pattern which was indicative of amyloidosis, secondary to peritonitis.

CASE SIX

A nine year-old female Cocker Spaniel.

Presenting Signs: The bitch presented with abdominal enlargement, anorexia and dull demeanour.

Clinical and Laboratory Findings: A fluid thrill was detectable on palpation of the abdomen indicating ascites. At first examination the bromosulphathalein (B.S.P.) retention test was 29.8% (normal $<$ 5%). On re-examination one week later, the B.S.P. retention test was 38%. The animal began to have increasingly frequent bouts of bizarre behaviour, aggression, circling and aimless wandering.

Radiographic Findings: A lateral abdominal radiograph demonstrated increased opacity of the abdomen and loss of visceral detail due to free fluid.

Ultrasonographic Findings: The spleen was of normal size and echogenicity. The liver was small and intestinal loops lay in a substernal position normally occupied by the liver. The fine granular pattern had been replaced by a patchy appearance with ill-defined hyperechogenic and hypoechogenic areas throughout the liver. Dilated portal vessels were identified and the abdominal organs were outlined by anechoic fluid which was indicative of ascites.

Diagnosis: Hepatic cirrhosis.

Confirmation of the Diagnosis: A post-mortem examination was not performed on this case. However, the clinical and biochemical findings support the diagnosis.

CASE SEVEN

An 18 month-old Lasa Apso.

Presenting Signs: The dog demonstrated intermittent episodes of vomiting and bizarre behaviour.

Clinical and Laboratory Findings: These are not available.

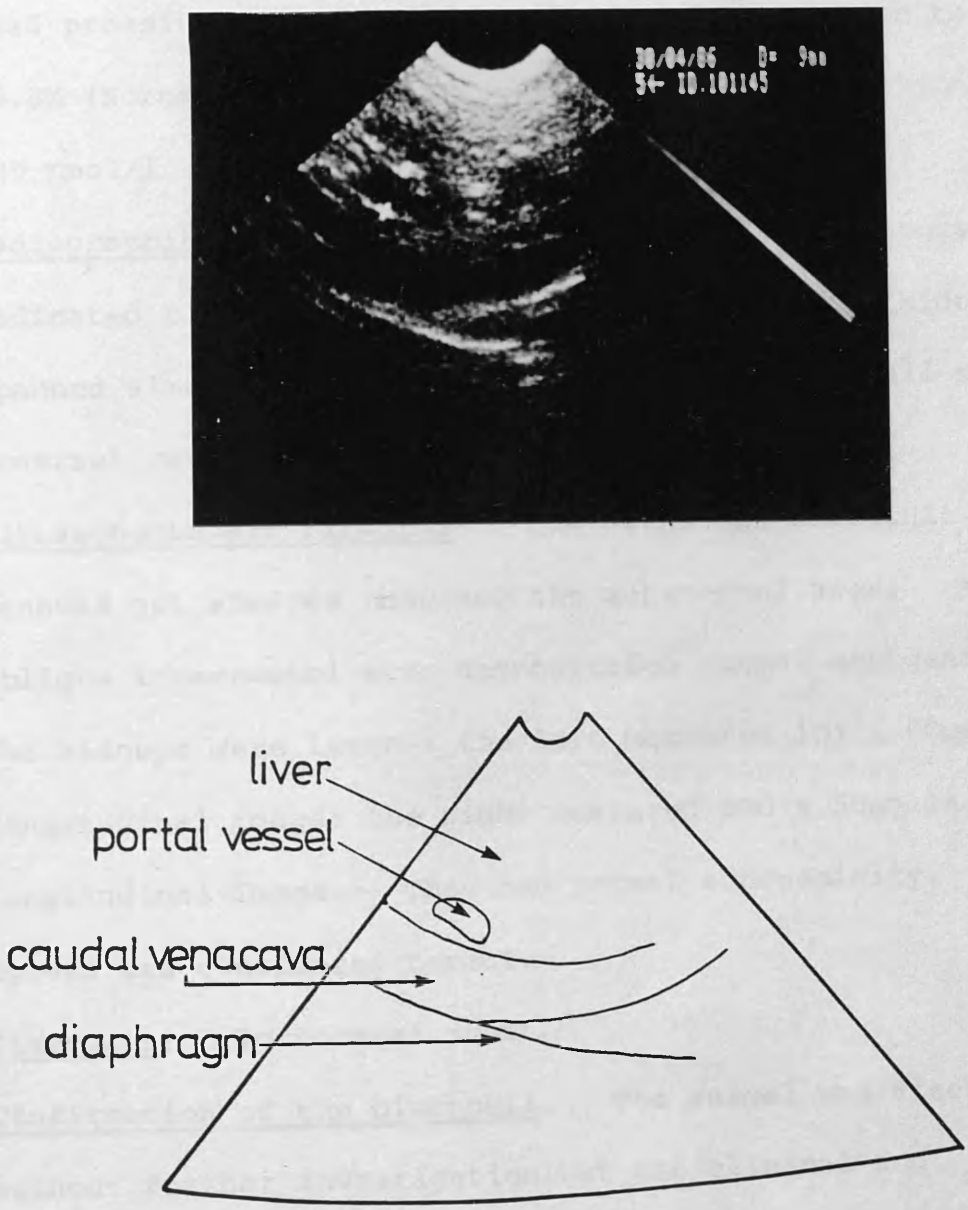
Radiographic Findings: A lateral abdominal radiograph indicated decreased liver size and enlarged kidneys. An intraoperative portal venogram confirmed the presence of a large intrahepatic portosystemic shunt.

Ultrasonographic Findings: The liver was small and both portal and hepatic vessels were distended. The caudal vena cava was identified 30mm to the right of midline and its diameter was 22mm. A portal vessel of 9mm diameter was communicating directly with the caudal vena cava (Fig. 42). Both kidneys were hyperechogenic when compared to the liver which had the same echogenicity of the spleen and, therefore, the liver was considered to be hypoechogenic.

Diagnosis: Portosystemic shunt.

Confirmation of the Diagnosis: A laparotomy was performed and an intrahepatic portosystemic shunt was identified in association with a small liver. Subsequent post-mortem examination confirmed this finding.

Fig. 42 A hepatic ultrasonograph (Case 7, portosystemic shunt). The liver is small and a dilated portal vessel with echogenic walls can be seen adjacent to the caudal vena cava.



CASE EIGHT

A 14 month-old male Springer Spaniel.

Presenting Signs: The dog was admitted following vomiting and demonstration of bizarre behaviour for one week.

Clinical and Laboratory Findings: The animal was restless; he wandered aimlessly with his head down and occasionally head pressing was observed. The B.S.P. retention test was 15.8% (Normal $<$ 5%) and plasma ammonia concentration was 229 mmol/l (normal $<$ 100 $mmoll^{-1}$).

Radiographic Findings: A lateral abdominal radiograph indicated bilateral renal enlargement : the left kidney spanned almost four lumber vertebrae. The overall radiographic contrast was poor due to the thinness of the dog.

Ultrasonographic Findings: The liver was difficult to image because gut shadows obscured the substernal area. An oblique intercostal scan demonstrated normal echogenicity. The kidneys were large : the left measured 103 x 60mm in longitudinal image; the right measured 100 x 58mm in longitudinal image. They had normal echogenicity. The spleen was considered normal.

Diagnosis: Portocaval shunt.

Confirmation of the Diagnosis: The animal was discharged without further investigation but the clinical and biochemical findings support this diagnosis.

CASE NINE

A three year-old male Cairn Terrier.

Presenting Signs: The dog was polydipsic and polyuric for three weeks prior to admission.

Clinical and Laboratory Findings: The dog was dull with variable appetite and melaenia. Haematological examination demonstrated regenerative anaemia with a packed cell volume of 16%. Serum amylase concentration was raised. On initial examination, serum glucose concentration was 23.2 $mmoll^{-1}$ (normal 2.5 - 7.5 $mmoll^{-1}$). Following institution of insulin therapy the serum glucose concentration fell to within normal range.

Radiographic Findings: A lateral abdominal radiograph demonstrated hepatomegaly and moderate enlargement of the left kidney.

Ultrasonographic Findings: The liver was enlarged and it extended 50mm beyond the costal arch. The echogenicity and attenuation of the liver were normal. The spleen had normal echogenicity and size.

Diagnosis: Diabetes mellitus and secondary fatty infiltration of the liver.

Confirmation of the Diagnosis: An exploratory laparotomy was performed and a liver biopsy was taken. The animal was subsequently euthanased when his clinical condition deteriorated. Post-mortem examination confirmed the presence of fatty infiltration of the liver.

CASE TEN

A five year-old male Cairn Terrier.

Presenting Signs: The animal displayed vomiting, weight loss and polydipsia for one month.

Clinical and Laboratory Findings: The dog was bright and had a normal appetite but the heart rate was increased. Serum urea, creatine, bilirubin and total plasma protein concentrations were normal. Thyroid function arrays, resting serum cortisol concentration and B.S.P. retention tests were normal. Haematological examination indicated numerous target cells were present which was indicative of hepatic disease.

Radiographic Findings: A lateral abdominal radiograph demonstrated a massively enlarged hepatic shadow.

Ultrasonographic Findings: The liver extended 70mm caudal to the costal arch and, therefore, was considered to be enlarged. The echogenicity and attenuation were normal. The gall bladder, kidneys and spleen were normal.

Diagnosis: No final diagnosis was made in this case. The dog remained bright but several repeat examinations had indicated that there was no change in the clinical or radiographic findings.

CASE ELEVEN

A ten year-old male Boxer.

Presenting Signs: The animal suffered episodes of syncope.

Clinical and Laboratory Findings: The dog was not observed to faint during hospitalisation. Ascites was detected on abdominal palpation and this diminished with diuretic therapy. Haematological and biochemical examinations revealed no abnormalities.

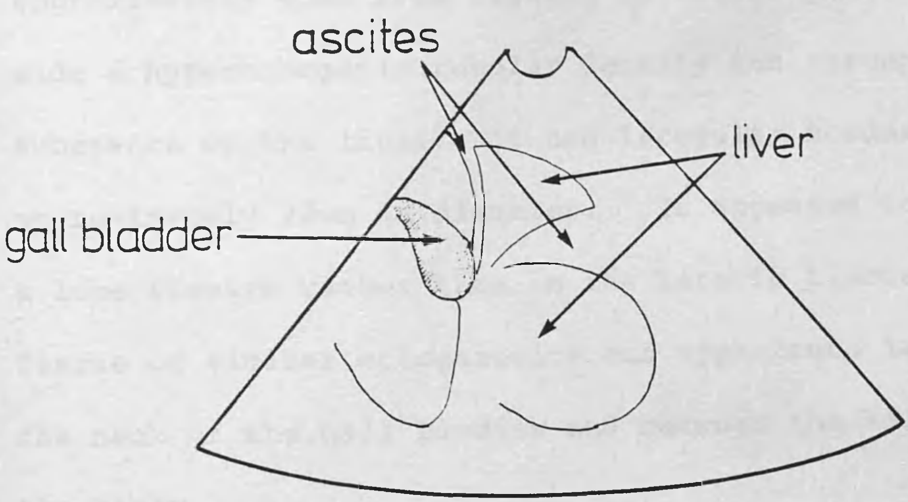
Radiographic Findings: Lateral and dorsoventral thoracic radiographs demonstrated elevation of the trachea, cranial to the tracheal bifurcation and to the right of midline. The posterior vena cava was distended and followed a downward course and the mediastinal area was widened.

Ultrasonographic Findings: Examination of the heart demonstrated an echogenic mass located in the left atria. The liver lobes were each outlined by anechoic areas representing free fluid. The liver was hyperechogenic but few hepatic or portal vessels were noted (Fig. 43).

Diagnosis: Heart base tumour and right cardiac failure.

Confirmation of the Diagnosis: Post-mortem examination confirmed this diagnosis.

Fig. 43 An ultrasonograph of the liver outlined by ascitic fluid (Case 11, right sided cardiac failure). The liver lobes are separated by anechoic areas of ascites.



CASE TWELVE

A four year-old male neutered Domestic Short-Haired Cat.

Presenting Signs: The cat displayed dullness and increased thirst.

Clinical and Laboratory Findings: The cat was extremely pale and the liver was palpable beyond the costal arch. The pulse rate was elevated and had a tapping quality. The packed cell volume was 8.9% and serological investigations produced a positive result for feline leukaemia virus isolation.

Ultrasonographic Findings: The liver extended 60mm beyond the costal arch and, therefore, was considered to be enlarged. The hepatic echogenicity was reduced evenly throughout the organ. Both left and right kidneys were hyperechogenic when compared with the liver (Fig. 44). The kidneys measured approximately 40mm from cranial to caudal pole. On the left side a hyperechogenic tubular density ran through the substance of the liver. It had irregular borders and was approximately 22mm in diameter. It appeared to be within a lobe fissure rather than in the hepatic tissue (Fig. 45). Tissue of similar echogenicity and appearance lay around the neck of the gall bladder and between the kidneys and the liver.

Diagnosis: Leukaemia associated with feline leukaemia virus.

Confirmation of the Diagnosis: At post-mortem examination,

Fig. 44 An ultrasonograph of the hypoechoic liver (Case 12, myeloid leukaemia). The echogenicity of the liver is reduced when compated with that of the adjacent right kidney.

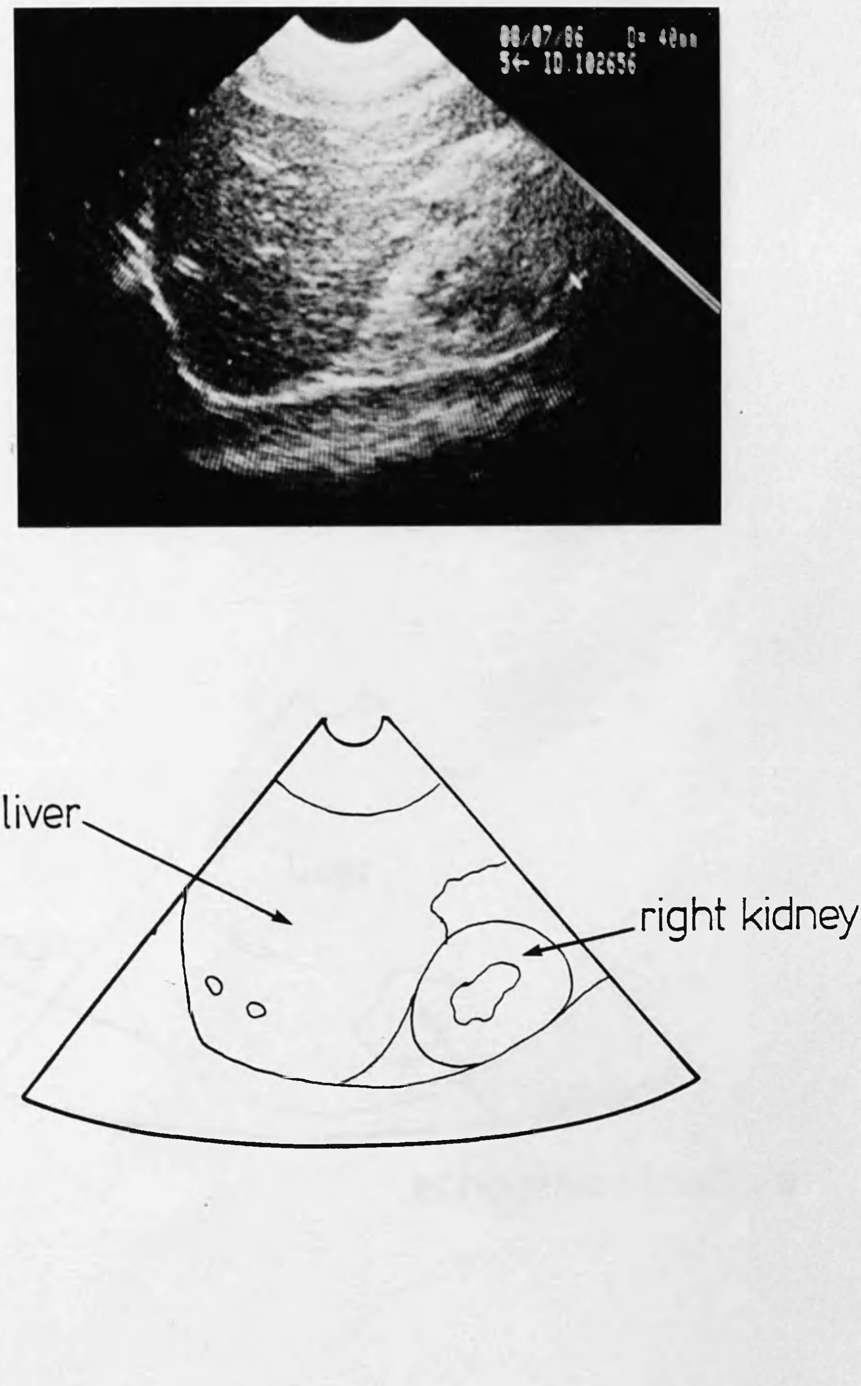
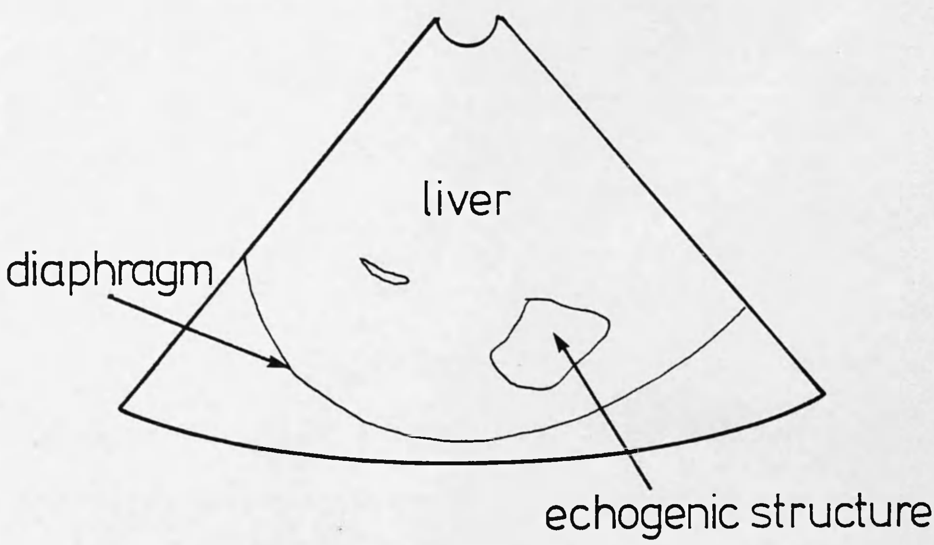


Fig. 45 A hepatic ultrasonograph with a hyperechoic area (Case 12, myeloid leukaemia).



the liver and kidneys were infiltrated with myeloid cells secondary to myeloid leukaemia. There was no abnormality detected which explained the presence of the hyperechoic areas around the liver and kidneys.

CASE THIRTEEN

A nine year-old male German Shepherd dog.

Presenting Signs: The dog was progressively anorexic, weak and dull over a two week period.

