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November 2005

Animal agriculture is being presented with an exciting group of new technologies associated with animal identification systems. New ideas, concepts, and technology are becoming part of livestock producers' daily lives. The emergence of precision agriculture involves the application of technologies like global positioning systems, geographic information systems, biometrics, and DNA-based biotechnologies. These new technologies are being adopted from other industries as a result of economic signals in the marketplace. It will be important for producers to evaluate these various identification (ID) technologies and adopt practices that fit into their production system, improve their operations, and increase their opportunities to command a top price for their product. As companies like WalMart continue to adopt new tracking technologies, such as radio frequency identification (RFID)<sup>1</sup>, animal agriculture can benefit because economies of scale will act to continually lower the cost of these emerging technologies. The decision livestock producers need to make is whether to use, wait, or ignore these new technologies. These decisions should be made with profitability in mind.

The goal of this fact sheet is to provide a brief overview of some new technologies not detailed in previous fact sheets. These technologies are not currently part of the National Animal ID System (NAIS) for cattle; however, they may be valuable tools to consider in your operation. Emerging management systems are also described, along with a discussion of how they might change the way cattle are identified, managed, and marketed.

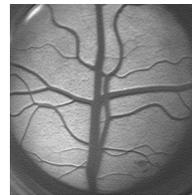
### Advances in Animal ID Technology

In the fact sheet "An Introduction to Electronic Animal Identification Systems and Comparison of Technologies," RFID ear tags are the proposed NAIS method for unique ID of cattle. Although, there are several ID systems available that satisfy the same requirements for unique ID as RFID, many of these systems have not been endorsed yet by the NAIS cattle work group. These technologies include nose

prints, iris scans, retinal images, and DNA-based identification technologies.<sup>2</sup> For this discussion, the focus will be on retinal imaging and DNA analysis because they are already available in the animal ID marketplace.

### Retinal Imaging

Retinal imaging is a form of identification that can be used in both animals and humans.<sup>2</sup> An image of the blood vessel pattern on the retina is analogous to a fingerprint (Fig. 1). This pattern is fixed at birth and does not change throughout the animal's lifetime. Using a computer algorithm, the retinal image is converted into a unique ID.<sup>2,3</sup>



**Figure 1. Digital image of retinal blood vessel pattern (Photo obtained from Optibrand Ltd, LLC, Ft. Collins, CO. Used with permission).**

Optibrand, a Colorado company, is applying the retinal imaging technology to the livestock industry. They use digital camera technology to capture an image and combine this with an encrypted position, date, and time using a Global Positioning System (GPS).<sup>2,3</sup> The reader can also be used to collect and store several forms of data and interface with other devices including bar code readers, electronic scales, and RFID transponders (Fig. 2).

The combination of technologies is promoted as a tamperproof system that addresses requirements for both unique ID and traceability. There is a challenge with line-of-sight issues because the camera and eye must be lined up and close enough to the animal to capture the image.<sup>4</sup> For most cattle, this would require each animal to be restrained in a chute. In the packing plant, the technology is only valid up to the time the animal's head is removed from the carcass. Optibrand does provide solutions to capture other forms of ID, such as bar codes and RFID tags so that in combination with the packing plant trolley tracking system, a unique ID can be maintained on each animal.<sup>1</sup>



**Figure 2. Optibrand Animal ID System (Photo obtained from Optibrand Ltd, LLC, Ft. Collins, CO. Used with permission).**

### DNA Identification Analysis

The term DNA is familiar to many livestock producers because it is frequently used in the daily news, television shows, trade publications, and newspapers. The application of DNA technologies is becoming more popular for animal ID and parentage analysis.

A common challenge with many animal ID technologies is the harvest process. At the time of harvest, the animal ID device (i.e., RFID ear tag) is removed and the tracking of the animal is based on ID systems within the packing plant. In more advanced packing plants, a trolley tracking system is used to uniquely ID carcasses. Currently, DNA analysis for ID by single nucleotide polymorphism (SNP) fingerprinting is the proposed method to overcome this problem and truly track animals from “farm to fork.”<sup>1</sup> After an animal has been harvested,

DNA remains a stable, identifiable component to track the origin of beef products.

