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Real-Time Ultrasound: Possible Uses in Genetic Prediction

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Ultrasound found its first applications in livestock research in the 1950s. Since that time, the great strides that have been made in ultrasound research have benefited both human medicine and the livestock industry. Most people probably associate ultrasound with human fetal examination. In human medicine, it is most commonly used in routine pregnancy exams and sex determination. This same technology, including identical equipment, is used in the beef cattle industry to evaluate reproductive and carcass characteristics (Figures 1 and 2). However, this publication concentrates on the use of ultrasound to predict carcass merit, specifically genetic prediction for seedstock producers.

Figure 1
Real-time ultrasound imaging is a noninvasive way of seeing inside a human body or an animal

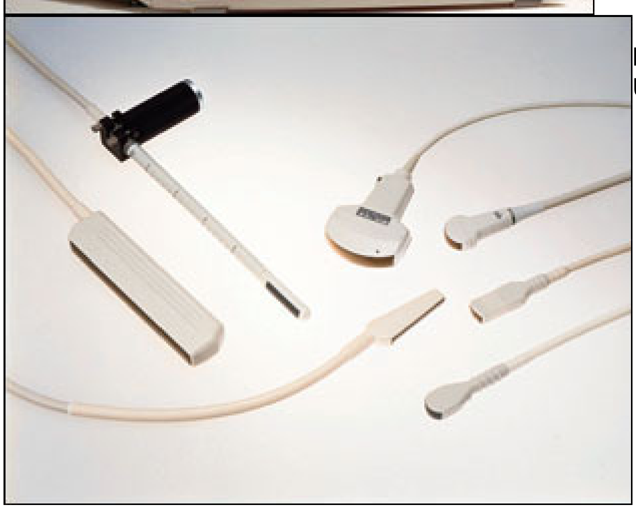

Figure 2
Ultrasound transducers acquire the images displayed on a monitor

What is ultrasound?

Technically, ultrasound is mechanical pressure waves, or sound waves, with frequencies above 20,000 hertz (oscillations per second). The portion of an ultrasound unit that actually emits and receives sound waves is known as a transducer (Figure 2). As sound waves are emitted from the transducer and pass through tissues with different densities, the echoes passed back to the transducer show this density change. For example, muscle and fat have different densities, thus allowing for their differentiation.

"Real-time" ultrasound is most commonly used in industry, although other ultrasound technologies are being investigated. Simply put, real-time ultrasound allows the operator to view the image while the measurement is being made. For example, when using real-time ultrasound in human pregnancy examinations, the heartbeat of an unborn child can be viewed on a television monitor.

Traits measured

The most common traits measured in live beef cattle include 12-13th rib fat thickness, ribeye area, and percentage intramuscular fat. When measured in the carcass, 12-13th rib fat thickness and ribeye area are used to calculate U.S. Department of Agriculture yield grade. We also know that these two measurements, particularly fat thickness, account for an important amount of the variation in carcass cutability.

The trait having the most influence on USDA quality grade is marbling score. Although this is the most important commonly measured trait contributing to beef palatability, it accounts for only a small portion of the variation in beef palatability. Marbling score is an estimate of the amount of intramuscular fat present in the ribeye between the 12th and 13th ribs. Ultrasound can also be used to estimate the amount of intramuscular fat in the ribeye in live cattle. It is not an estimate of marbling score but a direct estimate of the amount of intramuscular fat present in the ribeye.

Accuracy, precision and repeatability

For ultrasound measurements to be useful in measuring fat thickness, ribeye area and percentage intramuscular fat, they must be accurate, precise and repeatable. Accuracy and precision are not necessarily the same thing. Think of precision as the ability of a technique to rank the measurements correctly. Accuracy would imply not only a correct ranking but also that the measurements taken were the same as some objective comparison. Therefore, measurements may be precise but not accurate.

For example, say the true average fat thickness on a group of fed steers is 0.6 inch, with the fattest being 1.2 and the leanest 0.2 inch. Ultrasound might rank the steers correctly but overestimate every animal by 0.5 inch. The ultrasound measurements might say the leanest steer was 0.7, the fattest at 1.7, with an average fat thickness of 1.1 inches. In other words, the differences between animals would be the same (1.7 - 0.7 = 1.0 and 1.2 - 0.2 = 1.0). These measurements would be precise but not accurate. If the ultrasound measurements were also accurate, the smallest ultrasound measurement would identify the lean steer at 0.2, the fat steer at 1.2 and the group average at 0.6 inch. For purposes of genetic prediction, contemporary groups of animals need only be ranked correctly. For predictions used to market fed cattle, measurements should also be accurate.