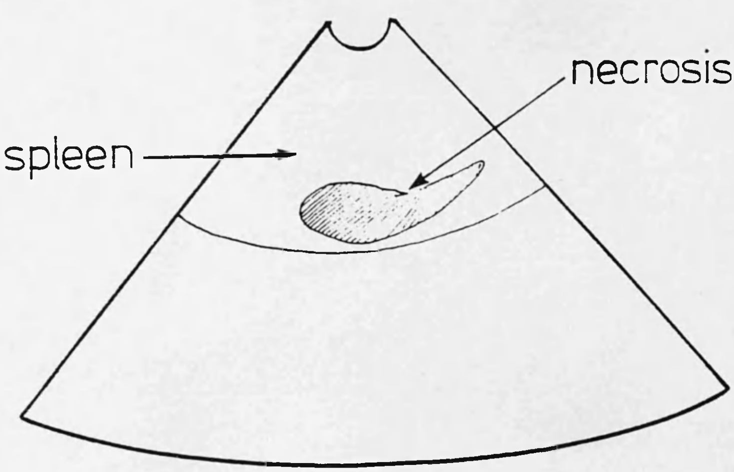
Clinical Findings: The dog was dull, pyrexic with pale mucous membranes. It was weak and unwilling to stand but no neurological deficit was detected.

Laboratory Findings: Haematological examination revealed anaemia (haematocrit 0.142 ll^{-1}, normal 0.37-0.55 ll^{-1}; total red blood cell count 1.9 x 10^{12} l^{-1}, normal 5.5-8.5 x 10^{12} l^{-1}; mean cell volume 76 fl, normal 65-77 fl), leucocytosis (white blood cell count 63.4 x 10^{9} l^{-1}, normal 6.00-15 x 10^{9} l^{-1}) and lymphocytosis with numerous lymphoblasts (total lymphocyte count 56.7 x 10^{9} l^{-1}, normal 1.00-4.80 x 10^{9} l^{-1}). These findings were indicative of lymphoblastic leukaemia.

Radiological Findings: A lateral abdominal radiograph demonstrated an enlarged spleen.

Ultrasonographic Findings: The spleen was markedly enlarged; it extended laterally to the right side of the midline of the ventral abdomen and caudally to the pelvic brim. It was up to 50mm thick at the ventral midline. The echogenicity was reduced throughout and localised anechoic areas were identified within its substance (Fig. 46). These anechoic areas measured approximately 15-20mm in diameter and were irregularly shaped with ill-defined borders. The

Fig. 46 A splenic ultrasonograph with numerous anechoic areas (Case 13, lymphoid leukaemia). These areas represent necrosis within the spleen.



liver was considered to be normal.

Diagnosis: Lymphoblastic leukaemia with splenic infiltration.

Confirmation of the Diagnosis: On post-mortem examination, the spleen was markedly enlarged and the splenic pulp was replaced by soft pink tissue. There were multiple infarcts which were similar in size and shape to the anechoic areas which were identified ultrasonographically (Fig. 47). The liver was also enlarged and pale and the bone marrow was replaced by soft creamy tissue. Histological examination confirmed the diagnosis of leukaemia with infiltration of the marrow, spleen, liver and kidneys by malignant cells.

Fig. 47 The enlarged spleen with necrotic areas (↑↑↑↑). (Case 13, lymphoid leukaemia).

CASE FOURTEEN

A ten year-old Labrador bitch.

Presenting Signs: The bitch had been treated for Diabetes Mellitus for two years. One month post oestrus the bitch presented with anorexia and dullness.

Clinical Findings: The bitch was pyrexic and slightly dull.

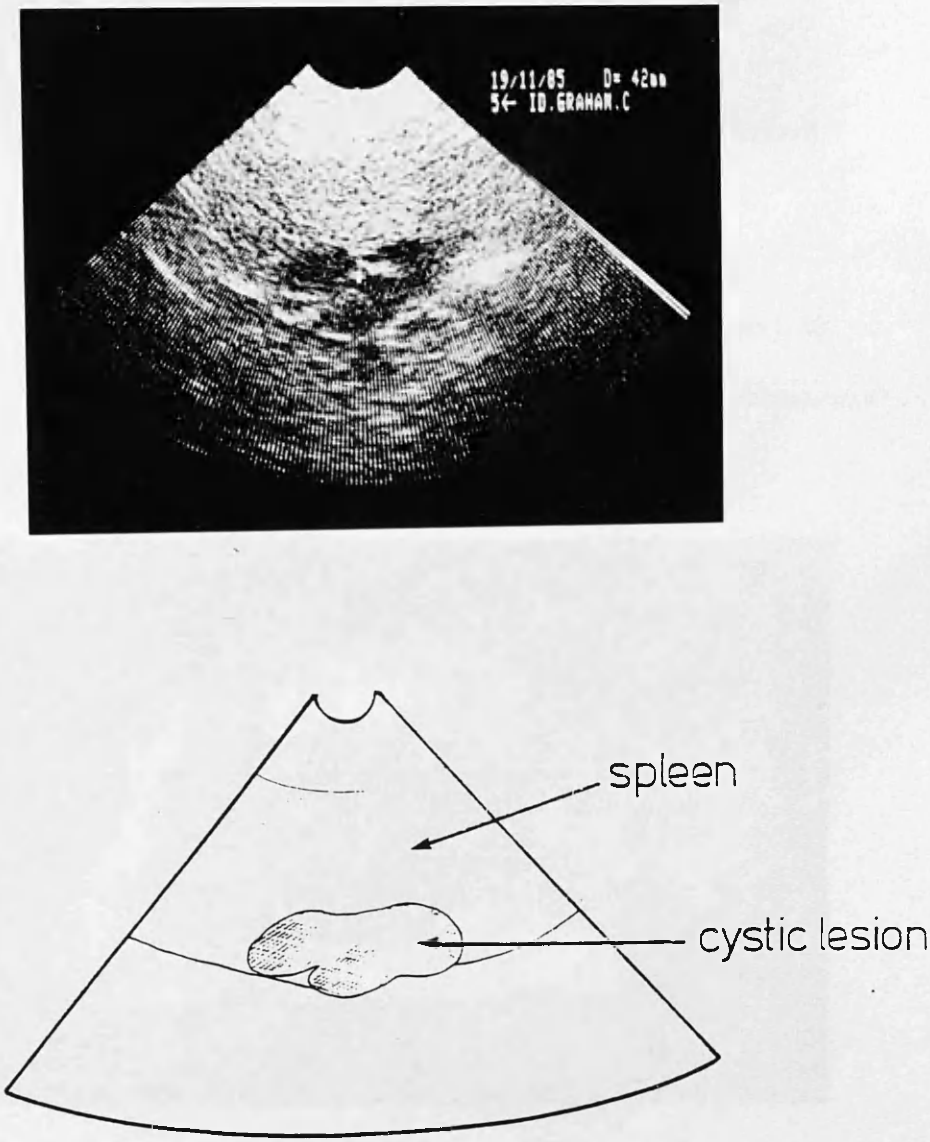
Radiographic Findings: A lateral abdominal radiograph demonstrated a soft tissue opacity in the cranioventral abdomen. The structure and position of the organs of the caudal abdomen were normal.

Ultrasonographic Findings: The spleen was enlarged and the more dorsal part of it had normal echogenicity. Several localised anechoic areas were identified in the ventral portion (Fig. 48). These areas measured between 10 and 20mm and were divided by hyperechogenic strands and were grouped together at two separate sites.

Diagnosis: Splenic haemangiosarcoma.

Confirmation of the Diagnosis: An exploratory laparotomy was performed and the spleen was removed. Two haemangiosarcomas were present on the tail and mid-body of the spleen (Figs. 49, 50).

Fig. 48 A splenic ultrasonograph with a multicystic mass (Case 14, splenic haemangiosarcoma). Several anechoic foci are grouped together and separated by hypoechoic septae.



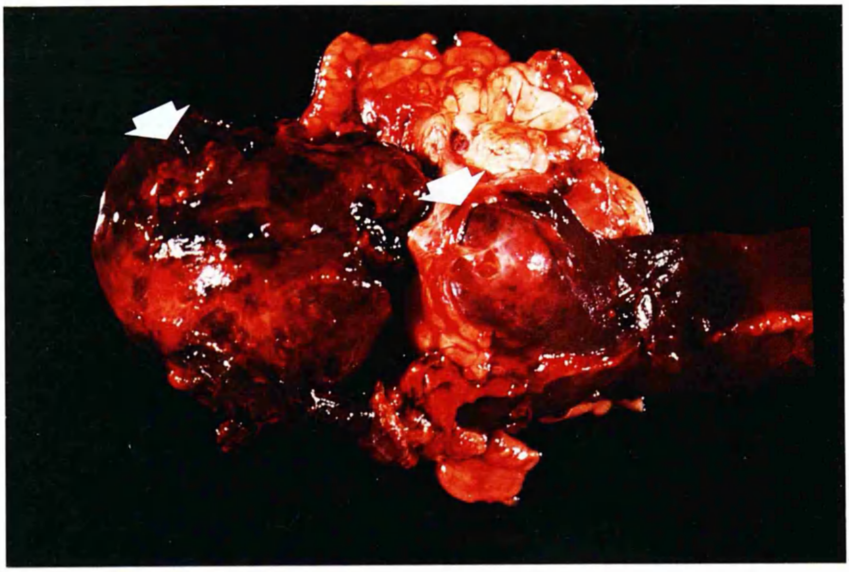


Fig. 49 Two haemangiosarcomas (↑ ↑) attached to the spleen (Case 14, splenic haemangiosarcoma).

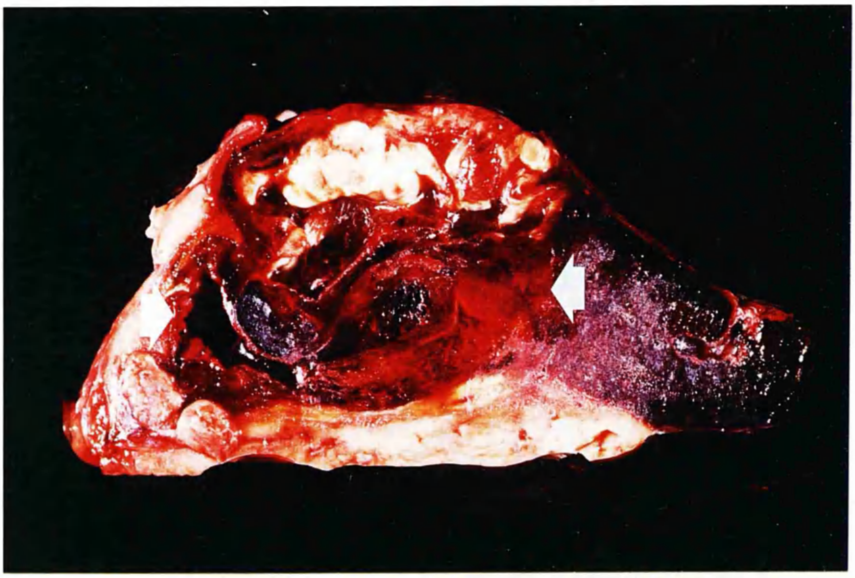


Fig. 50 A frozen section of the haemangiosarcoma (↑) (Case 14, splenic haemangiosarcoma). The cystic nature of the mass is demonstrated.

CASE FIFTEEN

A ten year-old German Shepherd bitch.

Presenting Signs: The owner had noticed that the animal's abdomen had become progressively distended over a period of three weeks.

Clinical Findings: The bitch was alert, bright and eating normally. The abdomen was markedly distended and on palpation a soft mass was detected in the cranial abdomen.

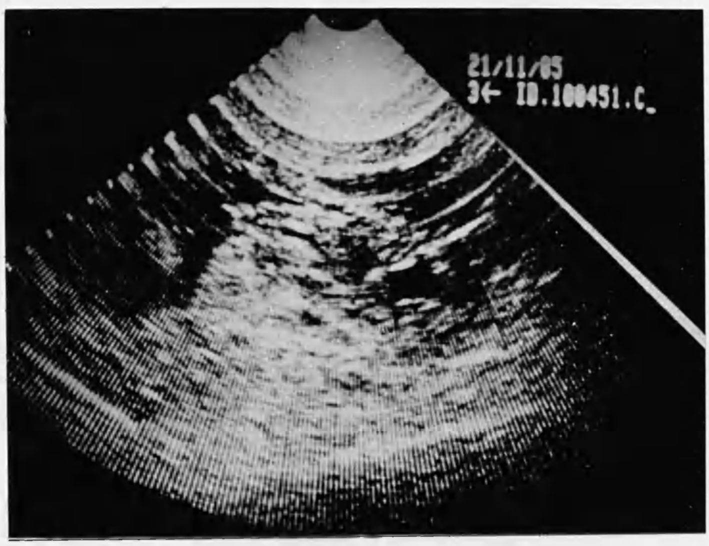
Radiographic Findings: On a lateral abdominal radiograph a well-defined area of increased opacity was distinguished which lay in the ventral abdomen, caudal to the liver and it displaced the small intestine caudodorsally.

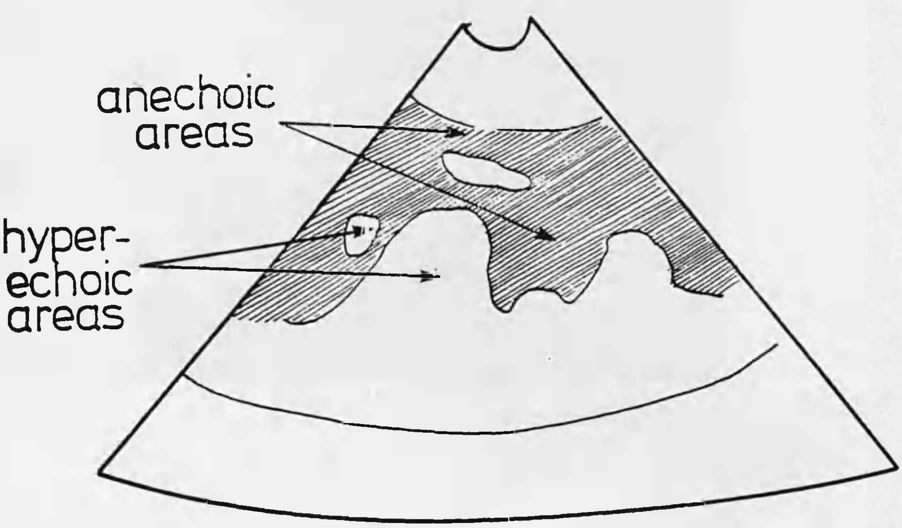
Ultrasonographic Findings: An area of the spleen was identified in the left dorsal flank which had normal echogenicity. Caudal to this lay an area composed of numerous anechoic foci (Fig. 51). It extended from the sternum caudally to the pelvic brim and, therefore, filled the entire ventral abdomen. The anechoic foci were separated by hyperechoic strands.

Diagnosis: Splenic haemangiosarcoma.

Confirmation of the Diagnosis: A laparotomy was performed and the spleen was removed. A haemorrhagic mass of 300mm diameter was attached to the tail of the spleen (Figs. 52, 53). Histological examination confirmed that this was a haemangiosarcoma. The mass was subsequently frozen and sectioned to demonstrate its cystic structure.

Fig. 51   An ultrasonograph of a mylticystic mass (Case 15, splenic haemangiosarcoma). The mass consists of both anechoic and hyperechoic areas.





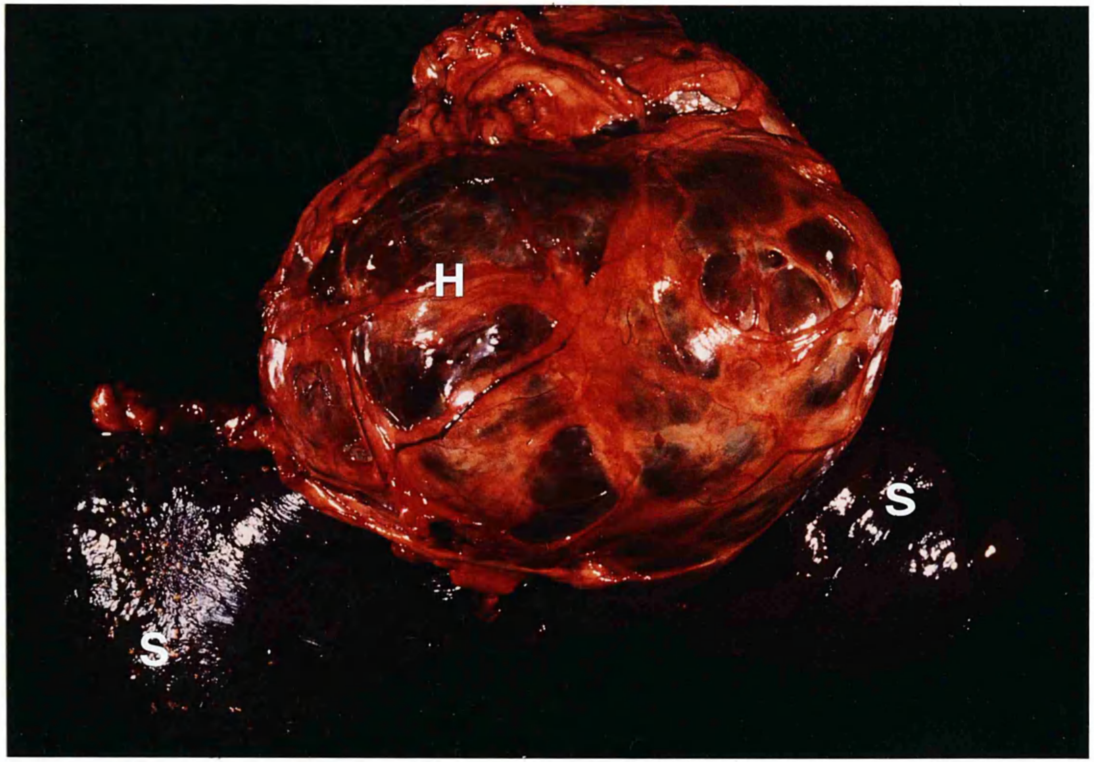


Fig. 52 The haemangiosarcoma (H) attached to the spleen (S). (Case 15).

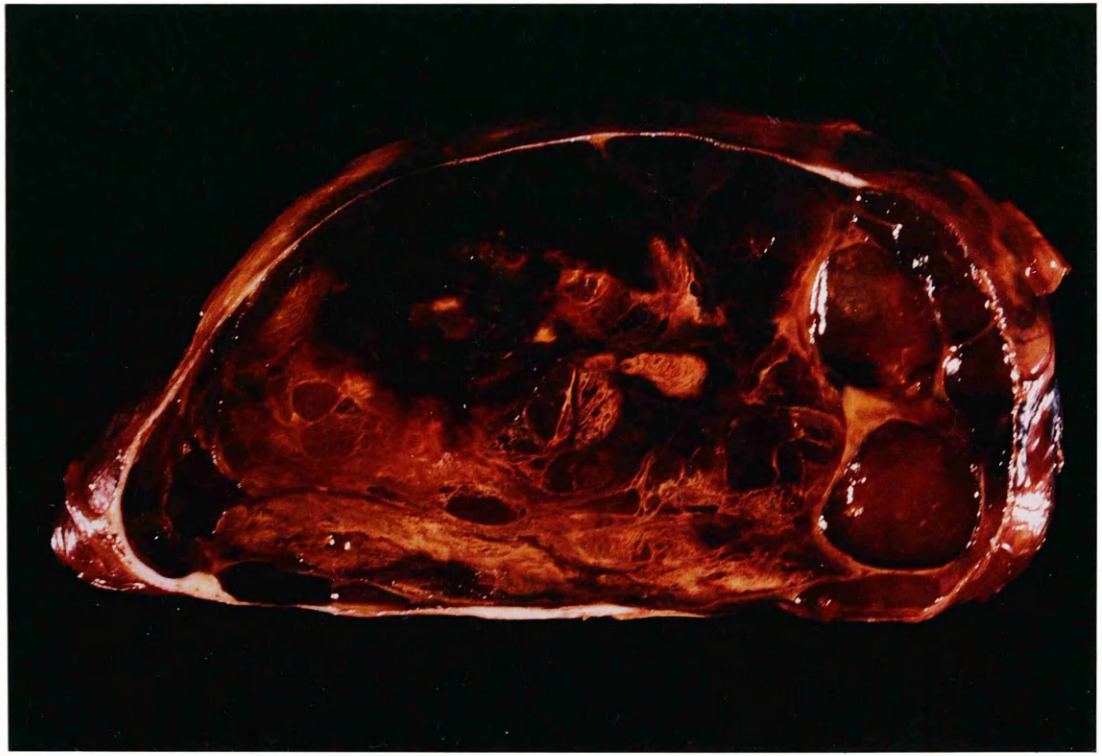


Fig. 53 A frozen section of the haemangiosarcoma (Case 15). This illustrates that the mass was composed of numerous cysts.