Genotyping 30 SNP loci that exhibit variability across all common beef breeds would be sufficient to uniquely identify 900,000 cattle.<sup>5</sup> The odds that two individuals coincidentally possess identical 30-SNP loci genotypes is less than one in a trillion! And 45 highly-informative SNP loci are estimated to be sufficient to identify all of the cattle in the world (estimated to be approximately 1 billion). In the past, the commercial implementation of DNA analysis has not been cost effective; however, recent advances in both technology and reduction in price might improve its commercial acceptance.<sup>6</sup> Currently, several European research groups are conducting a large study to look at multiple technologies including the combination of RFID and DNA to insure traceability through the entire production system.<sup>7</sup>

Parentage analysis with DNA markers is the most frequently used of the molecular technologies.<sup>8</sup> DNA markers come in two forms, microsatellites and SNPs. DNA markers can be used to assign calves to their individual sires based on the inheritance of markers (See example). Sires pass on only one of the two marker alleles that they carry for each gene. If a calf does not have a marker allele in common with a sire at a particular gene, then that sire is excluded as being the parent of that calf. Paternity “identification” involves examining each calf’s genotype at multiple different gene loci and excluding as potential sires those bulls that do not share common alleles with the calf. Because paternity identification is a process of excluding potential sires on the basis of their genotype, it is therefore important that DNA from all possible sires be included in paternity tests.

#### Example:

	<b>Bull A</b>	<b>Bull B</b>	<b>Bull C</b>	<b>Bull D</b>
<b>Genotype</b>	140,140	134,146	152,140	152,140

- A calf with the genotype “134,140” could have received one allele from any of these bulls and so none of these bulls can be excluded as the possible sire.
- A calf with genotype “134,148” could not have been sired by Bulls A, C or D, and must have received the “134” allele from Bull B, and by a process of elimination the “148” allele must have come from its dam.
- A calf with genotype “130,152” could have been sired by either Bull C or Bull D. The fact that these two bulls have the same genotype at this particular marker locus, means that more loci will have to be tested to exclude one of these bulls as the sire. If these bulls are closely related such that they have the same genotype at many marker loci, then it will require more loci testing to uniquely assign one of the bulls as the sire of the calf.

While parents can be excluded using this process, results cannot be used to “prove” parentage. Parentage testing identifies individuals that, due to a specific combination of marker alleles, could qualify as a parent for a particular offspring. Paternity testing is complicated by genetic relationships between the bulls. If bulls are closely related then they are more likely to carry the same marker alleles. Consequently, it will be more difficult to definitively make paternity assignments on closely related bulls in a multiple-sire breeding pasture. Forming multiple-sire groups for each pasture from unrelated animals, i.e. putting full-brothers in with different groups of cows, will help to minimize this problem. If there is only one potential sire for a calf (e.g. an A.I. calf), then paternity can be “assigned” by confirming that the calf’s genotype shares a marker allele in common with the alleged sire at all of the genetic loci that are tested.



Multi-sire pasture breeding is a common practice in the western US. This makes it difficult to identify parentage unless you use DNA analysis to determine the parentage of a calf. Uses of parentage testing include identifying the sire(s) of outstanding or poorly performing calves and ascertaining whether one particular bull is routinely siring progeny that require calving assistance. To identify the sire(s) of a select group of calves (e.g., calves that are pulled or top 10% of carcass quality animals) the costs of DNA analysis are minimized by sampling and DNA testing the herd bulls and only the targeted subsample of the calves. More extensive sampling of the entire calf crop can allow for a determination of the proportion of the calf crop attributable to each bull in the herd. It is generally assumed that each bull contributes equally to the calf crop. However, studies have shown that some bulls sire more than their “fair share” of the progeny, while other bulls sire none of the progeny.<sup>9</sup> Matching individual sires with the performance

records of their entire calf crop also provides the data required to develop within-herd EPDs for herd sires.<sup>8</sup> This may be particularly important in the case of postmortem traits such as carcass quality where progeny testing is the most accurate way to determine the genetic value of a bull. As with any new technology, the value associated with the parentage information must be estimated to ensure that it outweighs the expense of collecting and analyzing the DNA samples (currently ~ \$10-35 per DNA sample submitted, although this cost is predicted to decrease markedly in the future).