Useful measurements should also be repeatable. For example, if a group of cattle was measured ultrasonically one day, would the same measurement result if done the next day? If producers are using experienced, well-trained ultrasound technicians, the answer should be yes. For measuring backfat and ribeye area, research clearly indicates that when using qualified technicians, ultrasound can be a useful tool for gathering carcass information in live cattle. Recently, the Beef Improvement Federation has sponsored annual ultrasound certification programs. To be certified, technicians must pass accuracy, precision and repeatability tests for measuring 12-13th rib fat thickness and ribeye area and must also pass a written examination. A list of certified technicians is produced annually and can probably be obtained through your local MU Extension center or your breed association office.

The prediction of percentage intramuscular fat is a newer developing aspect of ultrasound and has probably been the source of the most excitement. Several research groups across the country are working in this area. Early results are encouraging, but it is still unclear how useful this concept will be for measuring genetic merit in breeding animals.

Genetic prediction for carcass merit

In the past and still for the most part, beef cattle producers are paid by the pound, whether it be for weaned calves, stockers or fed cattle at slaughter. Just as expected progeny differences (EPDs) have been used to alter growth, so can they be used to alter carcass merit. Studies from the University of Nebraska and the University of Georgia involving Angus-sired progeny indicate carcass EPDs do work and are valid means of altering carcass traits by selection. In the Nebraska study, six bulls with high marbling EPDs and six bulls with low marbling EPDs were bred to cows. In the Georgia study, nine high-marbling-EPD bulls that were below breed average for backfat EPDs and three control line bulls were selected for mating. Progeny were slaughtered and carcass data collected (Tables 1 and 2). Results indicate marbling can be increased while holding backfat at acceptable levels when using carcass EPD as the basis for sire selection.

Table 1
Results from Nebraska study evaluating progeny sired by low- and high-marbling-EPD sires.

	Steers		Heifers	
Trait	**Low**	**High**	**Low**	**High**
percent Choice	47	77	47	72
Yield grade	2.82	2.90	2.52	2.47

Source: Taken from 1994 Nebraska Beef Report.

Currently only a few breed associations calculate carcass EPDs. The main reason more associations are not calculating carcass EPDs is lack of, and difficulty in collecting, carcass data. Ultrasound may provide a new data source for calculation of carcass EPD.

Table 2
Results from Georgia study evaluating progeny from high-marbling-EPD and control line sires.

Trait	Control line	High-marbling
percent Choice	75	95
Carcass backfat	0.55 inches	0.44 inches

Source: University of Georgia study.
Steers slaughtered when group averaged 0.5 inch.

Carcass EPD based on carcass data

Carcass EPDs produced to date have been based on slaughtered progeny data on sires of interest. Most of these data have been produced based on designed sire progeny tests. For purposes of EPD calculation, these progeny tests must be correctly designed to ensure correct contemporary group structure and sire connectedness across contemporary groups. These progeny tests may require producers to randomly mate a sire of interest along with other reference sires to a group of females from which the progeny will be reared in a single environment until slaughter. These reference sires will most likely be bulls that already have carcass data from slaughtered progeny. For this kind of evaluation, you can see that artificial insemination, availability to large cow numbers, and ability to track progeny through slaughter are needed. From these data, traits that can be used include fat thickness, ribeye area, marbling score, hot carcass weight, USDA yield and quality grades, and percentage kidney, pelvic and heart fat.

While this is probably the most accurate method for calculating carcass EPDs, there are other disadvantages. Most seedstock producers do not have access to the large cow numbers needed. However, commercial bull customers that have the ability to do artificial insemination may provide a source of cow numbers. Let's say a purebred producer wants to collect carcass data on two of his young sires. This would require that these two bulls be randomly mated to a group of females along with at least one reference sire that already had progeny carcass data. For the sake of discussion let's assume a 50 percent conception rate from artificial insemination and a requirement of contemporary groups with at least 15 progeny by each sire of one sex. Assuming no mortality from conception to slaughter and a 1:1 sex ratio, 180 cows would be needed for this small test resulting in carcass data on 45 steers, 15 from each sire.

You can also see this is a time-consuming and possibly somewhat expensive process. Let's say it's not until a young herd sire prospect reaches yearling age that you decide to progeny test. Considering it would be a year later until resulting calves are born, another 14-18 months before they are slaughtered, a sire would be at least four and probably five years of age before that data could be collected and used for genetic evaluation purposes. However, in most situations, bulls are much older before owners decide to perform a progeny test. A more timely method of determining genetic merit for carcass traits is needed.

Though progeny testing requires a serious commitment on the part of the seedstock producer, it provides the only previously validated means of genetic prediction for carcass merit and cannot be overlooked by the serious breeder.