CASE SIXTEEN

A five year-old Thoroughbred Gelding.

Presenting Signs: The horse presented with a two week history of polydipsia and polyuria. The trainer had observed that the horse had been dull for two to three weeks prior to the onset of these signs.

Clinical Findings: The horse was thin and slightly dull. His water consumption averaged 20 gallons per day (normal, up to 10 gallons per day). A Grade 11/V bilateral systolic murmur was detected on auscultation of the heart. On rectal examination, a firm mass was palpable on the left side of the abdomen lying ventrolateral to the left kidney. The caudal border of the spleen was firm, rounded and lay immediately cranial to the pelvic inlet. Paracentesis abdominis was performed at several sites and yielded whole blood on each occasion; this was considered to have resulted from splenic puncture.

Laboratory Findings: The horse was anaemic (haematocrit 0.2-0.24 ll^{-1}, normal 0.3-0.53 ll^{-1}; total red cell count 4.4-5.04 x 10^{12} l^{-1}, normal 6.5-12.5 x 10^{12} l^{-1}). The biochemical findings are listed in Table 31. 29

The concentrations of serum phosphate were markedly elevated whereas concentrations of serum calcium were high but remained within the normal range. Serum aspartate transferase concentrations were consistently elevated and serum urea and creatinine concentrations were moderately

TABLE 29 : THE BLOOD BIOCHEMICAL FINDINGS ON FIVE OCCASIONS FOLLOWING HOSPITALISATION (DAY O) OF CASE SIXTEEN

	Day 0	8	11	13	18	Normal Range (Mean)
Urea mmol l^{-1}	6.2	8.9	9.4	9.1	9.2	0-6.64
Creatinine umol l^{-1}	212	239	221	194	221	62-133
Bilirubin umol l^{-1}	58	36	17	31		0-35.6
Alkaline Phosphatase IU l^{-1}	57	231	231	244	963	20-480
Aspartate Transferase IU l^{-1}	4649	1284	1822	1084	885	90-240
Gamma Glutamyl Transferase IU l^{-1}	33	32	27	25	25	0-25
Total Protein g l^{-1}	74	72	70	74	70	60-83
Albumin g l^{-1}	43	36	39	39	40	30
Globulin g l^{-1}	31	36	31	35	30	38
Sodium mmol l^{-1}	135	138	133	136	136	130-151 (139)
Potassium mmol l^{-1}	3.8	3.5	3.2	3.4	2.9	2.6-5.2 (4.0)
Chloride mmol l^{-1}	89	87	86	84	87	94-113 (104)
Calcium mmol l^{-1}	3.1	3.1	2.85	3.16	3.12	2.7-3.38 (3.06)
Magnesium mmol l^{-1}	0.45	0.54	0.82	0.7	0.69	0.69-1.27 (0.94)
Phosphate mmol l^{-1}	1.83	2.6	2.43	2.09	2.3	0.9-1.93 (1.42)
Glucose mmol l^{-1}	4.2	ND	4.3	ND	4.1	2.7-55
Cortisol nmol l^{-1}	ND	ND	ND	59	ND	10.8-182.2

ND = not done

elevated.

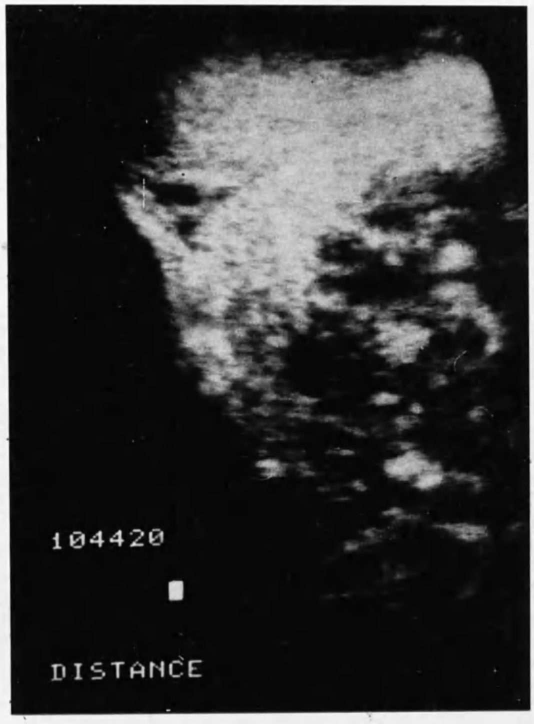
The urine had a low specific gravity (1.0011, normal 1.01-1.04). A water deprivation test demonstrated that the horse was unable to concentrate urine over a 20-hour period. Qualitative examination of the urine for glucose, ketones, blood pigments and bilirubin was negative.

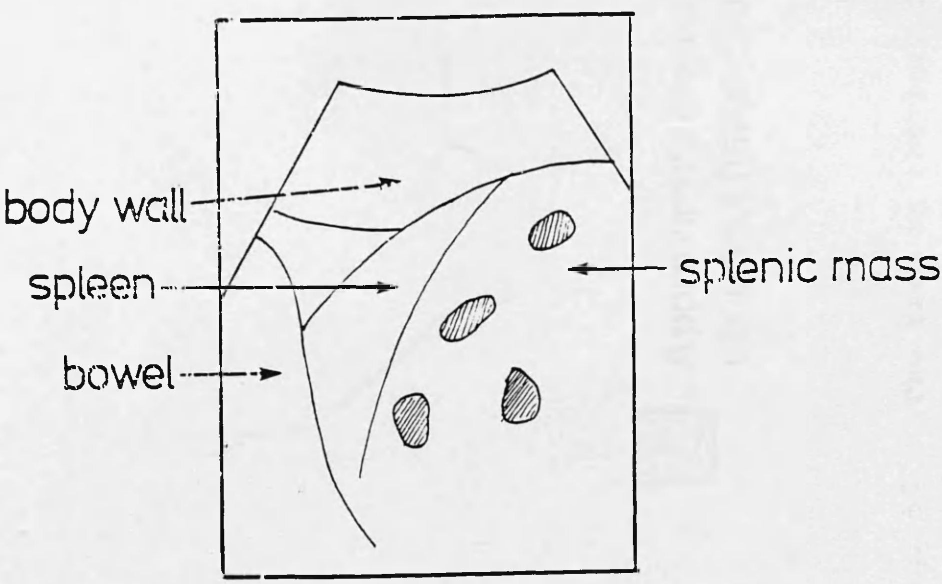
Ultrasonographic Findings: The left kidney was identified in the sublumbar fossa and it appeared to be of normal size, shape and echogenicity with a smooth outline suggesting that the capsule was intact. Ventral to the kidney a mass composed of numerous irregularly-shaped hyperechoic nodules of up to 30mm diameter extended caudally to the inguinal region. These nodules were interspersed with anechoic areas. The ventral border of this area was obscured by a hyperechoic area with acoustic shadowing which represented the large colon (Figs. 54, 55). Cranially the mass was continuous with splenic tissue which had normal echogenicity. A blood vessel could be identified running from the normal splenic tissue into the area of abnormal echogenicity which indicated that the mass was confluent with the spleen. Ultrasonographic examination of the liver and the right kidney revealed no abnormality.

Diagnosis: The diagnosis was of splenomegaly and splenic neoplasia in association with anaemia and impaired renal function.

Confirmation of the Diagnosis: On post-mortem examination,

Fig. 54 An ultrasonograph of the splenic mass (Case 16, splenic lymphosarcoma). The spleen lies between the body wall and bowel and the mass has a heterogeneous echogenicity.





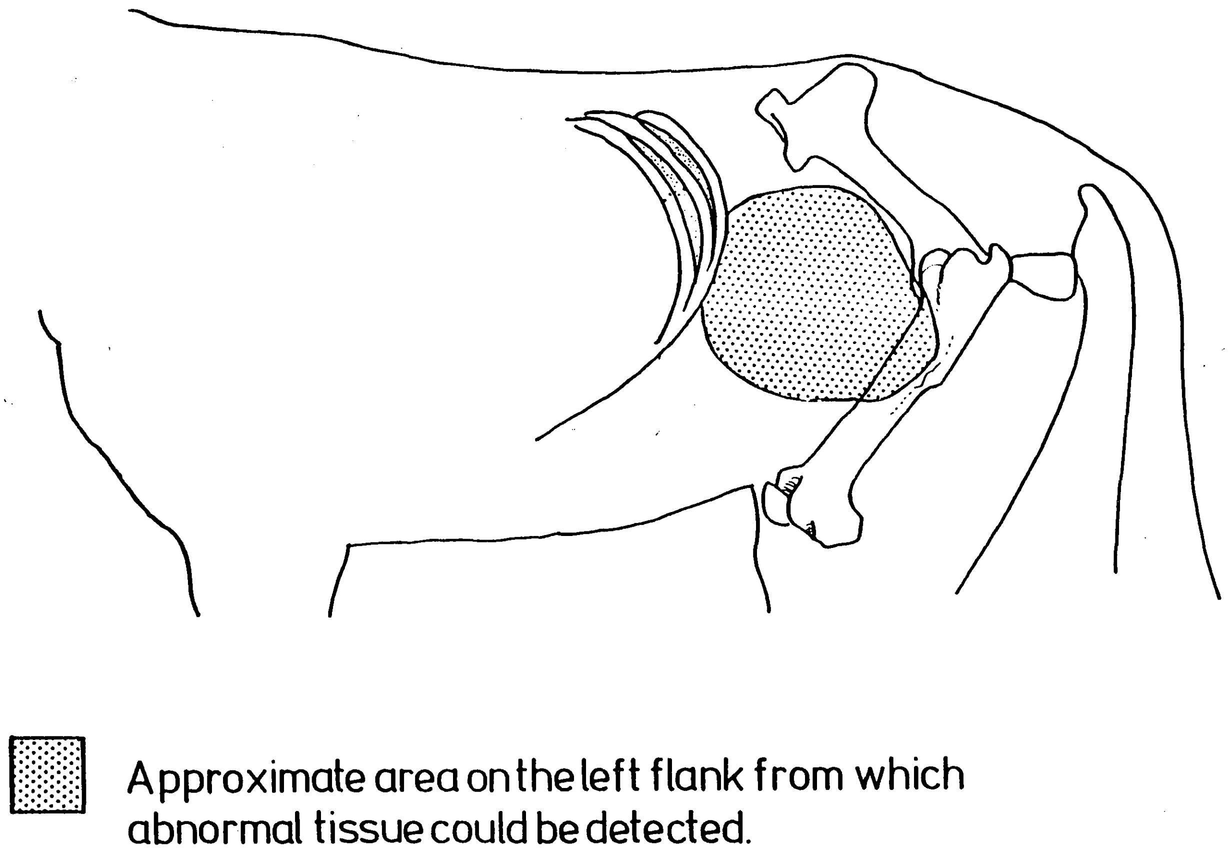


Fig. 55 The area on the left flank in which abnormal splenic tissue was detected. (Case 16).

the spleen was enormously enlarged and congested. In the dorsal half there was a huge nodular white tumour (Fig. 56). Its cut surface was smooth and white except for a considerable number of pale yellow areas of necrosis (Fig. 57). On histological examination this was found to be a splenic lymphosarcoma. The liver was enlarged and pale with fatty infiltration. At numerous sites in the cardiovascular system, plaques of mineralised tissue were identified. Histological examination of the kidney revealed widespread changes which were characteristic of hypercalcaemic nephropathy. The parathyroid glands were normal.

The final diagnosis was of splenic lymphosarcoma in association with pseudohyperparathyroidism.

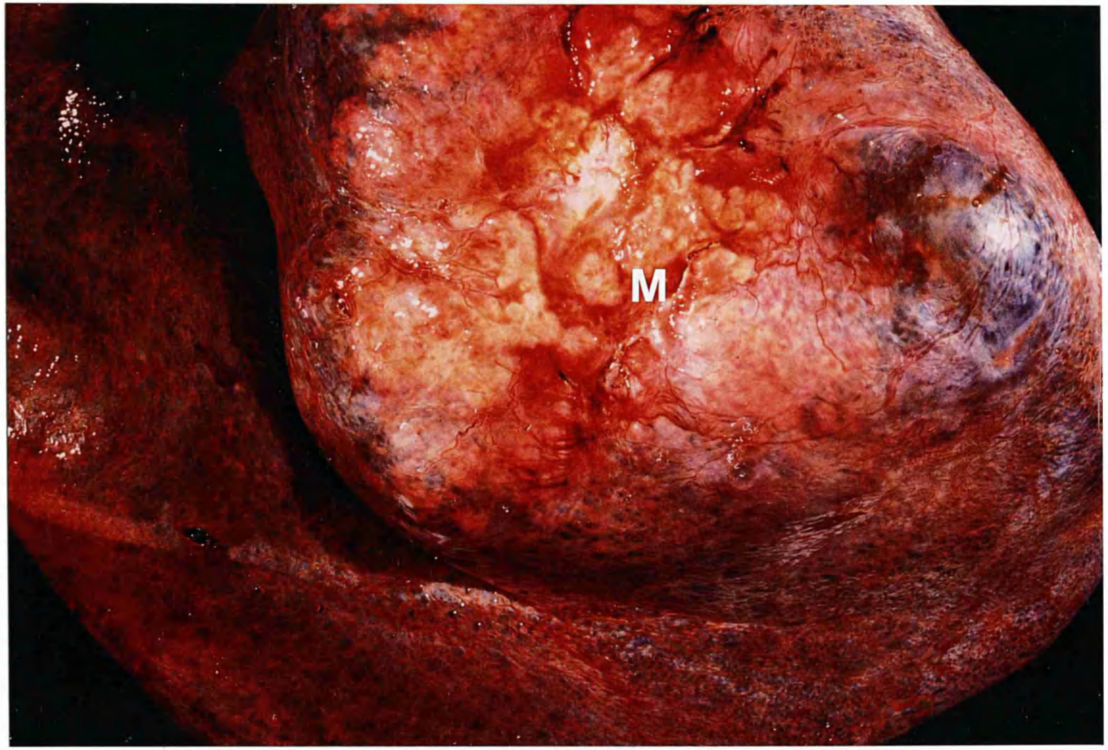


Fig. 56 The splenic mass (M). (Case 16, lymphosarcoma).

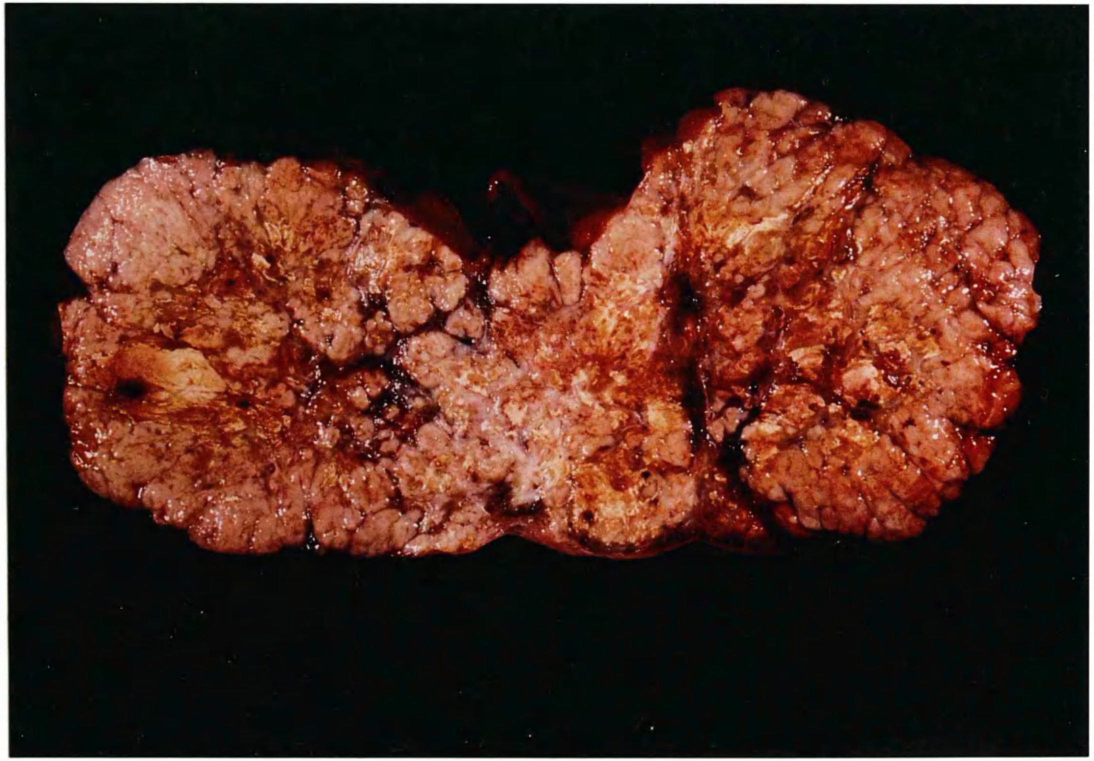


Fig. 57   The cut surface of the splenic lymphosarcoma. (Case 16).

CASE SEVENTEEN

A three year-old male German Shepherd dog.

Presenting Signs: The referring veterinary surgeon had detected a caudal abdominal mass during a routine clinical examination when the dog was presented for vaccination. No clinical signs were associated with it.

Clinical Findings: A mass was palpable in the caudal abdomen which had an eggshell-like texture. No further abnormalities were detected.

Radiographic Findings: A flocular mineralised opacity of irregular shape was detected in the caudoventral abdomen on a lateral abdominal radiograph (Fig. 58).

Ultrasonographic Findings: An anechoic structure was apparent lying cranial and dorsal to the bladder which lay in the caudoventral abdomen (Fig. 59). This anechoic area measured 65 x 70mm longitudinally and 60 x 65mm transversely. The prostate appeared to be of normal size and echogenicity.

Diagnosis: Mineralised paraprostatic cyst.

Confirmation of the Diagnosis: An exploratory laparotomy was performed and a paraprostatic cyst removed. The wall was composed of lattice-like calcified plaques embedded in soft tissue (Fig. 60). Sectioning of the structure demonstrated its cystic nature.

