EXTERNAL reflection echo or amplitude-depth ultrasound has been employed by Lindahl (1966), Horak and Hrazdira (1968) and Campbell, Herve and Bell (1969) for the detection of pregnancy in ewes during the last half of gestation.

The gravid uterus of ewes increases markedly in size from 30 to 60 days after conception (Curson and Malan, 1936) and provides an excellent contrast in acoustical impedance, thus research regarding the use of internal reflection echo ultrasound for early assessment of the pregnancy status of ewes is warranted. Early detection of pregnancy is possible in humans by internal amplitude-depth ultrasound (Fukuda et al., 1965). The following study was part of an investigation conducted to evaluate the use of amplitude-depth ultrasound in the rectum of ewes as a complementary method to the intrarectal Doppler procedure recently described by Lindahl (1971).

Materials and Methods

A probe containing a 2.25 MHz transducer of 15 mm. diameter was fabricated (figure 1). A standard ultrasonic analyzer employing 2.25 MHz pulsed ultrasound, at intervals of 10 microseconds, was used in conjunction with the probe. The ultrasonic echoes were displayed on a cathode ray tube provided with an electronic marker. The instrument was calibrated so that each mark was equal to 1 cm. of tissue. A sensitivity time control switch was used to eliminate surface echoes. The output control was set at 0.5 to 1.0, the rejection control at 9.0 to 9.5, and the gain at 9.5 to 10.0.

Determination of pregnancy involves turning the ewe on her back by means of a tilt chute (Lindahl, 1971) and slowly inserting the probe (lubricated with water soluble gel) into the rectum. The probe is inserted so that the transducer is directed toward the midline of the abdomen. The first echo pattern originates from the pubis. After passing the pubis only shallow echoes or no echo pattern is observed from normal non-pregnant ewes. A definite wide multiple echo pattern, ranging from a depth of 5 to 20 cm is observed from pregnant ewes (figure 2).

Accuracy of the technique has been based on observations taken when the tested ewes lambed. If a ewe did not have a record of lambing or did not show signs of lambing or aborting, she was recorded as non-pregnant. Six hundred and seventy-two ewes of various breed types and ages were examined in two different trials at Beltsville, Maryland, in late 1970 and early 1971, using both the intrarectal amplitude-depth probe and the intrarectal Doppler (Lindahl, 1971). The ewes were field mated and exact breeding dates were not available. All ewes were given a subcutaneous injection of a tranquilizer from 30 min. to 1 hr. before examination. The ewes were examined first with the intrarectal amplitude-depth probe; examination with the intrarectal Doppler followed immediately.

Since previous studies (Lindahl, 1969) showed that Doppler ultrasound indicated fetal life while amplitude-depth ultrasound could detect both dead and live fetuses, the intrarectal Doppler was used as the reference method in the present investigation. Any bias in the experimental design favored the intrarectal Doppler however only a standard maximum search time of 2 min. was employed.
with the intrarectal Doppler regardless of the reaction obtained with the amplitude-depth probe. Subsequent work indicates that the conclusions were not biased by the experimental design.

In trial I, 578 ewes mated between September 11 and October 27, 1970, were checked between November 14 and November 24, 1970. Ewes not diagnosed as pregnant by both procedures (negative ewes) were rechecked on December 8, 9 and 10. The remaining negative ewes were again checked on December 28 and 29. Ewes diagnosed as pregnant by both procedures were not rechecked. In trial II an additional 94 ewes mated between December 16, 1970, and January 26, 1971, were checked as above on February 24, March 8 and March 25, 1971.

Single classification analysis of variance (Snedecor, 1956) was used to evaluate the data.

Table 1

<table>
<thead>
<tr>
<th>Pregnancy check</th>
<th>Approximate length of pregnancy</th>
<th>Procedure A*</th>
<th>Procedure D*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No.</td>
<td>% of total</td>
</tr>
<tr>
<td>1st</td>
<td>18-74</td>
<td>429</td>
<td>90.3</td>
</tr>
<tr>
<td>2nd</td>
<td>42-90</td>
<td>43</td>
<td>9.1</td>
</tr>
<tr>
<td>3rd</td>
<td>62-109</td>
<td>3</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>475</td>
<td></td>
</tr>
</tbody>
</table>

Trial II

|              | 29-70                           | 55  | 91.7       | 85.2± 8.0 | 50 | 83.3 | 84.9± 8.2 |
| 2nd           | 41-82                           | 5   | 8.3        | 81.8± 9.4 | 9  | 15.0 | 79.6± 7.7 |
| 3rd           | 58-99                           | 84.9± 8.2 |
| 60            | 84.9± 8.2 | 60 |            | 83.6± 9.2 |

*Procedure A = amplitude-depth, Procedure D = doppler.