Collecting ultrasound data from breeding animals

Ultrasound may provide an opportunity to determine a sire's genetic merit for carcass traits much more quickly. Unlike actual carcass data, ultrasound provides a quick, nondestructive means of measuring the same traits in the live animal. Although there are still many uncertainties about when and how these measurements should be collected, several universities across the country are conducting research in this area.

What and when to measure

Unlike collecting slaughter data on commercial progeny, this approach involves measuring seedstock. More than likely, measurements would focus on young bulls. These groups of bulls would obviously include sons of herd sires but might also include other potential purebred herd sire prospects. So in a sense this approach is also a progeny test.

These measurements would more than likely be taken on groups of yearling bulls that had been developed on a higher-energy, post-weaning ration. On the average, bulls will not exhibit as much external or intramuscular fat as their steer counterparts. For purposes of genetic prediction, enough variation must be present to ensure that the animals can be correctly ranked.

At present, bulls should probably be measured using the same guidelines for collecting yearling weight that are used by your breed association (i.e., recommended yearling age ranges and contemporary group definitions within your breed association), although at this time there is no scientific basis for determining the optimum ranges. This will most likely be determined by the individual breed associations based on pending research results.

Growing heifers might also be measured. There is some concern over the future reproductive ramifications of feeding a group of growing heifers a ration that is sufficient for fat variation to be displayed. For females, it may be more appropriate to measure fat after a year of age, which would allow for more potential expression of external and intramuscular fat.

Just as when considering traits such as birth or weaning weight, it is important that a contemporary group structure be defined. A contemporary group is a management group of animals of the same sex that have had the same opportunity to perform. Anything that violates this definition, such as animals being reared in different pastures or being fed different rations, constitutes a separate contemporary group. For genetic evaluations, contemporary groups are necessary to remove effects of different environments and provide a means of analyzing the genetic ties that exist between these groups. Therefore, accurate contemporary group definitions are a must.

However, just as with some of the other ultrasound areas, there is no research to indicate what contemporary group structure is appropriate. Can we group animals that were reared in separate pastures into single contemporary groups for ultrasound testing? More specifically, would those early environmental differences mask the genetic differences being measured ultrasonically? These answers are not yet available. When faced with variables of this type, it is in the association's best interest to use the most conservative contemporary group definition.

Who should take the ultrasound measurements? As previously mentioned, ultrasound technicians certified by the Beef Improvement Federation have been evaluated for accuracy, precision and repeatability. The cost of measurements may range from $10 to $20 per animal. Some producers in a single area may be able to coordinate with a single technician to reduce individual measurement costs.

Information collected would include an animal's tattoo, registration number, birth date and weight; ultrasound fat thickness, ribeye area and marbling; technician name; measurement date; and contemporary group.

Potential concerns

From the standpoint of using ultrasound as a tool for gathering data for EPD calculation, there are still many questions that require further research. Most researchers would agree, however, that ultrasound is probably useful for genetic prediction of ribeye area. There is more concern with 12-13th rib fat thickness and intramuscular fat. More specifically, would ultrasound measurements for fat thickness and intramuscular fat on a contemporary group of bulls rank those animals the same if they were steers? Is it the same trait? Intuitively, we would say yes. Sex differences and the possible limited variation in those traits in bulls may lead to difficulty in genetic prediction methods.

Equipment, software and method of data collection are somewhat standardized for measuring 12-13th rib fat thickness and ribeye area with ultrasound. However, there are currently at least five different methods of measuring the percentage of intramuscular fat with ultrasound. The main differences occur with the software and algorithms used to analyze the ultrasound images. Some of these methods have undergone validation by the developers. However, it is unclear which of these techniques offers the most accuracy and would lead to measuring traits that result in the largest heritabilities.

Research is either currently under way or soon will be in all of these areas. Several breed associations are either currently collecting structured ultrasound data or have programs in place for collecting data.

Calculation of EPD

There is no doubt that ultrasound offers a potential means of calculating carcass EPDs for animals much sooner than the designed sire progeny test based on a carcass data. However, progeny tests based on slaughter data will still be useful. At least three different possibilities exist for the types of data used to calculate carcass EPDs. First, only carcass data based on the designed sire progeny test could be used. This is currently the only approach that has been validated by research. Second, a system using only ultrasound data based mainly on breeding animals might be used. Third, a system that would incorporate both ultrasound and carcass data could be developed. Even though the first method is the only one known to work, it will be in the best interest of the industry and research groups to make sure that the second and third options are successful. Most breed associations that do not already have carcass data collection programs in place, or breeders who have not taken part in collecting carcass data in those associations that do, are years away from a viable genetic prediction system. If the industry does shift to a true value-based marketing system, those groups that can provide their clientele with genetic information for carcass traits will be more competitive.

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