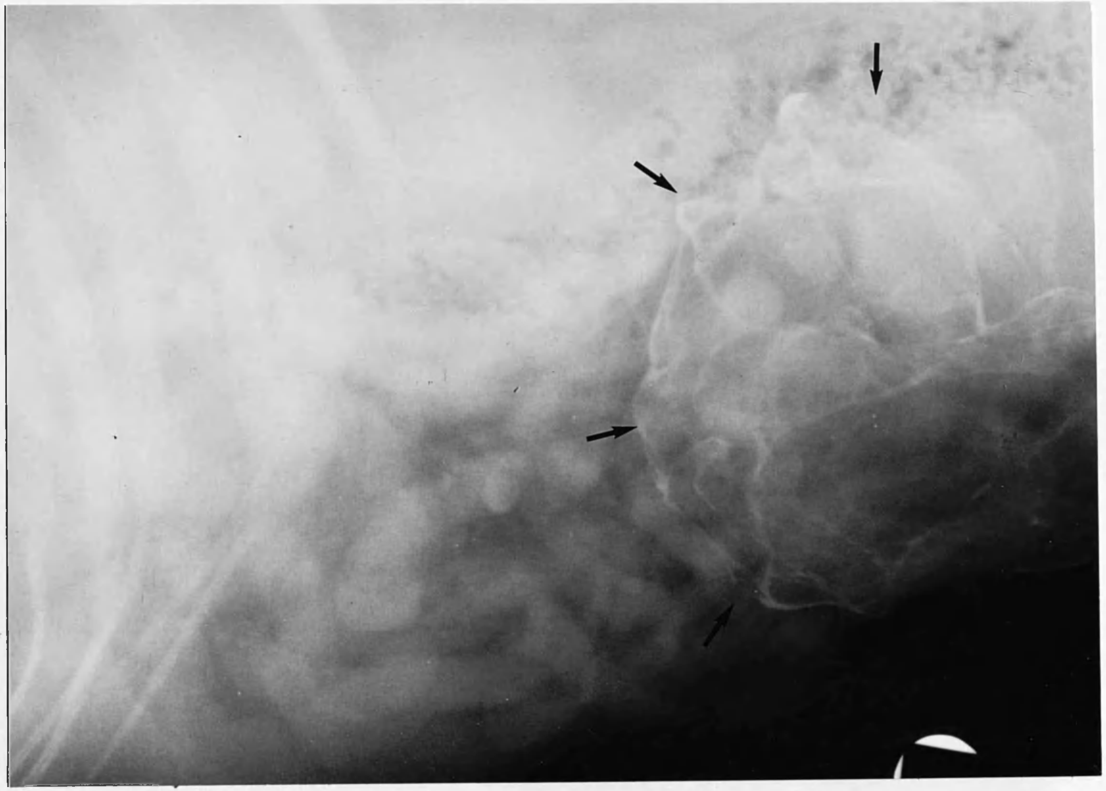
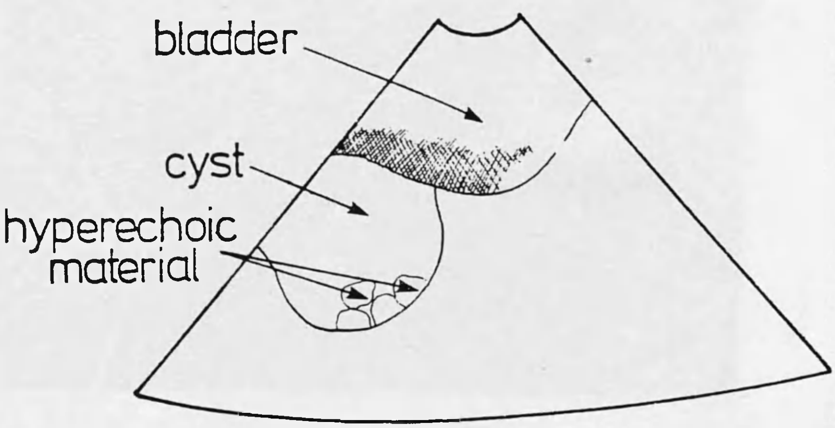


Fig. 58 A lateral abdominal radiograph (Case 17, paraprostatic cyst). A partially mineralised opacity visible in the caudal abdomen (↑↑↑↑).

Fig. 59 A caudal abdominal ultrasonograph (Case 17, paraprostatic cyst). Two anechoic structures are visible : the most ventral is the bladder; the most dorsal is a cyst which contained some hyperechoic material.



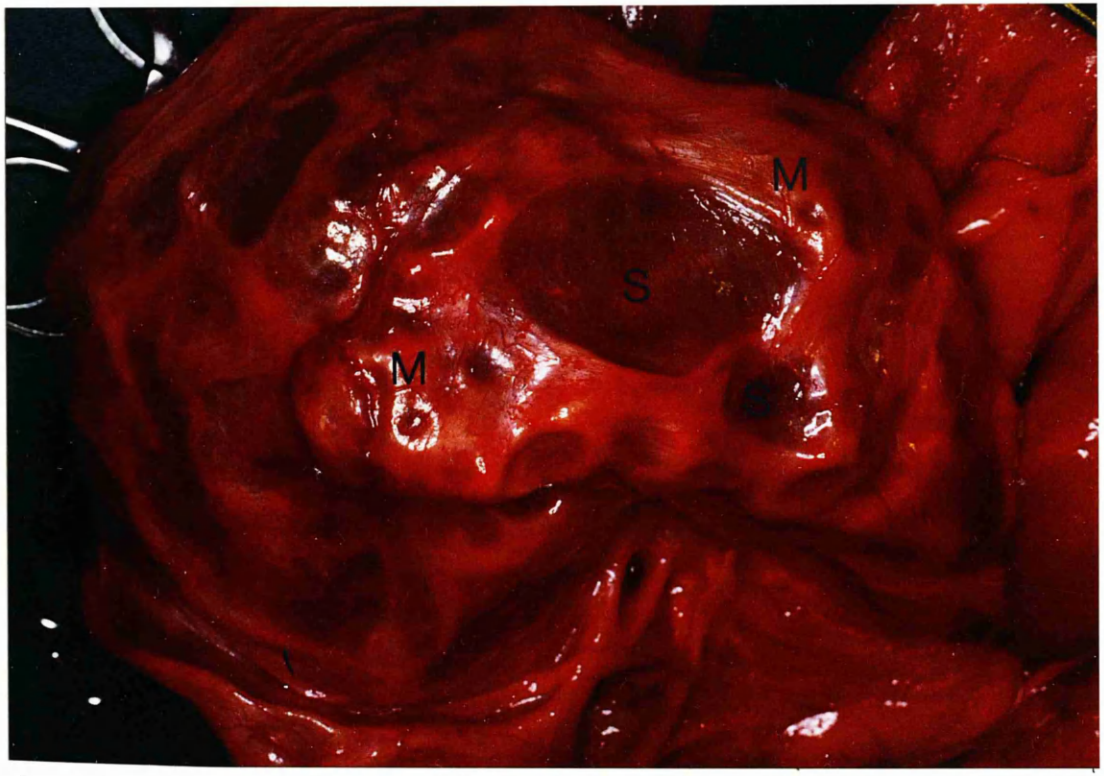


Fig. 60 The paraprostatic cyst (Case 17). Its wall was composed of a lattice of mineralised areas (M) interspersed with soft tissue (S).

CASE EIGHTEEN

An 11 year-old male German Shepherd dog.

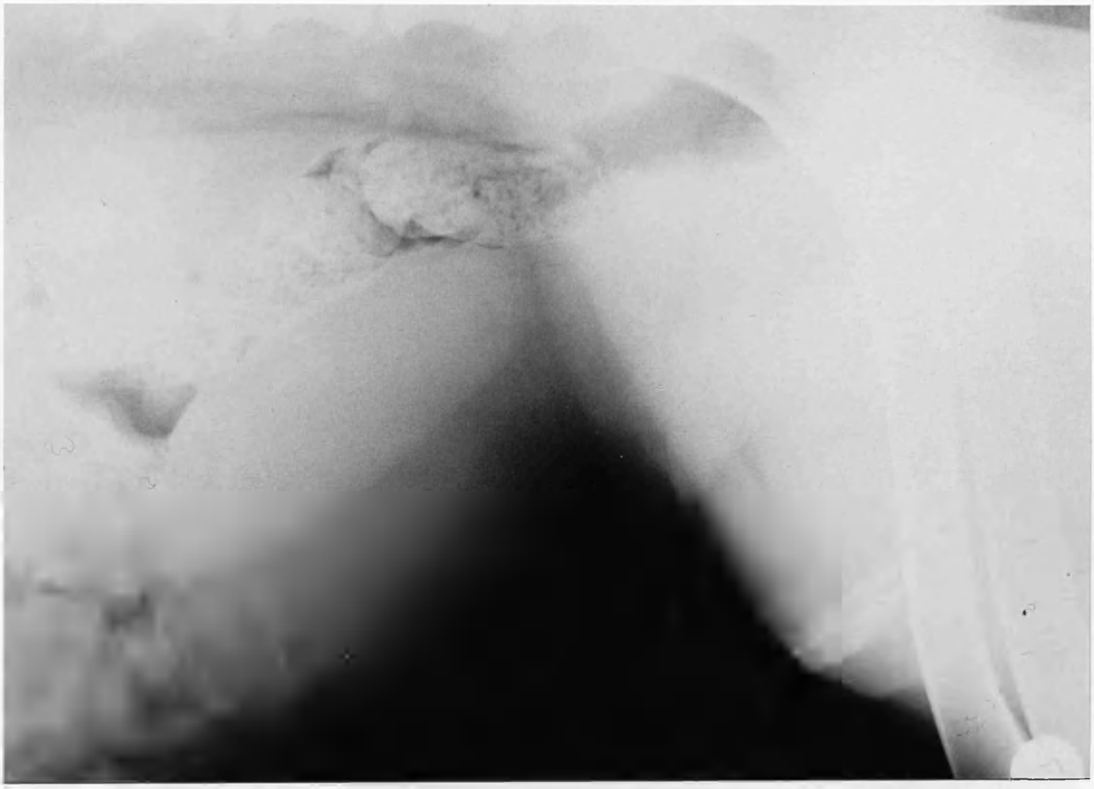
Presenting Signs: Pain demonstrated on defaecation.

Clinical Findings: The dog had difficulty in passing faeces which were reduced in volume and of watery consistency. On rectal examination, the anal sacs were distended and the prostate gland was firm and painful to the touch but there was no evidence of a perineal hernia.

Radiographic Findings: A lateral caudal abdominal radiograph demonstrated two overlapping, circular soft tissue opacities lying cranial to the pelvis (Fig. 61). There was dorsal displacement of the colon at this point. A pneumocystogram indicated that the bladder was displaced dorsally by a circular soft tissue density lying on the abdominal floor (Fig. 62).

Ultrasonographic Findings: The prostate measured 30mm in diameter. The borders were smooth and the gland was symmetrical. The urethra, which measured 7mm in diameter, could be traced from its origin at the neck of the bladder. A hypoechoic structure measuring 101 x 99 x 95mm, with a wall of 10mm thickness, was present in the caudal abdomen (Fig. 63). This structure contained small hyperechoic particles and had a double layered appearance, the ventral area was completely anechoic and was distinctly delineated from a hypoechoic dorsal area. The structure displaced both the bladder and the colon dorsally. The bladder was

Fig. 61 A lateral abdominal radiograph (Case 18, paraprostatic cyst). Two overlapping soft tissue opacities are visible in the caudoventral abdomen.



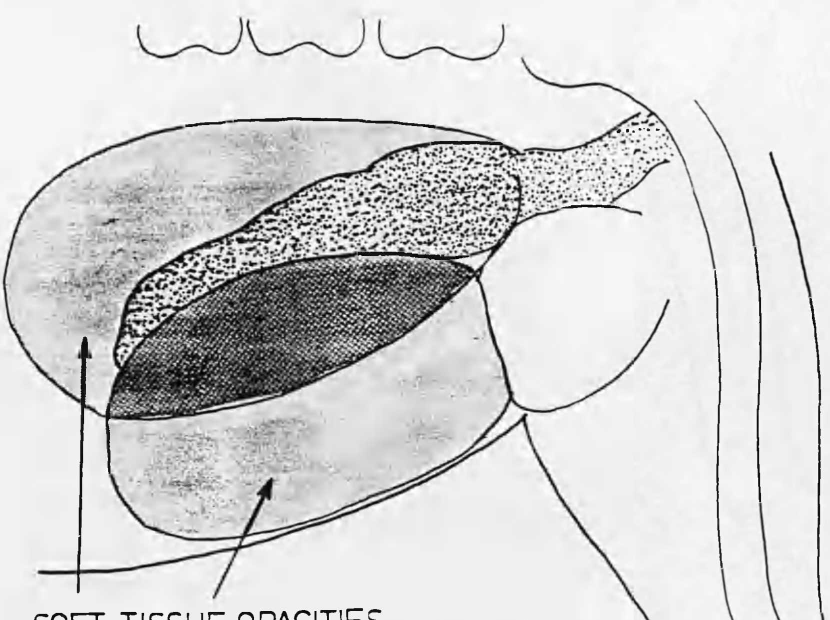


Fig. 62 A lateral pneumocystogram (Case 18, paraprostatic cyst). The pneumocystogram demonstrated that the more dorsal opacity was the bladder.

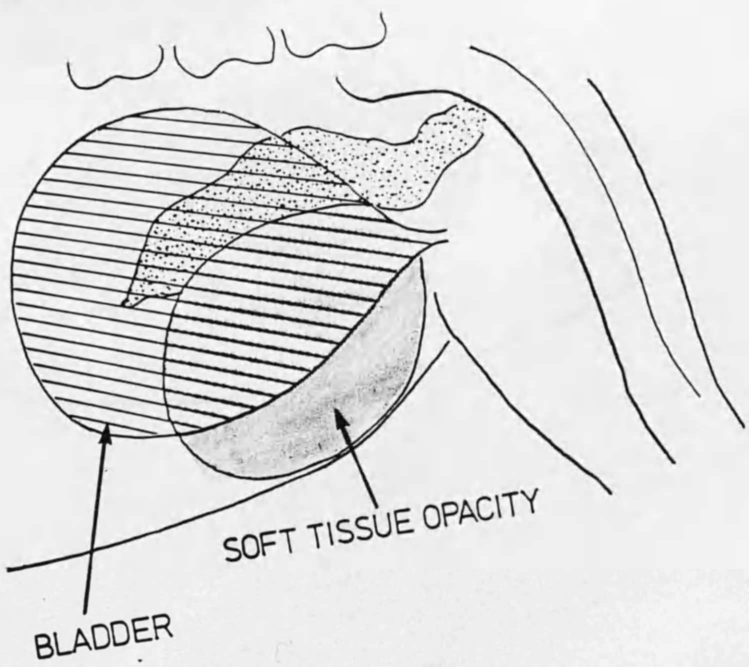
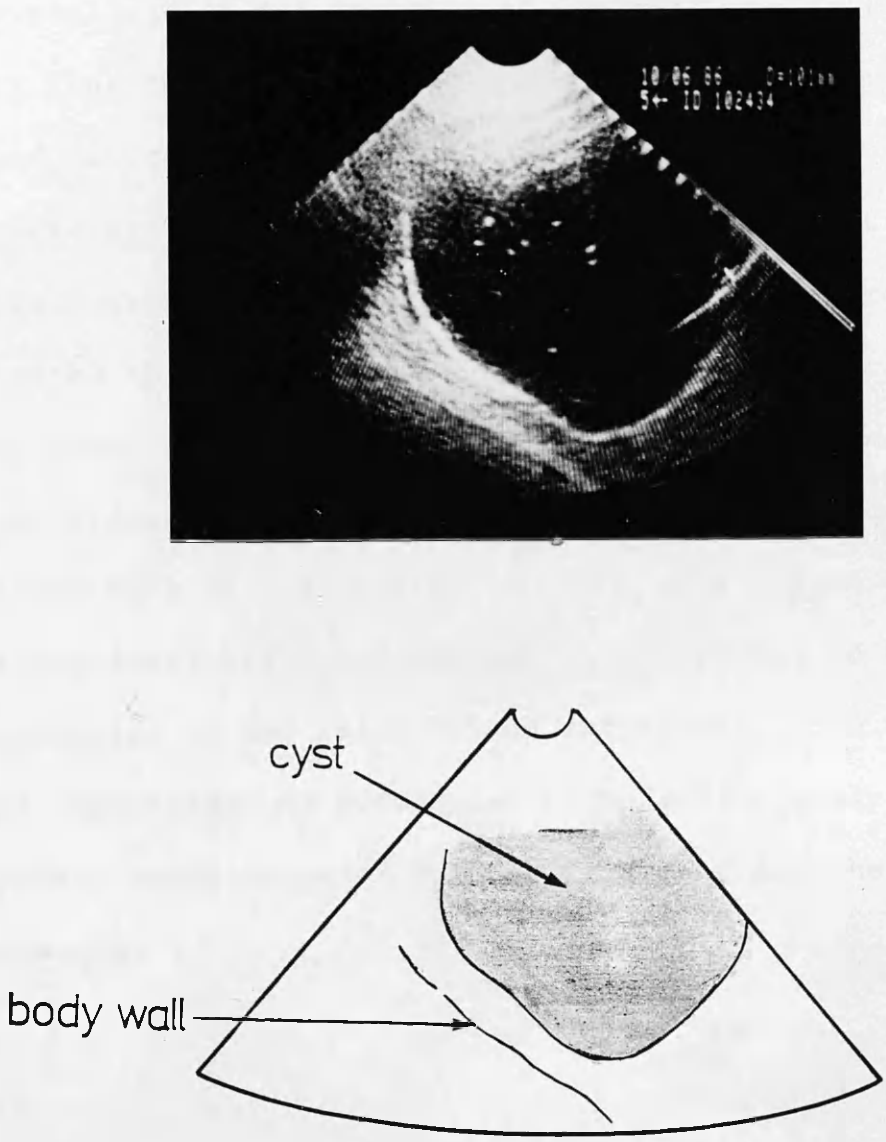


Fig. 63 A caudal abdominal ultrasonograph (Case 18, paraprostatic cyst). The cyst is represented by an anechoic area which contains hyperechoic foci. The body wall has produced a strongly echogenic line.



further identified by injecting saline via a urinary catheter. This caused microbubbles to accumulate within the bladder but not the cyst.

Diagnosis: Paraprostatic cyst.

Confirmation of the Diagnosis: A laparotomy was performed which confirmed the presence of a paraprostatic cyst. Marsupialization and drainage of the cyst was followed by daily flushing of the area with an irritant solution to induce fibrosis.

Post-Operative Ultrasonographic Findings: Repeat ultrasonographical examinations one week after surgery indicated that the prostate was now 50mm in diameter and a small anechoic area was identified within the gland. Caudal to the prostate an irregularly shaped fluid collection remained with no distinct wall. The area around the marsupialization wound could not be imaged due to the accumulation of gas which caused artifacts. The volume of fluid identified was considered to be sufficiently diminished to permit curtailment of further treatment and the animal was discharged.

CASE NINETEEN

A two year-old male German Short-haired Pointer.

Presenting Signs: On initial presentation to this hospital, the dog exhibited signs related to a cervical abscess following trauma. There was no difficulty in urination or defaecation at that time. A paraprostatic cyst was diagnosed as an incidental finding. The dog was subsequently represented two months later with faecal and urinary tenesmus.

Clinical Findings: A large mass was palpable in the ventral abdomen. The dog was straining frequently and passed small amounts of discoloured urine. No other abnormalities were detected.

Radiographic Findings: A lateral radiograph of the abdomen demonstrated two oval soft tissue opacities lying in the caudal abdomen. A pneumocystogram demonstrated that the more ventral of these was the bladder.