Results

In trial I, 506 ewes were diagnosed as pregnant, at one check or another, and 72 were diagnosed as non-pregnant using the amplitude-depth probe. None of the ewes diagnosed as non-pregnant lambed. As shown in table 1, 475 ewes diagnosed as pregnant had lambing records; an additional eight died, two aborted, four lambed (based on extensive udder development without recorded lambs) and 17 did not lamb. Four hundred and ninety-nine ewes were diagnosed as non-pregnant and 79 were diagnosed as non-pregnant. None of the ewes diagnosed as non-pregnant lambed. The ewes lambling were the same as those recorded for the amplitude-depth procedure. The pregnant ewes...
that died, aborted or lambed also were the same. Ten ewes diagnosed as pregnant did not lamb. Accuracy was 97.1% for the amplitude-depth procedure and 98.3% for the Doppler.

In trial II, 70 ewes were diagnosed as pregnant and 24 as non-pregnant using the amplitude-depth procedure. None of the ewes diagnosed as non-pregnant lambed. Sixty ewes diagnosed as pregnant lambed (table 1), two died, one aborted and six did not lamb. Sixty-five ewes were diagnosed as pregnant and 29 as non-pregnant with the Doppler procedure. None of the ewes diagnosed as non-pregnant lambed. Again the ewes lambing were the same as those recorded for the amplitude-depth procedure as well as the pregnant ewes that died or aborted. Two ewes diagnosed as pregnant did not lamb. Accuracy was 93.6% for the amplitude-depth procedure and 97.9% for the Doppler. Overall accuracy, therefore, was 96.6% for the amplitude-depth procedure and 98.2% for the Doppler.

Although a greater percentage of ewes lambing were detected at the first check with the amplitude-depth procedure in both trials, the mean days prior to lambing did not differ significantly for the two procedures.

In trial I, 237 ewes had single lambs and 238 had multiple births. Ewes with multiple fetuses were detected 92.0 ± 9.5 days prior to lambing with the amplitude-depth procedure and 91.3 ± 9.9 days prior to lambing with the Doppler. Ewes having single lambs were detected 89.8 ± 10.4 days prior to lambing with the amplitude-depth procedure and 89.0 ± 10.4 with the Doppler. Multiples were detected earlier than singles by both procedures. The differences were significant at the 5% level. However, differences between the means for the two procedures were not significantly different for either singles or multiples.

In trial II, 40 ewes had single lambs and 20 had multiples; differences between the mean detection dates for singles or multiples were not significant for either procedure.

There were no indications that breed differences affected either accuracy or time in gestation when pregnancy was first detected.

Time required for diagnosis of pregnancy was only 2.2 ± 1.3 sec. after insertion of the amplitude-depth probe in 480 determinations; this is considerably less than that required for the Doppler. In a previous study with ewes in a comparable stage of pregnancy 27.3 ± 18.6 sec. were required for diagnosis of pregnancy with the intrarectal Doppler (Lindahl, 1971). Total time required for diagnosis with the amplitude-depth probe was about 1.5 min. per ewe while about 2 min. were required with the intrarectal Doppler.

Discussion

Differences in accuracy, based on lambing records, between the two methods undoubtedly is due to fundamental differences between the two procedures. Echoes from the uterine body in toto during pregnancy provides the basis for pregnancy detection by the echo procedure. Enlarged uterine horns filled with fluid, mucous or abnormal tissue can result in a similar echo pattern to that observed with pregnant ewes. By contrast fetal life must be present for a positive diagnosis of pregnancy by the Doppler technique.

In trial I, differences in accuracy between the two procedures was due to seven additional positive amplitude-depth reactions at the first examination. Six of these ewes did not give positive reactions on subsequent examinations. A similar situation existed in trial II, where five additional positive amplitude-depth reactions were observed only at the first examination; one of these ewes had a vaginal discharge at the next examination.

Subsequent results indicate that some or all of the ewes giving positive reactions at the first examination undoubtedly had conceived but the embryos had died at an early stage and the uterine horns had not returned to normal size.

In additional studies with ewes constantly exposed to rams except during late pregnancy, positive amplitude-depth reactions have not been observed in ewes that have never been pregnant. At the same time ewes that have given repeated positive echo reactions such as shown by figure 2 and negative Doppler reactions have been found to have marked pyometra or other reproductive tract abnormalities. A narrow range echo pattern from 5 to 10 cm indicates enlargement of the uterine
body and is usually an indication of early pregnancy and the need for additional diagnosis within a few days.

The described procedure is intended only for use during the first half of gestation. The use of low output and high rejection settings on the analyzer coupled with marked enlargement of the fetus and uterine body will result in negative reactions during advanced pregnancy.

Simultaneous use of the intrarectal amplitude-depth probe and the intrarectal Doppler, followed by indicated rechecks within a few days can result in diagnosis of pregnancy during the early part of second trimester with an accuracy approaching 100%.

Soft feces interfere with transmission of ultrasound and can result in errors. This usually can be avoided by putting the ewes on dry feed for 2 to 3 days prior to examination. The transducer should be directed only toward the midline of the abdomen of the ewe or very slightly to the right or left.

**Summary**

A technique for early detection of pregnancy in ewes with intra-rectal amplitude-depth ultrasound is described. Used as a complementary method with the intrarectal Doppler, pregnancy can be detected during the early part of the second trimester with an accuracy approaching 100%. Repeated positive amplitude-depth responses coupled with negative Doppler responses indicate early fetal death or reproductive tract abnormalities.

**Literature Cited**