Ultrasonographic Findings: Two anechoic structures were identified in the caudal abdomen. The presence of acoustic enhancement was evidence that they were fluid-filled. Insertion of saline solution with air microbubbles via a urinary catheter caused numerous hyperechoic particles to accumulate in the more ventral of these two structures, confirming that this was the bladder. The cyst measured 60 x 60 x 90mm and lay to the right of the prostate over which it extended both cranially and caudally. The prostate was of normal size and shape but several small, poorly defined anechoic areas were distributed throughout its substance.

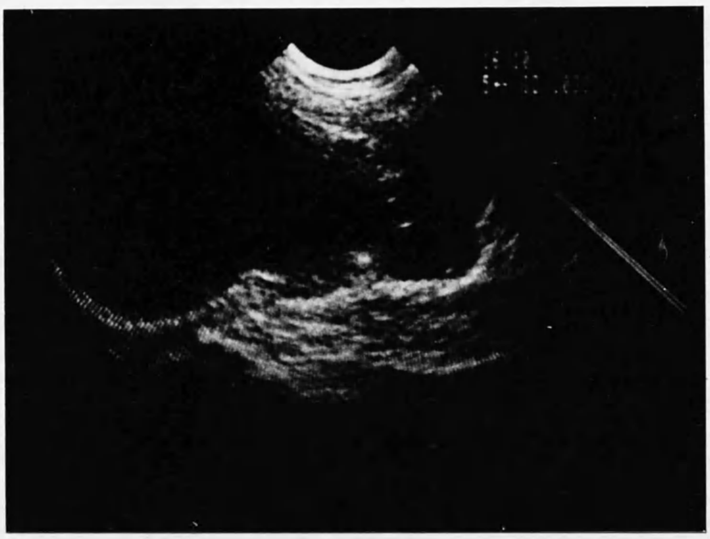
Diagnosis: Paraprostatic cyst.

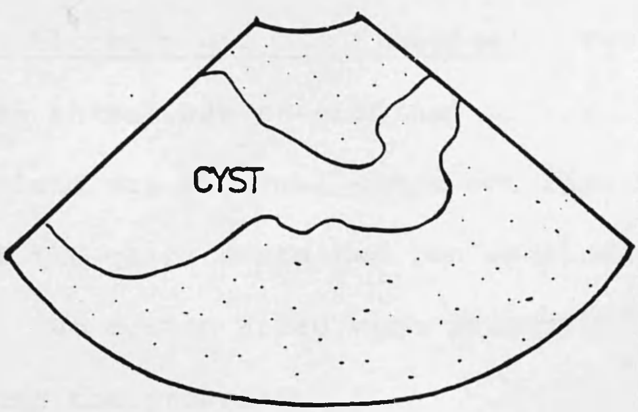
Confirmation of the Diagnosis: A laparotomy was performed and the cyst identified and two drains inserted into the cavity. Cytological examination of the fluid aspirated from the cyst indicated that it had a total white cell count of $21.8 \times 10^{9} l^{-1}$ of which 90% were neutrophils. No bacteria were cultured.

Post-Operative Ultrasonographic Findings: One week post-operatively, the dog was re-examined ultrasonographically to assess if there had been resolution of the cyst. The prostate gland measured approximately 45mm in diameter. Several small ill-defined anechoic areas were present within the gland. Dorsocaudal to the prostate a 30 x 50 x 70mm area was identified which was anechoic ventrally (Fig. 64). The dorsal portion was separated from the rest of the area by hyperechoic septa and had a uniform hypoechoic appearance. Cranial to the prostate a small anechoic area was identified which was surrounded by a hyperechoic wall. This appearance was interpreted as representing partial resolution of the cyst.

One month post-operatively, the dog was re-examined ultrasonographically. The bladder was empty and, therefore, small at the time of examination. It was identified by insertion of a saline solution mixed with air

Fig. 64 A caudal abdominal ultrasonograph (Case 19, paraprostatic cyst). One week post-operatively, the cyst is represented by an anechoic area.





to produce microbubbles. The prostate gland appeared to have decreased in size, measuring 21 x 30mm in a transverse plane. Anechoic areas were present within the gland and an anechoic area was identified dorsal to the prostate (Fig. 65). It had a distinct thick wall and was divided into two areas by a hyperechoic septae (Fig. 66). Its longitudinal dimensions were 40 x 30mm. This was interpreted as incomplete regression of the paraprostatic cyst.

<u>Confirmation of the Diagnosis</u>: An exploratory laparotomy was performed. Two connecting cysts were identified in the caudal abdomen lying dorsal to the prostate and the contents were removed. One cyst was marsupialized via the right ventral abdominal wall. A drain was inserted into the other cyst as its removal was prevented due to attachment of blood vessels. Castration was performed.

<u>Post-Operative Ultrasonographic Findings</u>: Two weeks post-operatively the animal was re-examined ultrasonographically. The prostate gland was a normal shape and size but the dorsal part of the gland contained two anechoic areas of 5mm diameter. No cystic areas were identified in the area surrounding the prostate.

Fig. 65 A caudal abdominal ultrasonograph (Case 19, paraprostatic cyst and prostatic retention cysts). Within the prostate gland an anechoic retention cyst was identified and an anechoic area lay adjacent to the prostate which represented the remnant of the paraprostatic cyst one month after surgery.

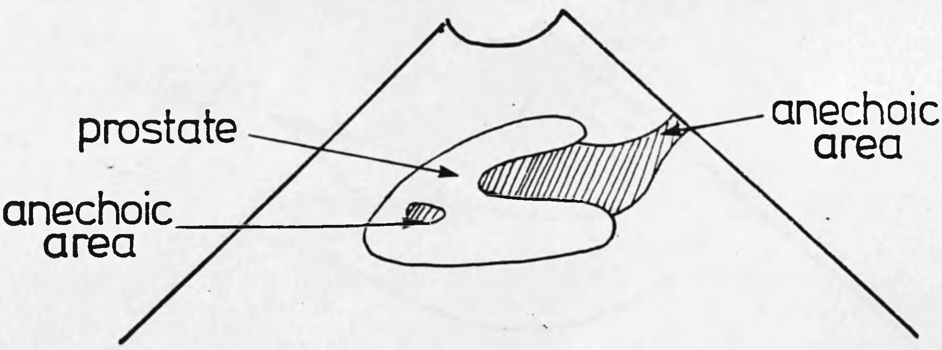
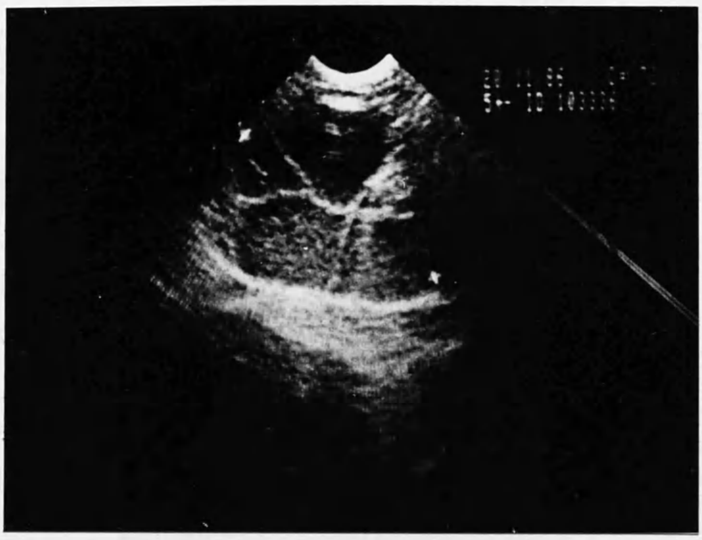
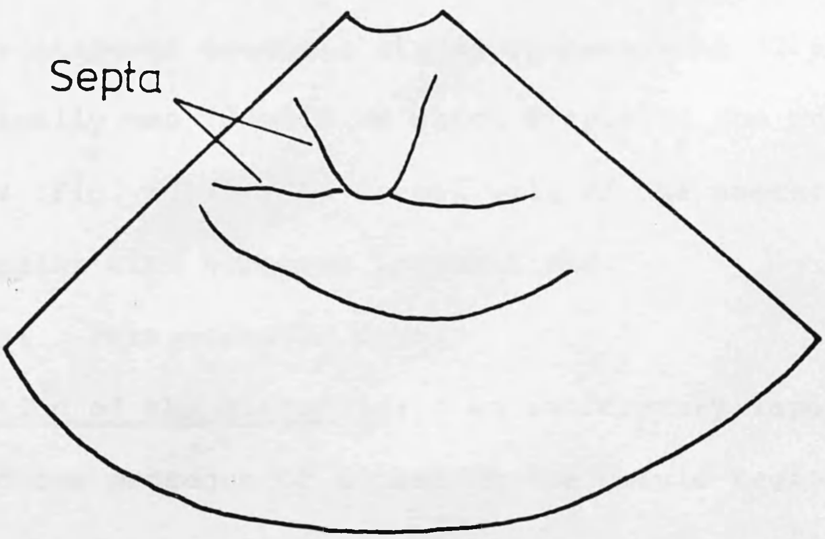


Fig.66. A caudal abdominal ultrasonograph (Case 19. paraprostatic cyst). One month after surgery, the paraprostatic cyst was divided into anechoic and hypoechoic areas by septae.





CASE TWENTY

A four year-old male German Shepherd dog.

Presenting Signs: Faecal tenesmus.

Clinical Findings: Pain was evident when the dog strained to pass faeces and frequently this procedure was unproductive. The dog squatted to pass small amounts of urine and frequently licked its perineal area. Rectal examination revealed a downward deviation of the dorsal rectal wall.

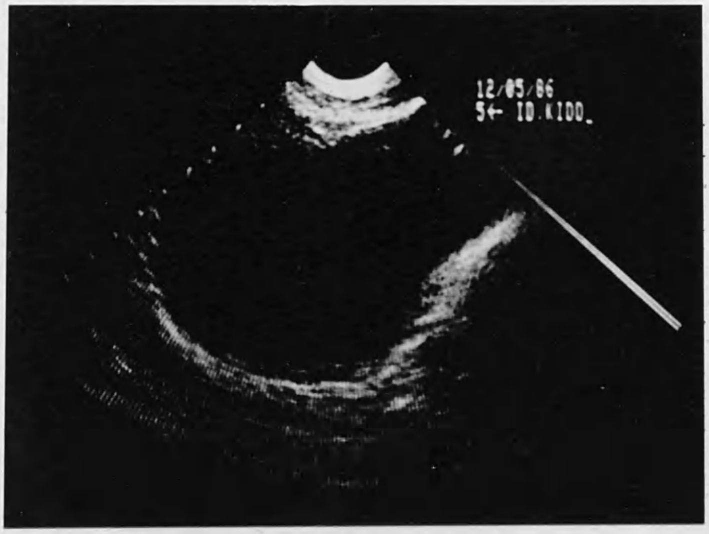
Radiographic Findings: A lateral abdominal radiograph and a pneumocystogram indicated that the bladder and prostate were of normal size but both structures were displaced cranially by an ill-defined intrapelvic soft tissue mass.

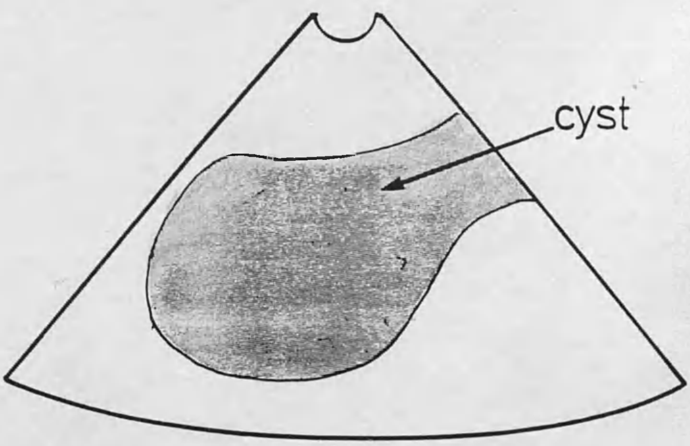
Ultrasonographic Findings: The prostate measured 56 x 66mm longitudinally and 54 x 33mm transversely. The contours were smooth and the echogenicity was normal. Caudodorsal to the prostate an anechoic structure measuring 72 x 91mm longitudinally was identified which displaced the colon to the right (Fig. 67). The dorsal wall of the anechoic area was irregular with numerous indentations.

Diagnosis: Paraprostatic cyst.

Confirmation of the Diagnosis: An exploratory laparotomy confirmed the presence of a mass in the pelvic region. However, the thick walls and enlargement of the sublumbar lymph nodes suggested that it was neoplastic. The animal was euthanased and post-mortem examination confirmed the

Fig. 67 An ultrasonograph of the pelvic region (Case 20, anal sac neoplasia). An anechoic area represents the cystic mass.





cystic nature of the mass (Figs. 68, 69), which was found on histological examination to be an anal gland tumour.

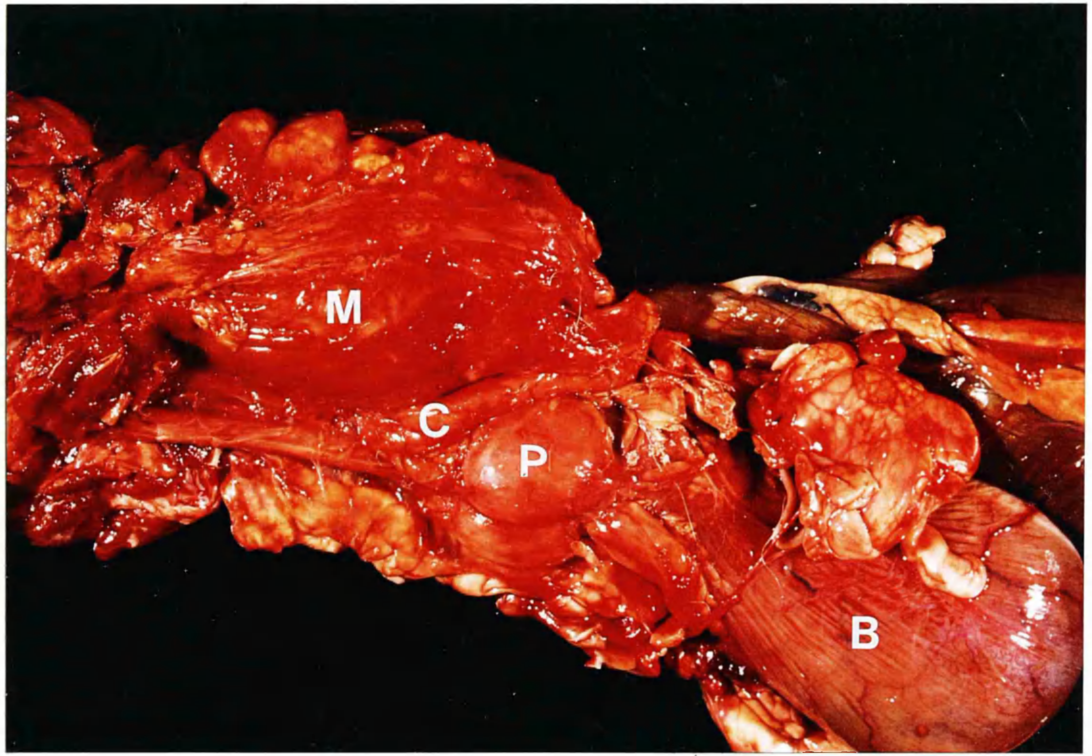


Fig. 68 The caudal abdominal and pelvic organs (Case 20, anal sac neoplasia). On post-mortem examination, a mass (M) was identified which lay dorsal to the colon (C) and caudodorsal to the prostate gland (P) and the bladder (B).

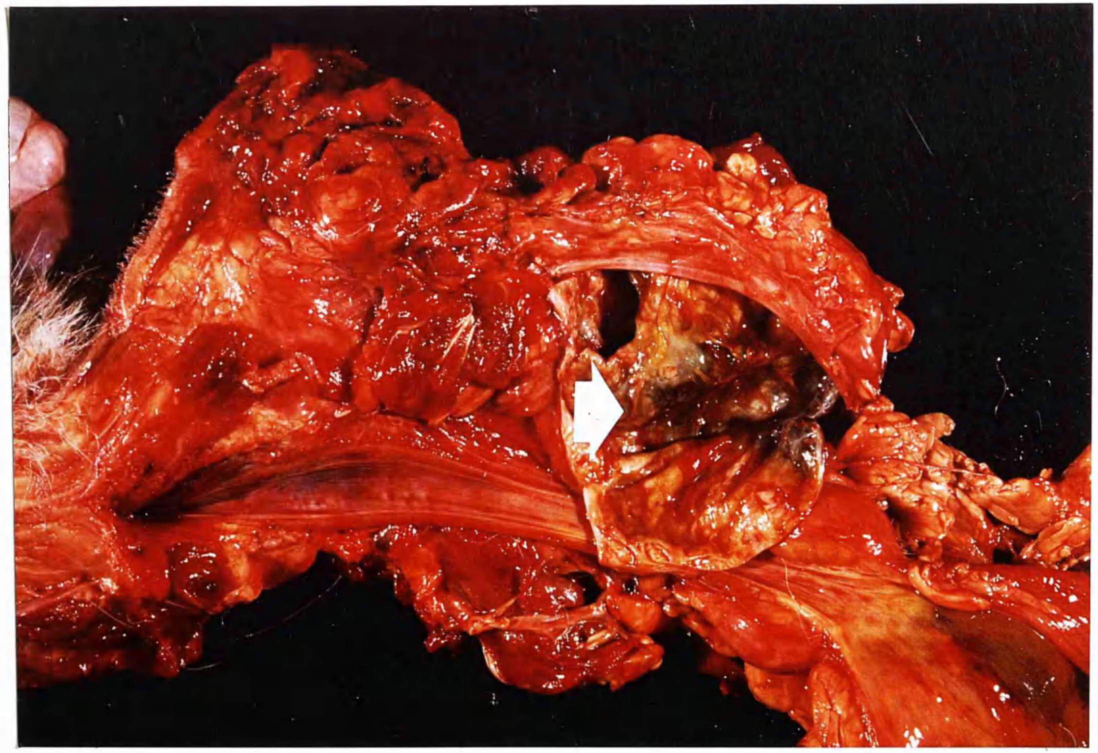


Fig. 69 The sectioned intrapelvic mass (↑). (Case 20, anal sac neoplasia).

CASE TWENTY-ONE

A nine year-old male German Shepherd dog.

Presenting Signs: Dyschezia.

Clinical Findings: Pain was evident on defaecation and ribbon-shaped faeces were produced. A large irregular-shaped mass was palpable in the caudal abdomen.

Radiographic Findings: A lateral abdominal radiograph demonstrated a poorly-defined bladder opacity which was displaced dorsally by an indistinct mass extending into the pelvic inlet, causing compression of the bladder neck and the colon. A pneumocystogram confirmed these findings.

Ultrasonographic Findings: The prostate gland was enlarged. The normal even granular appearance was disrupted by multiple indistinct hypoechogenic and hyperechogenic areas. An anechoic area was present within the gland immediately caudal and dorsal to the bladder neck.

Diagnosis: Benign prostatic hyperplasia or prostatic adenocarcinoma.

Confirmation of the Diagnosis: On exploratory laparotomy, numerous pea-sized nodules were found in the periprostatic tissue. The prostate gland was enlarged and contained a cystic area, as indicated ultrasonographically. The gross appearance of the prostate and local invasion was consistent with the diagnosis of prostatic adenocarcinoma and so the animal was euthanased. This diagnosis was subsequently confirmed histologically.

CASE TWENTY-TWO

A ten year-old male Crossbred dog.

Presenting Signs: Intermittent dysuria and urinary tenesmus which had progressively worsened over two months. Temporary remission of signs was observed following treatment with delmadinone acetate (Tardak, Syntex).

Clinical Findings: The dog was unable to pass urine. The faeces were normal and were passed without difficulty. Following catheterisation of the urinary bladder, 700 mls of urine were collected which were normal on gross examination. On rectal examination, the prostate was markedly enlarged and firm.

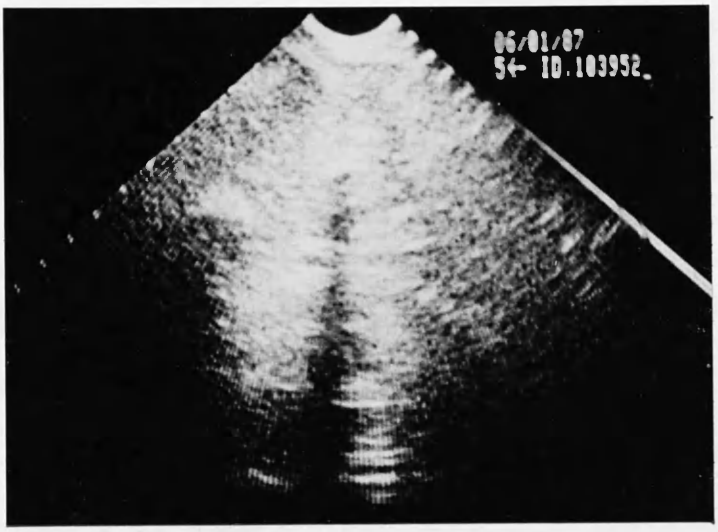
Radiographic Findings: A lateral abdominal radiograph demonstrated a large bladder which was displaced cranially by a soft tissue opacity in which there was some mineralisation. A pneumocystogram confirmed the position of the bladder. The prostate was irregular in shape and extended over the dorsal aspect of the bladder neck. The prostatic urethra was narrow. Focal mineralisation was evident within the ventral part of the gland and the sublumbar lymph nodes were enlarged.

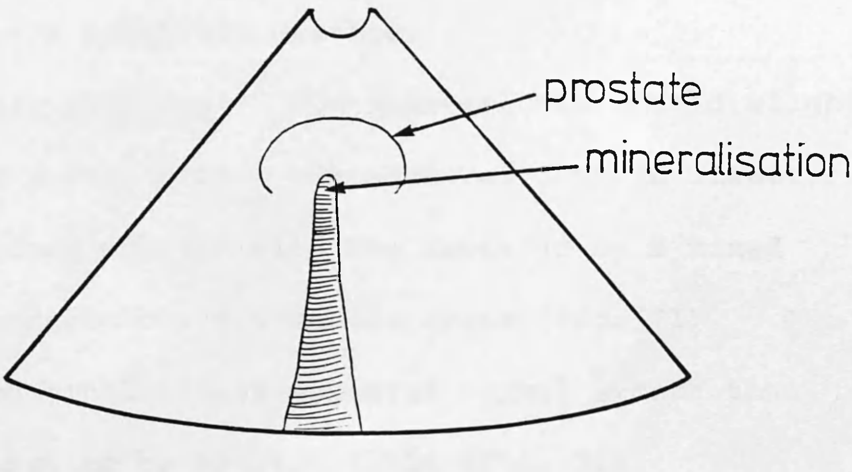
Ultrasonographic Findings: At the time of examination the bladder could not be identified as it had been catheterised and emptied immediately prior to the examination. The prostate lay cranial to the pelvic brim. The normal rounded shape was distorted and in a longitudinal plane the prostate was ovoid and measured 54mm from cranial to caudal pole and the margin appeared to be smooth. In a transverse plane the gland appeared roughly circular and measured 58mm in width. The caudal two-thirds of the gland had a more echogenic appearance than the rest of the prostate. Scattered throughout the gland were numerous anechoic areas causing a diffusely irregular appearance within the substance. An extremely echogenic area was identified in association with acoustic shadowing implying that there was mineralisation within the gland (Fig. 70). In view of the altered echogenicity, loss of symmetry and mineralised areas, the diagnosis of prostatic neoplasia was reached.

Diagnosis: Prostatic neoplasia.

Confirmation of the Diagnosis: An exploratory laparotomy was performed and the prostate gland was found to be enlarged, measuring 70 x 60 x 60mm. The substance was irregular with firm gritty areas and pus-filled areas. Histological examination of a biopsy of the gland confirmed the diagnosis of prostatic adencarcinoma.

Fig. 70 A prostatic ultrasonograph (Case 22, prostatic adenocarcinoma). Within the prostate gland an extremely echogenic area is producing acoustic shadowing. This represents mineralisation of the prostatic tissue.





CASE TWENTY-THREE

A ten year-old male Crossbred dog.

Presenting Signs: Over the past two months the dog had intermittently demonstrated faecal tenemus. This had become almost continuous over the previous two weeks.

Clinical Findings: The dog exhibited faecal tenemus. A fluid thrill was present on abdominal palpation indicating the presence of free abdominal fluid. On rectal examination, the prostate gland was not palpable. A prostatic wash failed to provide further information.

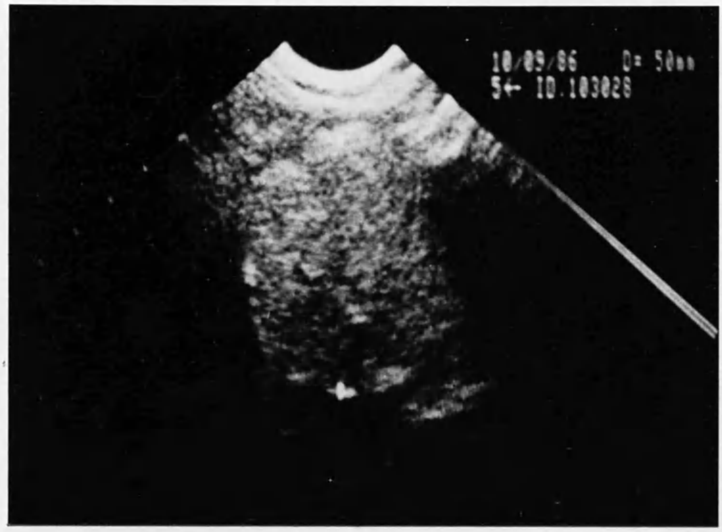
Radiographic Findings: No visceral detail was evident on a lateral abdominal radiograph due to a marked accumulation of free peritoneal fluid. A barium enema provided no further information, except that some mineralisation was noted in the region of the prostate. Positive contrast cystography indicated compression of the bladder neck and an irregular, narrow prostatic urethra.

Ultrasonographic Findings: The prostate was imaged slightly cranial to the pelvic brim. It measured 60mm in diameter. The normal uniform echogenicity was replaced by a mixed pattern of hyperechoic and anechoic areas (Fig. 71). The rest of the abdominal organs appeared normal except that they were delineated by ascitic fluid (Fig. 72).

Diagnosis: Prostatic neoplasia.

Confirmation of the Diagnosis: An exploratory laparotomy was performed. The prostate gland was enlarged and

Fig. 71 A prostatic ultrasonograph (Case 23, prostatic adenocarcinoma). The prostate gland is enlarged and its echogenicity is uneven. Anechoic areas are evident within its substance.



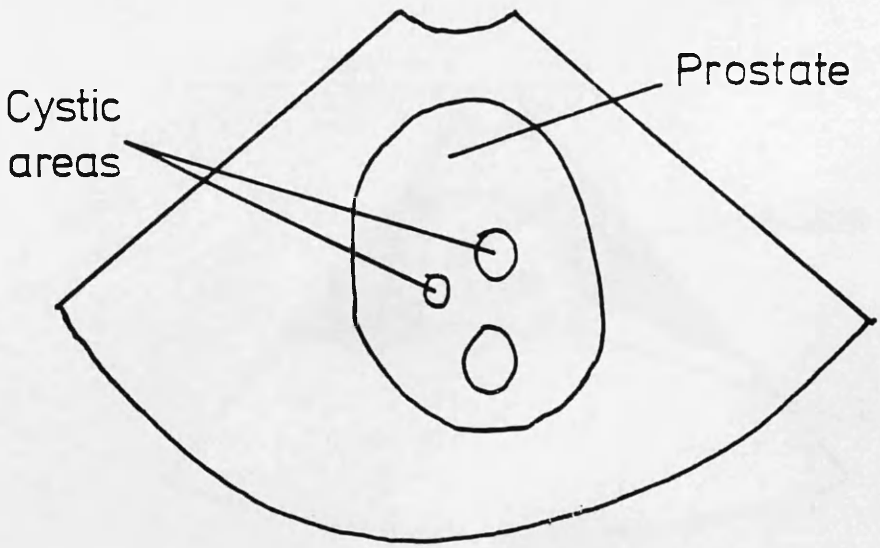
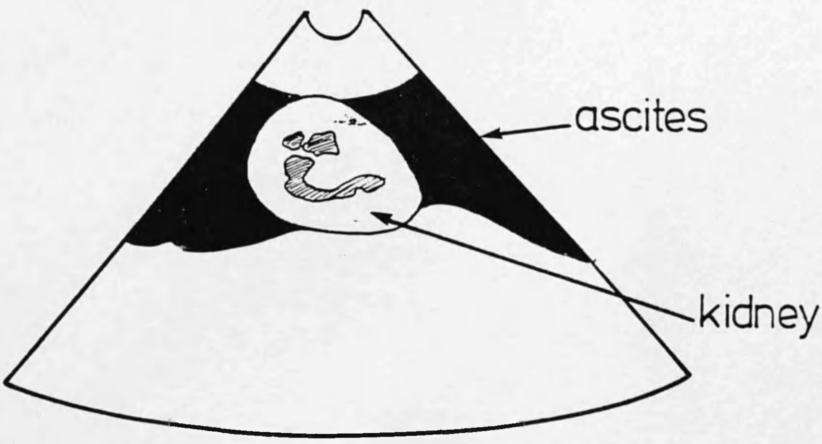


Fig. 72 A cranial abdominal ultrasonograph (Case 23, ascites). Ascitic fluid surrounds the left kidney and produces acoustic enhancement which reveals the detail of the kidney.



irregular. Its gross appearance was consistent with the diagnosis of prostatic neoplasia and, therefore, the dog was euthanased.

CASE TWENTY-FOUR

A 13 year-old Crossbred dog.

Presenting Signs: The dog demonstrated signs which were attributable to gingivitis. There was no evidence of prostatic disease.

Clinical Findings: On rectal examination the prostate gland was enlarged but not painful on palpation.

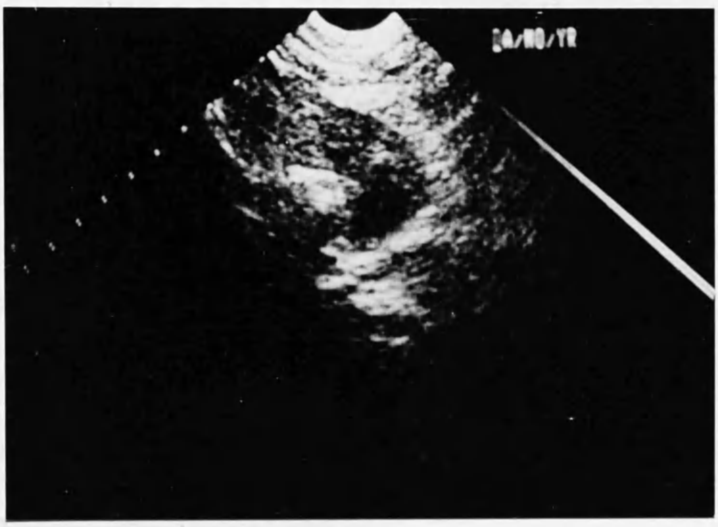
Radiographic Findings: A lateral caudal abdominal radiograph demonstrated enlargement of the prostate. There was no evidence of lymph node enlargement or periosteal reaction on the pelvis.

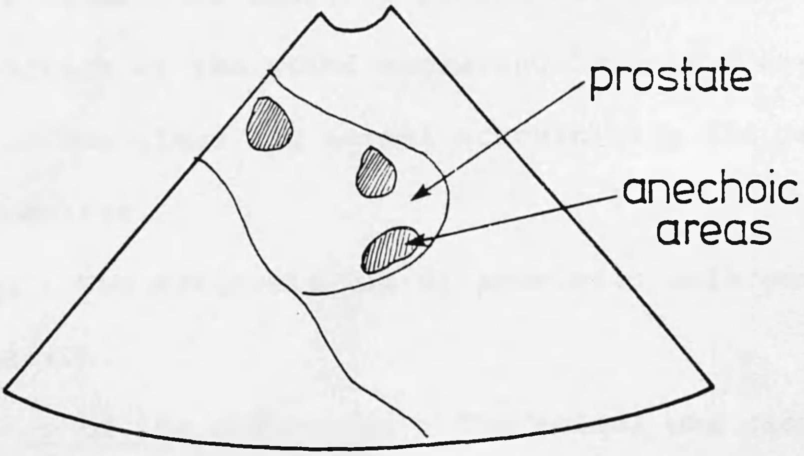
Ultrasonographic Findings: The prostate gland was found to be asymmetrically enlarged. On a transverse image, the right lobe appeared to be larger than the left. Anechoic areas of less than 2mm diameter were scattered throught its substance (Fig. 73).

Diagnosis: Benign prostatic hyperplasia.

Confirmation of the Diagnosis: Therapy was instituted with intramuscular injection of delmadinone acetate (Tardak, Syntex). The prostate gland subsequently was found to be reduced in size on rectal examination thus supporting the diagnosis.

Fig. 73 A prostatic ultrasonograph (Case 24, B.P.H.).
Anechoic areas are present within the prostate and are producing a heterogeneous appearance.





CASE TWENTY-FIVE

A ten year-old male Labrador dog.

Presenting Signs: Difficulty in passing faeces and urine.

Clinical Findings: On rectal examination, the prostate was bilaterally enlarged but not painful on palpation. No other significant abnormalities were detected.

Laboratory Findings: Urine culture produced a growth of gram-negative bacilli of unknown significance. Haematological examination was normal.

Radiographic Findings: A lateral caudal abdominal radiograph demonstrated enlargement of the prostate gland. There was no evidence of lymph node enlargement or periosteal reaction on the pelvis. A pneumocystogram failed to provide further information.

Ultrasonographic Findings: The prostate was imaged in the normal position. An anechoic sphere was found in the ventral portion of the gland measuring 13mm in diameter. The rest of the gland had normal echogenicity and measured 40mm in diameter.

Diagnosis: The diagnosis was of prostatic enlargement with cyst formation.

Confirmation of the Diagnosis: The animal was castrated by scrotal ablation. Clinical signs regressed following surgery thus supporting the diagnosis.

CHAPTER FOUR

DISCUSSION

4:1A HEPATIC ULTRASONOGRAPHY : TECHNIQUE AND NORMAL FINDINGS

The ultrasonographic appearance and location of the liver in the dog and the horse (Figs. 4, 6) were consistent with those described previously (Cartee, 1981; Nyland and Park, 1983; Nyland and Hager, 1985; Wrigley, 1985; Rantanen, 1986[b]). Examination of the entire liver was easily performed in small animals and was well tolerated by the subjects. In the horse, although large portions of the liver could be examined, the caudal vena cava was not observed in every case and, therefore, it was assumed that the entire organ had not been examined.

4:1B HEPATIC ULTRASONOGRAPHY : INDICATIONS

The indications for hepatic ultrasonography in the cases reported are summarised in Table 2. The commonest indications were non-specific clinical signs with or without biochemical or radiographical evidence of hepatic disease. These signs included weight loss, anorexia, dullness and pyrexia. In six of the nine animals examined, ultrasonographic abnormalities were detected.

Five cases were examined due to biochemical evidence of hepatic dysfunction (elevated hepatic enzymes or B.S.P. retention test). In four of these cases, ultrasonographic abnormalities were detected. One case (35) had an elevated B.S.P. retention test and had a normal ultrasonographic appearance. No final diagnosis was reached in this case. However, the presenting signs of anorexia and halitosis resolved and the dog was discharged.

Six animals were examined for possible hepatic metastases following the identification of a primary neoplasm. These were detected in two cases. Ultrasonography has been routinely used for identification of metastases in human patients as useful prognostic information has been provided (Merritt, 1980). In veterinary medicine, such information may be useful in treatment planning although, in the cases described in this study, both those with and those without metastasis were euthanased on identification of a primary neoplasm.

The radiographic diagnosis of hepatic enlargement has been reported as a reliable indicator of hepatic disease (Suter, 1982). However, substantial errors have occurred (Suter, 1982). In the three cases examined due to radiographic evidence of hepatomegaly, two were confirmed ultrasonographically. In both cases which were examined due to radiographically-detected decreased hepatic size, this finding was confirmed ultrasonographically. The use of ultrasonography to evaluate palpable and radiographically-detected abdominal masses, to confirm the organ of origin of masses and to determine the extent of disease in and around an affected organ, has been described in dogs (Feeney, Johnston and Hardy, 1984). Two cases were evaluated ultrasonographically following the detection of cranial abdominal masses and, in both, ultrasonographic abnormalities were located. In the four cases which demonstrated signs which were considered to be indicative of hepatic disease (hepatic encephalopathy 7, 8; hepatomegaly 12; and right sided cardiac failure 11), ultrasonographic abnormalities were noted in every case.

The conclusion from consideration of these data is that all the indications listed above were valid for performance of hepatic ultrasonography.

Five cases were examined during an abdominal scan which was performed due to clinical, radiological or biochemical findings which were referrable to another abdominal organ and these animals were considered to have normal hepatic ultrasonographic findings. Nevertheless, it has been considered important to examine all abdominal organs during an abdominal ultrasonographic examination as failure to do so may lead to misdiagnosis (Herring, 1988).

4:1C ULTRASONOGRAPHIC FINDINGS IN LOCALISED HEPATIC DISEASE

One of the advantages of ultrasonography over radiography has been that the internal structure of organs can be assessed in addition to evaluating the overall size, location and borders. This ability has permitted an identification of localised lesions within the liver which may not produce radiographic abnormalities (Wrigley, 1985).

Cysts within the liver have been congenital or acquired from previous trauma or the result of a previous inflammatory process (Merritt, 1980; Nyland and Hager, 1985).

They have been identified and regarded as an incidental ultrasonographic finding in the dog. The differential considerations included haematoma, abscess, liver necrosis and primary or metastatic neoplasia (Nyland and Hager, 1985). In the case described in this report (Case 3, Fig. 41), they were easily identified as echo-free structures resulting in distal enhancement and were regarded as an incidental finding.

Ultrasonography has proved an excellent modality for evaluating the size, number and distribution of neoplastic lesions (Nyland and Park, 1983). The liver has been the most common site for metastatic disease in man and, therefore, hepatic ultrasonography has been especially important in evaluating the liver of persons with neoplastic disease (Merritt, 1980). Numerous attempts have been made to characterise neoplasms by their ultrasonographic appearance. However, the differentiation of tumour type has not been possible from ultrasonographic findings alone (Green et al, 1977; Hillman et al, 1979; Scheible, Gosink and Leopold, 1977).

Hepatocellular carcinoma has produced three ultrasonographic patterns in man: discrete masses with diminished numbers and/or strength of echoes as compared with the surrounding liver; discrete masses with increased number or strength of echoes as compared to surrounding liver and diffuse alteration of echo architecture with mixed echogenic and/or echo-free areas without discrete masses

(Green et al, 1977; Kamin, Eernardino and Green, 1979).

A hypoechogenic mass, similar to that described in this report (Case 2, Figs. 38, 39, 40) has also been found in another case of canine hepatocellular carcinoma (Feeney, Johnston and Hardy, 1984). However, anechoic and hypoechoic masses have also been reported in association with canine fibrosarcoma (Feeney, Johnston and Hardy, 1984) and canine lymphosarcoma (Nyland, 1984). Therefore, this pattern, which was observed in Case 2, cannot be regarded as specific for hepatocellular carcinoma. Hepatic metastases have most frequently resulted in anechoic, mixed or target lesions (Nyland and Park, 1983; Feeney, Johnston and Hardy, 1984). Multiple hyperechoic lesions have been reported in association with mast cell tumour and also in association with nodular hyperplasia (Nyland and Park, 1983). This appearance has been recognised as being non-specific in man (Merritt, 1980). Cases 1 and 4 had identical ultrasonographic findings of multiple hyperechogenic masses (Fig. 36) throughout the liver. In Case 1, these masses represented localised fatty change and in Case 4 the masses represented metastatic carcinoma. Thus, these cases demonstrated the difficulty in correlating ultrasonographic and histopathological findings and illustrated the non-specific nature of ultrasonographic abnormalities.

4:1D <u>ULTRASONOGRAPHIC FINDINGS IN DIFFUSE HEPATIC DISEASE</u>

Table 5 summarises the ultrasonographic abnormalities which were detected and the final diagnosis of the eight cases of hepatic disease described in this study. The specific parameters which were evaluated to determine the presence of diffuse ultrasonographic changes were alteration in echogenicity, which was assessed by comparing the liver with the other abdominal organs (Wrigley, 1985), alteration in size, which was assessed subjectively as no data is available as yet on the range of normal size and the appearance of the hepatic and portal vasculature.

Decrease in hepatic size was detected in Cases 6, 7 and 8. Case 7 was diagnosed on clinical and biochemical evidence as suffering from hepatic cirrhosis. Considerable controversy exists as to the usefulness of ultrasonography in the diagnosis of cirrhosis (Giorgio et al, 1986). Increased echogenicity and attenuation has occurred in these cases which resulted in a "bright liver" (Taylor, 1977[a]; Joseph, Dewbury and McGuire, 1979; Cohen, Kaude and Wright, 1981). However, cirrhotic livers have been observed to have normal echogenicity in many cases (Cohen et al, 1981) and increased hepatic echogenicity has also been found in association with fatty infiltration and acute hepatitis (Taylor, 1977[a]; Joseph et al, 1979; Foster, Dewbury, Griffith and Wright, 1980; Kurtz et al, 1980; Cohen et al, 1981). A new method of tissue characterisation by analysis of frequency change in addition to amplitude change has been applied to the investigation of hepatic disease and this may prove to be useful in clinical practice in future (Taylor et al, 1986). Dilation of the portal vessels due to secondary portal hypertension has also been described in some cirrhotic cases (Taylor, 1977[a]). A small liver has been detected ultrasonographically in one dog (Cartee, 1981). In this case, the echogenicity had no overall increase or decrease but it was uneven throughout, resulting in a heterogeneous appearance.

The liver was considered to be small in both cases of portacaval shunt described in this report. In Case 7, dilation of the portal vessels was noted and a portal vessel was seen to communicate with the caudal vena cava (Fig. 42). This shunt was also identified and ligated using splenic artery portography (Suter, 1982). Ligation of a ductus venosus in a dog, using intraoperative ultrasonographic guidance, has been described (Wrigley, Macy and Wykes, 1983), but this procedure was not attempted in the cases described in this report. In case 8, a decreased liver size was noted but no abnormality was detected in association with the hepatic vasculature. In this case, surgery was not performed and the dog died some weeks after discharge and so the exact location of the shunt was not established. Therefore, the diagnosis of portosystemic shunt was based on clinical and biochemical findings alone.

An increase in hepatic size was noted in four cases (Cases 9, 10, 11, 12). Fatty infiltration in man frequently results in a characteristic but non-specific pattern of increased echogenicity (Joseph et al, 1979). However, this was not detected in Case 9. The significance of the hepatomegaly detected in Case 10 was uncertain as no final diagnosis was reached.

Venous congestion in right sided or congestive cardiac failure has resulted in dilation of hepatic vessels in man and dogs (Henriksson et al, 1982; Nyland and Hager, 1985). However, in the case described in this report (Case 11) this was not noted. The presence of ascites in this dog was clearly demonstrated due to the anechoic fluid which separated the liver lobes (Fig. 43). Ultrasonography has now been recognised as the standard technique for detection of ascites in man (Bundrick, Cho, Brewer and Beachley, 1984).

Reduced echogenicity, which was detected by comparing the liver with the kidney and spleen, was found in the case of myeloid leukaemia (Case 12, Fig. 44). This condition has also produced this appearance in man (Birnholz, 1979) and in the dog (Feeney et al, 1984). The localised hyperechoic structure (Fig. 45) which was observed in this case may have been produced by decreased hepatic echogenicity when compared to the perihepatic tissues as no localised masses were identified on post-mortem examination of this case. The case of lymphoid leukaemia (Case 13) was considered to have normal echogenicity. However, the echogenicity of the spleen was reduced and, therefore, it was difficult to evaluate the liver accurately. In man, this condition has resulted in reduced echogenicity; however, this appearance was neither specific nor sensitive (Green et al, 1977; Scheible, Gosink and Leopold, 1977; Birnolz, 1979; Braschо, 1980). In addition, the markedly enlarged spleen, which filled the entire ventral abdomen in this case, may have contributed to the inaccurate assessment of liver size in Case 12.

Echogenicity has also been altered in hepatic amyloidosis (Joseph et al, 1979). In the case described here this was not uniform, but the lobe of liver, which was adherent to the diaphragm and stomach, had increased echogenicity when compared to other organs and the rest of the liver. This localised increase in echogenicity is difficult to explain. It may indeed be the result of hepatic amyloidosis. However, this was detected histologically throughout the liver and was not localised to one lobe. Alternatively, an increase in echogenicity is to be anticipated in the presence of free fluid which was present in this case (Bartrum and Crow, 1983). The increase in echogenicity was uniform throughout the lobe and, therefore, presumably did not represent the fibrous material which formed the adhesions as these were confined to the surface of the liver lobe. Some difficulty was experienced in assessing the findings in this case and this may represent an error in interpretation.

4:1E HEPATIC ULTRASONOGRAPHY : CONCLUSIONS

In conclusion, hepatic ultrasonographic examination was performed easily without anaesthesia or sedation in both small animals and horses. The abnormalities which were detected in this study were confined to small animal cases although similar principles of interpretation would apply to equine cases.

Abnormalities were detected in 12 out of the 30 cases examined with one false negative. In seven cases the ultrasonographic findings confirmed the diagnosis and in five cases further information was obtained which contributed to the final diagnosis. In two cases, the ultrasonographic abnormalities which were detected were regarded as incidental (Table 7). However, interpretation of ultrasonographic findings must be made in the knowledge that ultrasonographic changes are generally non-specific and exact correlation with histological findings is impossible. Nevertheless, hepatic ultrasonography was considered to be a useful adjunct to diagnosis in the cases described.

4:2A SPLENIC ULTRASONOGRAPHY : TECHNIQUE AND NORMAL FINDINGS

The technique and normal findings of splenic ultrasonography in the dog and the horse corresponded with those that have been described previously (Figs. 7, 10) (Nyland and Hager, 1985; Rantanen, 1986[b]; Rawlinson and Hoffman, 1986).

Examination of the spleen was easily performed in dogs and horses. Difficulties were encountered when examination of the feline spleen was attempted and the resolution of the available equipment was not considered to be sufficient to image the spleen with confidence.

4:2B SPLENIC ULTRASONOGRAPHY : INDICATIONS

The indications for splenic ultrasonography are listed in Table 8. They were defined as clinical and radiographical evidence of an abdominal mass, radiographic splenomegaly and elimination of the possibility of splenic metastases. The majority of the cases (12/20) were examined during an examination of the abdomen which was indicated to investigate another abdominal organ. No splenic abnormalities were detected in these cases. However, routine examination of all organs has been advocated during an abdominal examination (Herring, 1988).

4:2C ULTRASONOGRAPHIC FINDINGS IN SPLENIC DISEASE

Two cases of haemangiosarcoma were described (Cases 14 and 15). Diagnosis of haemangiosarcoma has previously relied on clinical, laboratory and radiographic findings and paracentesis abdominis where indicated (Brown, Patnaik and MacEwen, 1985). The multicystic pattern which was observed in Cases 14 and 15 (Figs. 48, 51) was identical to that previously described in association with splenic haemangiosarcoma (Foss et al, 1983; Feeney et al, 1984; Nyland and Hager, 1985). Identification of a localised multicystic mass cannot be considered to be diagnostic for this neoplasm because a similar appearance has been reported in association with splenic haemangioma in man (Ros et al, 1987), and splenic haematoma in the horse (Spier et al, 1986). However, the ultrasonographic findings did provide evidence of a cystic lesion (Figs. 48, 51) which was not available from radiographic findings alone.

Splenic involvement in both Hodgkin's and non-Hodgkin's lymphoma has resulted in a diffuse alteration in splenic echogenicity (Brascho, 1980). Lymphoma has also resulted in the formation of multiple hyperechoic masses with a heterogeneous appearance in both man and dog (Costello, Kane, Oster and Clouse, 1985; Feeney et al, 1986). In contrast, increased echogenicity has also been observed in man in association with leukaemia and lymphoma (Siler et al, 1980). Therefore, a range of ultrasonographic abnormalities have been reported in association with splenic lymphoma.

The ultrasonographic appearance described in Case 16 (Fig. 54) reflected the tumour's gross and histological appearance; namely a discrete multinodular mass rather than a diffuse tumour (Figs. 56, 57).

A diffuse hyperechoic ultrasonographic pattern was observed in Case 13 (Fig. 46); this was considered to be similar to that described for diffuse splenic neoplasia in man (Shawker, 1980; Sommer, Hoppe, Fellingham, Carroll, Soloman and Yousem, 1984).

Case 16 was diagnosed as having pseudohyperparathyroidism, a condition which has occurred in the horse in association with lymphosarcoma (Esplin and Taylor, 1977; Mair, Yeo and Lucke, 1989; Marr, Love and Pirie, 1989), ovarian tumour (McCoy and Beasley, 1986), gastric carcinoma (Meuten, Price, Seiler and Krook, 1978), adrenocortical carcinoma (Fix and Miller, 1987) and abdominal mesothelioma (Roussell, Lin, Strait and Modransky, 1978). Polydipsia and polyuria have been observed due to the improved ability to concentrate urine which ensued following the onset of hypercalcaemic nephropathy in this condition (Osborne and Stevens, 1974). In this case the serum calcium concentrations remained within the normal range but the characteristic changes which were associated with hypercalcaemic nephropathy were observed on histological examination. Hypercalcaemic nephropathy has produced an ultrasonographic pattern which was characterised by multiple hyperechoic foci at the corticomedullary junction in the dog (Barr, 1987). This observation was not made in Case 16; however, the quality of the ultrasonographic image may not have been sufficient to detect these changes.

4:3A ACCURACY OF ULTRASONOGRAPHIC DETERMINATION OF OVINE FOETAL NUMBER

The methods which were used for analysis of the data and determination of accuracy have been used in previous studies (Logue, Hall, McRoberts, Waterhouse, 1987). Method

Two detected the overall accuracy. However, Method One indicated the accuracy of detection at each litter size. This could be an important consideration in a commercial situation (Logue et al, 1987). In addition, the statistical method allowed for identification of sources of error. Those were both over and under estimations.

The results achieved in this study compared well with those achieved by the W.S.A.C., 1985/86 (Table 20). The inexperienced operator had considerably poorer results (Fig. 11), but there was a significant improvement in the accuracy of the examination at days 57 - 62 compared to the examination at day 42 (0.82 correct overall, 0.57 correct overall respectively) (Tables 11, 12). White, Russel and Fowler (1984) reported an improvement in accuracy from 69 to 93 per cent in a training period of five days. They concluded that after a suitable training period, improvement can be expected as experience is gained (White, Russel and Fowler, 1984).

Pregnancy could be detected by this method from 30 days onwards but high levels of accuracy of determination of foetal numbers were reported to be more likely from 45 to 50 days gestation. Beyond 100 days, the size of the foetus in relation to the area imaged was such that it was difficult to determine numbers rapidly (White, Russel and Fowler, 1984). Four occasions were selected during this time period to establish the day of gestation at which the highest accuracy could be achieved. On days 57 - 62 the best overall accuracy was demonstrated by both the inexperienced (Table 12) and experienced (Table 13) operator (Fig. 16). However, as noted previously, the inexperienced operator's improved results might have been due to improved ability rather than being dependent on gestation age. At days 78 - 83 (Fig. 16), the experienced operator achieved 0.80 accuracy (Fig. 6) compared with 0.89 at days 105 - 107. This result was difficult to explain as the smaller size of the foetus at days 78 - 83 might be expected to result in greater ease in detection of numbers.

The method of analysis of accuracy which was used indicated not only the overall accuracy but also illustrated how mistakes were made. Over-estimation resulted from imaging one foetus from different angles and interpreting that as two foetuses. Under-estimation resulted from failure to examine the full extent of the uterus. To overcome these problems the operator had to build up a mental three-dimensional picture of the location of each foetus and ensure that the entire uterus was examined. Applying the method of analysis which was selected the nature of the errors were appreciated and thus the analysis allowed the operator to improve his technique.

Both operators displayed a tendency to over-estimate triplets (Fig. 14), and this was the major component of the experienced operator's error. In twin estimation (Fig. 13), the inexperienced operator both over and underestimated the foetal numbers whereas the experienced operator's error was largely limited to over-estimation of foetal numbers. In single estimation (Fig. 12), both operators displayed both under and over estimations.

This pattern of mistakes was independent of gestation age in the inexperienced operator. However, the experienced operator demonstrated a marked tendency to over-estimating triplets at day 78 which was not obvious at day 106 (Fig. 19). However, the large percentages may have been due to errors in a small number of ewes as only one set of triplets was born. The composite results for both operators at all four time periods indicated an overall accuracy of 0.80 for foetal number detection and 0.87 for detection of the groups, barren, single, multiple (Table 19). These results are somewhat poorer than those reported by White, Russel and Fowler (1984) and Fowler and Wilkins (1982). This was due to the inclusion of the inexperienced operator's results. The composite accuracy of the experienced operator was 0.89 (Table 18) for foetal number detection and 0.96 for detection of groups, barren, single, multiple bearing ewes. In the commercial situation, foetal adsorption or abortion may be likely to introduce further error in apparent accuracy.

4:3B ACCURACY OF ULTRASONOGRAPHIC DETERMINATION OF OVINE FOETAL NUMBERS : CONCLUSIONS

The conclusions which were made from this study were, firstly, that ultrasonographic examination at or around day 60 appeared to yield the most accurate results (Figs. 16-20) and, secondly, that considerable improvement could be expected during the training period of the inexperienced operator (Tables 11, 12, Fig. 16.) although refining the technique to such a level as to be useful in a commercial situation may well require a lengthy training period as the results obtained in this study were unlikely to be acceptable in a commercial situation.

4:4 ULTRASONOGRAPHIC DETECTION OF PREGNANCY AND FOETAL NUMBERS IN BITCHES AND QUEENS

In the dog and cat, pregnancy could be diagnosed from day 23 onwards. The accuracy was 100%. This compared favourably with previously published results (Bondestam et al, 1984; Shille and Gontarek, 1985; Toal, Walker and Henry, 1986). Two potential sources of error were noted; an empty bladder could be mistaken for an amniotic vesicle and fluid filled loops of small intestine could resemble multiple small amniotic vesicles. For this reason care was taken to ensure the foetal mass was imaged before diagnosing pregnancy.

Sensitivity of determination of foetal numbers was 30.4% (Table 22) which was consistent with previous reports (Bondestam et al, 1984; Shille and Gontarek, 1985; Toal, Walker and Henry, 1986). Although dog owners are keen to know how many pups a bitch might be carrying, the information was of little medical significance during gestation.

Underestimation resulted from overlooking foetuses which had a number of sources of error: an incomplete search of the abdomen could lead to foetuses being missed and to overcome this the examination was made from the pelvic brim, cranially until the liver was imaged from midline and both left and right flanks; a foetus could be counted twice from two separate directions thus the operator must build up a three-dimensional mental image of where each foetus lies in the abdomen; foetuses could be obscured by acoustic shadowing due to overlying bowel but imaging of the abdomen in several planes should minimise this problem. The majority of estimations (78%) were within the range of plus or minus 2. The owner was warned of this limitation when the estimation was made.

Bondestam et al (1984) and Toal, Walker and Henry (1986) reported a tendency to overestimate the size of small litters and underestimate large litters (Table 23). This tendency was not apparent in this study. The most gross under-estimation (Bitch No. 8) was made in a bitch which was carrying a large litter and was examined late in gestation (Fig. 25). Both of these factors could contribute to this error. Toal et al (1986), also reported the highest accuracy in bitches carrying litters of five or less foetuses. (Accuracy of diagnosis in litters of five or less, 41% accuracy of diagnosis in litters of more than five, 18%

(Table 22). This tendency was apparent in this study (Table 21).

The accuracy within the medium litter size group (4-8 foetuses) was 38% (Table 24). However, given the small number of animals studied and the high levels of inaccuracy, these distinctions may have been of little significance.

The most accurate results were achieved between days 37 and 43 of gestation (Table 24, Fig. 27) which contrasted with previous studies which reported an increasing accuracy with gestation stage (Toal, Walker and Henry, 1986).

The conclusion was that ultrasonography provided an accurate means of pregnancy diagnosis and a guide to expected foetal numbers. Also foetal viability could be established and monitored using ultrasonography.

4:5 DETECTION OF THE INTRAUTERINE GROWTH RATE OF THE OVINE FOETUS

The parameters which were selected for assessment of growth rates were based on those used for ultrasonic measurement of the human foetus (DeVore and Hobbins, 1979; Hobbins, Winsberg and Berkowitz, 1983). Attempts were made to standardise the measurements using the landmarks described. However, in some cases, it was not possible to manipulate the transducer relative to the foetus in such a way that it was possible to demonstrate these landmarks.

Ultrasonographic techniques were used to determine growth rate by measurement of the foetus at more than one time because the growth rate was considered to be more useful than a single measurement in establishing human foetal growth retardation (DeVore and Hobbins, 1979).

In basic and applied research, the traditional methods of comparing growth rate was by sacrifice of pregnant ewes (Evans and Sack, 1973). More recently implantation of measuring devices (Mellor and Mathieson, 1979) or indwelling ultrasonic transducers (Taylor et al, 1983) has been used to monitor ovine foetal growth. Application of two-dimensional ultrasonography in this situation has the advantage that it is non-invasive and, therefore, measurements could be performed as often as was necessary with no risk to the operator or the animal. Analysis of the foetal parameters for twin and single lambs and for the lambs of parasitised and non-parasitised ewes in this study revealed no significant differences between the groups However, comparison of the various parameters measured at birth likewise revealed no significant difference. (Tables 26, 27,).

Cross-sectional abdominal diameter, ventrodorsal abnormal height and crown-nasal length data were discarded as few data had been obtained for that reason. Crown rump measurements were only possible in the initial stages of the study, while the foetus was small relative to transducer size.

Transthoracic and biparietal diameters were selected as the most useful parameters because they offered the largest time span, the landmarks for measurement were well defined and in many cases it was possible to produce the required image for making the measurement. Logarithmic relationships were selected as they offered the straightest curve (Figs. 31, 32).

Estimations of foetal age from biparietal diameter or transthoracic width were derived by two methods. Method three, the simple technique (Fig. 3), involved extrapolating a line from the y axis and recording the time span from the x axis on the curve of regression of log y upon x. Alternatively in method four, the equation of the regression of x upon log y was applied. Although the correlation coefficients for both sets of data were good, the confidence bands were wide (Figs. 33, 34).

Both methods of estimation of gestational age which were developed from the data collected in this study produced estimations which had an extremely wide range in age and these methods are unlikely to have a commercial application. In the field situation, estimation of ovine foetal age and, therefore, approximate time of lambing can be achieved by the use of coloured raddles at tupping time. Unless a reliable method for estimation of gestational age to within less than one reproductive cycle is developed, this technique is unlikely to be superseded.

4:6A PROSTATIC ULTRASONOGRAPHY : TECHNIQUE AND NORMAL FINDINGS

In the dog, the prostate gland could be easily identified using a sector scanner, especially if the bladder was full, thereby providing a landmark. The linear array transducer proved less useful because difficulty was encountered in orientating the beam caudodorsal to the pelvic brim due to the bulk of the transducer relative to the size of the inguinal area.

The resolution provided by the 5mHz transducer was superior to that of the 3mHz transducer and in all cases the 5mHz transducer had sufficient penetration for imaging the prostate gland itself. However, the 3mHz transducer was useful for examination of the more dorsal areas of paraprostatic cysts.

The description of the normal ultrasonographic appearance of the canine prostate (Fig. 35) corresponds with the findings of Cartee and Rowles (1983). A central hilar area with increased echogenicity relative to other areas, which was described by Feeney et al (1985), was not found in either normal or abnormal dogs in this study. This may be due to differences in the resolution of equipment or the gain settings which were employed.

4:6B ULTRASONOGRAPHIC FINDINGS IN PERIPROSTATIC AND CYSTIC PROSTATIC DISEASE

In three of the cases in this series the diagnosis was of paraprostatic cyst. The origin of these cysts is controversial. Some authors regard these as developing from vestiges of the Mullerian ducts (Harvey, Nunmaker and Weber, 1969; Johnson and Archibald, 1974; Zoltan, 1979). However, the development of a pus or urine-filled Mullerian duct with urethral attachment has been regarded by some authors as a separate condition (Weaver, 1978; Johnson, 1985).

Discrete cystic structures which arise from the prostate gland have accounted for 5 per cent of all prostatic problems in reviews of referred case material (Howard, 1975; Weaver, 1978). The clinical signs associated with paraprostatic cysts have been considered to involve principally those referable to the urinary system (Weaver, 1978). The development of urinary signs has been attributed to cranial displacement of the bladder neck and excessive pressure on the bladder wall (Weaver, 1978). White, Herrtage and Dennis (1978) reported that faecal tenesmus and gross abdominal distension or an obvious abdominal mass were also frequent findings. In the three cases described in this report, two were initially detected as incidental findings of a palpable abdominal mass while the dogs were being examined for concurrent illness. Urinary and faecal tenesmus became evident shortly afterwards in Case 19 and corrective surgery was performed immediately in Case 17 despite the absence of clinical signs.

Weaver (1980) stated that fluid-filled masses occupying the caudal abdomen, demonstrated by radiography, may be diagnosed as prostatic cysts. Prostatic cysts were demonstrated as soft tissue opacities by White, Herritage and Dennis (1987). However, these authors considered that cystography was required to further differentiate the bladder and the prostate gland.

Ultrasonography is a means of differentiation of solid and cystic structures. Thus it can be more accurate in the assessment of a soft tissue swelling than radiography alone and in the three cases of paraprostatic cyst described (Cases 17, 18, 19), it proved successful in demonstrating the cystic nature of the mass (Figs. 58 - 66).

Small prostatic retention cysts were also easily identified. These occurred in addition to a paraprostatic cyst in Case 19 (Fig. 65) and in association with B.P.H. in Case 25.

The use of microbubble contrast media is employed in examination of the heart (Bonagura, 1985). A similar technique was applied in this study to differentiate the paraprostatic cyst from the bladder as echogenic particles could be detected in the bladder following insertion via a urinary catheter. In Case 17, mineralisation of the cyst, which was demonstrated radiographically (Fig. 58), was not appreciated ultrasonographically (Fig. 59). In all three cases the cysts had intensely echogenic walls. Echogenic particles were observed within the cyst in Case 18 (Fig. 63) but microscopic examination of the fluid was not performed to discover the composition of the structures producing these echoes.

Complete dissection of the cyst was possible in Case 17, but in Cases 18 and 19 marsupialisation was performed as described by Hoffer, Dykes and Greiner (1977). Subsequent complications which have been recorded in association with this technique included prolonged drainage from the cyst (Johnson, 1985), cyst-bladder fistulation, abscessation and chronic urinary tract infection (Hardie, Barsanti and Rawlings, 1984). Ultrasonography was used as a monitoring technique in this study. Immediately post-operative examination of the area was not possible due to artifacts caused by accumulation of air within the abdomen. Seven days post-operatively, examination could be carried out to assess the quantity of residual fluid. In Case 19, a significant amount of fluid was observed and more aggressive therapy at this stage might have averted the need for subsequent surgery (Fig. 59).

The ultrasonographic and pathological findings of a fluid filled anal gland carcinoma (Case 20, Fig. 67), illustrated that care must be taken in interpreting cystic structures adjacent to the prostate gland as paraprostatic cysts; in this case the cystic lesion was an anal sac tumour (Figs. 68, 69). Assessment of the sublumbar nodes ultrasonographically would have been helpful in this case.

However, this was not successfully performed and exploratory laparotomy was required to provide the diagnosis.

4:6C ULTRASONOGRAPHIC FINDINGS IN DIFFUSE PROSTATIC DISEASE

The clinical signs associated with B.P.H. and prostatic neoplasia are similar (Allen et al, 1984). Definitive diagnosis of neoplastic and non-neoplastic causes of diffuse enlargement was not possible on the basis of ultrasonography alone in this study. The difficulty in distinguishing between B.P.H. and neoplastic change on ultrasonographic criteria has been recognised by several authors (Cartee and Rowles, 1983; Feeney, Johnston and Klausner, 1985). Cartee and Rowles (1983) suggested that it may be possible to distinguish neoplasia on the basis of loss of marginal smoothness due to invasion of the capsule. No such finding was made in the three cases of prostatic adenocarcinoma described in this study (Cases 21, 22 and 23). Feeney et al (1987[b]), in a retrospective study of 30 cases of prostatic disease, described loss of marginal smoothness in only one of seven cases of prostatic adenocarcinoma and in one of three cases of transitional cell carcinoma of the prostatic urethra. Loss of marginal smoothness was not observed in non-neoplastic conditions.

Asymmetry of the prostate gland has been found in both prostatic adenocarcinoma and prostatic abscessation (Feeney et al, 1987[a]). This was observed ultrasonographically in Case 22. In Case 21 asymmetry was detected radiographically but not ultrasonographically. Ultrasonographic asymmetry was observed in one case of B.P.H. (Case 24). Asymmetry was reported in association with B.P.H. by Foss et al (1984). However, in three cases of B.P.H. described by Feeney et al (1987[b]) asymmetry was not observed. Thus asymmetry appears to be an occasional finding in B.P.H., neoplasia and prostatic abscessation.

The mixed hyperechoic appearance observed in all five cases of diffuse prostatic enlargement was similar in both neoplastic and non-neoplastic enlargement (Figs. 71, 73). A similar appearance has been described in acute and chronic prostatitis (Feeney et al, 1987[b]). Thus differentiation between neoplastic and non-neoplastic processes is not possible on the basis of echogenicity. Both plain and contrast radiographic studies were similarly unable to accurately differentiate between neoplastic and non-neoplastic enlargement. However, the presence of hypertrophic osteopathy of the pelvis and lumbar vertebral bodies might be indicative of prostatic neoplasia (Feeney et al, 1987[a]).

Exploratory laparotomy was required to confirm the diagnosis of prostatic adenocarcinoma in the three cases described in this study. Perineal punch biopsy techniques have been successful in the dog (Barsanti et al, 1980), but in man, ultrasonically guided biopsy techniques have been advocated because visualisation of the prostate allows more precise needle placement (Holm and Gammalgaard, 1981). This procedure was not attempted in this study but the technique could equally be applied to the investigation of canine prostatic disease.

In summary, ultrasonography proved useful in confirming the presence of prostatic enlargement which had been detected radiographically and in distinguishing between cystic and solid enlargement of the prostate gland and surrounding tissues. Further, the cases described in this study confirmed the conclusions of previous reports that the ultrasonographic findings should be interpreted in conjunction with other investigative procedures as detected abnormalities were not specific to any one condition (Cartee and Rowles, 1984; Feeney et al, 1987[b]). The observations documented in this study were subjective and made by an inexperienced operator and further information is required on objective values such as the range in normal dimensions of the prostate gland relative to body size and weight, breed, age and sex. In addition, analysis of a larger series of cases may allow quantification of the relative frequencies of each ultrasonographic abnormality occurring in association with each prostatic disease entity. Thus the sensitivity and the specificity of the technique could be determined, and more objective interpretation of the ultrasonographic findings could be achieved.

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APPENDIX 1

APPENDIX 1

The value for each growth parameter which was recorded in the ovine foetuses throughout gestation and at birth.

DAY	BP	TT	CR	NAS	XA	VDH
40			44			
37			20			
37			20			
37			30			
37			16			
42			28			
40			32			
37			36			
37			34			
42	26		30			
42			28			
43			16			
42			20			
41			40			
42			46			
42			36			
42			40			
41			26			
43			30			
43			32			
41			20			
42			42			
42			46			
42			46			
42			42			
42			26			
42			30			
42			36			
42			40			
58			76			
58		20				
58	30		90			
57			96			
58			80			
58			90			
57		24				
58	36					
57		20	70			
57	28					
57		50	66			
57			60			
58		26				
57				44		
57			56			
58				50		
57		26				

APPENDIX 1 (Contd.)

DAY	BP	TT	CR	NAS	XA	VDH
57			96			
62	28					
62	26					
62		24				
57				50		
59	34	26				
59	34	26				
62		28				
59	28	36		50		
59				42		
59		30				
59		32				
62	26	36				
62		30				
57	26	30				
59	28			36		
83	34	46				
83		50				
83	36	42				
78						34
80	52					48
80						46
78	30	46				50
83	32	50				
80	44	42				
80	44	38				
80	28	34				
80	32	38				44
82		32				
83	32	50				40
83	34	42				
78		44				
78		40				
80	46	48				
80	44	40				
80	26	40				
80		34				
80	38	44				
80		38				
80		34				
80		44				
80		34				
78	22	44				
78		36				
80	32	34				
80		26				
79	40	52				
79	40	36				

APPENDIX 1 (Contd.)

DAY	BP	TT	CR	NAS	XA	VDH
80	30	28				
80		34				
80		32				
80		40				
80		46				
79		42				44
79		42				44
79		48				
79		42				
79		32				
80		34		56		
79	36					52
80		44				
79		38				
79		42				
79		48				
78	40	32		52		
78		28				
79	30	36				
78		50				
79	32	34				
78	48	36				
78		46				
79	38	50				
79		38				
79	48	48				
79		48				
79		44				
80		38				
79		48				
79	38	38				
79		42				
80		34		48		
80	36	52				
80	34	34		48		
80	26	44		60		
80		42		60		
107		64				
107	50				76	
107	40	50			72	
107		42				56
105		56				
107	48	42				
107	42	52				
106	40					
106	40	38				
107		56				
107		50				

APPENDIX 1 (Contd.)

DAY	BP	TT	CR	NAS	XA	VDH
107	36	48				
107		38				
106	40	40				
106	50					
106		60				
106		48				
107	48				62	
107		32				
106	30	40				
107	52				72	
106	38	50				
106	50				72	48
106	48					48
105		70				
105		68				
106		62				
106		56				
106	38	46				
107	52	52				50
107	44					
106	48	50				
106		40				
106	40	44				
107	40	72				80
106	40	48				68
107	34	54				
107		50				
106	50	60				
107	34	56				
106	34	48				
106		40				
106	44					
107	44	36				
107	38	40				
107	60	76				
107		60				
107	50	68				
107	42	72				
107	46	56				
	80	100	500	120	50	140
	70	100	440	120	50	130
BIRTH	80	60	480	120	40	120
	80	90	450	110	60	140
	90	100	440	140	60	150
	90	100	480	130	60	140
	70	90	430	110	50	110
	70	80	390	110	50	110
	60	70	400	90	40	90

APPENDIX 1 (Contd.)

DAY	BP	TT	CR	NAS	XA	VDH
	90	100	500	120	80	150
	70	80	440	110	50	120
	80	100	480	120	60	120
	60	100	470	120	50	140
	70	100	490	130	50	130
	70	90	400	100	50	130
	70	100	430	110	50	150
	70	90	36	100	50	110
	70	90	420	120	60	120
	60	70	410	100	50	100
	70	100	460	100	50	120
	60	70	350	90	50	100
	80	100	440	90	70	140
	80	110	410	110	60	130
	80	90	450	110	70	130
	80	100	430	110	60	130
	70	100	450	110	50	130
	70	100	430	100	50	140
	70	50	350	90	50	100
	70	80	370	100	40	100
	90	100	440	110	80	130
	80	100	430	120	60	140
	80	100	450	100	50	130
	80	100	470	110	60	140
	70	100	470	130	60	150
	80	100	440	120	40	120
	80	80	440	110	50	130
	80	100	490	130	60	150
	70	100	420	100	50	120
	70	90	400	110	50	120
	90	100	520	130	60	140
	80	100	420	110	60	130
	80	80	400	110	110	130
	70	90	450	130	110	130
	100	100	550	120	60	160
	80	120	460	110	60	140
	80	100	450	100	90	130
	70	80	380	100	50	100
	80	90	390	100	70	130
	80	90	450	100	70	130
	80	90	420	100	50	130
	90	100	470	100	50	120
	100	50	410	120	50	130
	86	90	440	120	50	140
	70	50	420	90	100	100
	70	100	430	110	70	150
	80	80	430	120	60	130
	90	100	450	110	60	140

APPENDIX 1 (Contd.)

DAY	BP	TT	CR	NAS	XA	VDH
	90	110	540	110	100	120
	80	100	400	110	50	140
	70	90	420	100	50	110
	70	90	410	100	50	120
	90	80	390	110	60	120
	80	100	440	110	70	140
	50	60	400	90	30	90
	80	100	400	100	70	130
	80	80	390	110	50	130
	80	100	390	110	60	140
	80	120	480	120	70	140
	80	100	490	100	50	140
	60	60	410	90	40	90

A P P E N D I X 11

APPENDIX 11

The stage of gestation, biparietal diameter and logarithm of that value which were recorded in the ovine foetuses.

DAY	BP	Log BP mm
62	28	1.447
62	26	1.414
59	34	1.531
59	34	1.531
59	28	1.447
62	26	1.414
57	26	1.414
59	28	1.447
58	30	1.477
58	36	1.556
57	28	1.447
42	26	1.414
79	40	1.602
79	42	1.623
83	34	1.5314
83	36	1.5563
80	52	1.7160
78	30	1.477
83	32	1.505
80	44	1.643
80	44	1.643
80	28	1.447
80	32	1.505
83	32	1.505
83	34	1.5314
80	46	1.6627
80	44	1.6434
80	26	1.4149
80	38	1.579
78	22	1.3424
80	32	1.505
79	40	1.602
79	40	1.602
80	30	1.477
79	36	1.556
78	40	1.602
79	30	1.477
79	32	1.505
78	48	1.681
79	38	1.579
79	48	1.681
79	38	1.579
80	36	1.556

APPENDIX 11 (cont'd)

DAY	TC ~~BP~~	log BP mm
80	34	1.531
80	26	1.414
107	50	1.6989
107	40	1.602
107	48	1.681
106	40	1.602
106	40	1.602
107	36	1.556
106	40	1.602
106	50	1.698
107	48	1.681
106	30	1.477
107	52	1.716
106	38	1.579
106	50	1.698
106	48	1.681
106	38	1.579
107	52	1.716
107	44	1.643
106	48	1.681
106	40	1.602
107	40	1.602
106	40	1.602
107	34	1.531
106	50	1.698
107	34	1.531
106	34	1.531
106	44	1.643
107	44	1.643
107	38	1.579
107	60	1.778
107	50	1.698
107	42	1.623
107	46	1.662

A P P E N D I X 111

APPENDIX 111

The stage of gestation, transthoracic diameter and logarithm of that value which were recorded in the ovine foetuses.

DAY	TT	Log TT mm
62	24	1.380
59	26	1.414
59	26	1.414
62	28	1.447
59	36	1.556
59	30	1.477
62	36	1.556
62	30	1.477
57	30	1.477
58	20	1.301
57	24	1.380
57	20	1.301
57	50	1.698
58	26	1.414
57	26	1.414
59	36	1.556
79	52	1.716
79	40	1.602
79	34	1.531
80	34	1.531
80	26	1.414
79	52	1.716
79	36	1.556
80	28	1.447
80	34	1.531
80	32	1.505
80	40	1.602
80	46	1.662
79	42	1.623
79	42	1.623
79	48	1.681
79	42	1.623
79	32	1.505
80	34	1.531
80	44	1.643
79	38	1.579
79	42	1.623
79	48	1.681
78	32	1.505
78	28	1.447
79	36	1.556
78	50	1.698
79	34	1.531
78	36	1.556
78	46	1.662

APPENDIX 111(cont'd)

DAY	TT	log TT mm
79	50	1.698
79	38	1.579
79	48	1.681
79	48	1.681
79	44	1.643
80	38	1.579
79	48	1.681
83	46	1.662
83	50	1.698
83	42	1.623
78	46	1.662
83	50	1.698
80	42	1.623
80	38	1.579
80	34	1.531
80	38	1.579
80	32	1.505
83	50	1.698
83	42	1.623
78	44	1.643
78	40	1.602
80	48	1.681
80	40	1.602
80	40	1.602
80	34	1.531
80	44	1.643
80	38	1.579
80	34	1.531
80	44	1.643
80	34	1.531
78	44	1.643
78	36	1.556
106	40	1.602
107	36	1.556
107	40	1.602
107	76	1.880
107	60	1.778
107	68	1.832
107	72	1.857
107	56	1.748
107	64	1.806
107	50	1.698
107	42	1.623
105	56	1.748
107	42	1.623
107	52	1.716
106	44	1.643

APPENDIX 111 (cont'd)

DAY	TT	log TT mm
106	38	1.579
107	56	1.748
107	50	1.698
107	48	1.681
107	38	1.579
106	40	1.602
106	60	1.778
106	48	1.681
107	32	1.505
106	40	1.602
106	50	1.698
105	70	1.845
105	68	1.832
106	62	1.792
106	56	1.748
106	46	1.662
107	52	1.716
106	50	1.698
106	44	1.643
107	72	1.857
106	48	1.681
107	54	1.732
107	50	1.698
106	60	1.778
107	56	1.748
106	48	1.681