### **Alternative Electronic ID Technology**

In the U.S., the RFID ear tag is currently the most widely used form of electronic ID in animal agriculture. The technology is relatively new compared to traditional ID methods like branding, but RFID is common in the pet industry.<sup>10</sup> In the pet and equine industries, RFID implants or microchips are implanted into the animal. It is possible to use the same technology in cattle or other livestock, but the industry is concerned about food safety issues due to potential migration and recovery of the implant.<sup>11</sup>

An RFID transponder also comes in a bolus form similar to magnetic boluses used to prevent hardware disease. The transponder is enclosed in a ceramic case and placed in the rumen.<sup>11</sup> The technology is more widely used in other countries and is currently being tested on species like sheep and goats because of challenges with tag type methods.<sup>9</sup> Research reports indicate a higher level of retention, but the cost of a rumen bolus is more than double that of tag technology.<sup>4</sup> Furthermore, there are concerns about ways to recover the bolus during the harvest process.

### **RFID Research**

The area of RFID research is popular with the retail industry, and the information that is provided by this research will eventually benefit agricultural applications. The current RFID tags in cattle operate on a low frequency bandwidth. That means that they have a limited read range of several inches to a few feet depending on the type of reader (handheld vs. stationary).<sup>10</sup> Scientists at North Dakota State University are researching higher frequency RFID systems to overcome some of the issues with close read ranges. Using higher frequencies, similar to ones found in your telephone at home, the read distances increase to 30 ft.<sup>12</sup>

The Kansas Animal Health Department and Kansas State University are applying technology from Osborne Industries and Digital Angel Corporation to track cattle movement using RFID systems mounted on livestock transport trucks. Using RFID technology coupled with GPS and cellular phones, they plan to track animal movements and report the movements to the Kansas Animal Health Department. This project is still in progress and research results are expected at the end of 2005.<sup>13</sup>

The health and general well being of animals is always a concern for the livestock industry. In a commercial setting the ability to monitor and correct problems associated with animal health is sometimes limited to available resources. However, advances in RFID technology are being researched that would allow producers to monitor physiological responses, such as heart and respiration rates, to daily stresses. Specifically, the stress of transportation is being investigated in pigs.<sup>14</sup>

In livestock, feed inputs represent a high percentage of annual costs. Therefore, it is very valuable to identify and potentially select animals with lower nutritional requirements because of the impact on profitability. A Canadian company named Grow Safe Systems developed technology to collect data on animal consumption and feeding behavior. Using RFID technology, the system can record feed and water consumption.<sup>11</sup> Researchers are also recording data on measures of heart rate and respiration rate to determine individual energy expenditure. The researchers are hopeful that they can use this approach to predict energy requirements in cattle, especially in pasture situations.<sup>15</sup>

### **Advances in Management**

Animal ID by itself does not automatically include data collection; however, the implementation of an electronic ID system combined with different industry databases most likely will increase both the volume and speed of information. As cattle industry segments become more vertically integrated, a higher proportion of data will be transferred to each segment. Typically, cattle alliance programs have some level of vertical coordination between different industry segments (i.e., cow-calf, feedlot, packer). As of 2001, there has been a 28% increase in the number of cattle enrolled in alliance programs.<sup>16</sup> As the volume of data increases, producers will require tools and information infrastructure to collect and

process the information so that they can use it to make management decisions.<sup>17</sup>

As livestock producers, you may feel overwhelmed by the thought of more information. The regular increases in information emphasize the need for tools to assist with management decisions. In response, software is needed to manage the distribution, security, and analysis of the information. Conceptually, the tools should assist producers with improving their production practices, managing their information for compliance with alliance or verified programs, and allow for quick feedback on the performance of their livestock from different segments of the industry.<sup>17,18</sup> Decision support and data mining tools are suggested approaches to this challenge. As part of the decision support tools, some companies offer access to benchmark data to rank your operation against producers with similar programs. Using these benchmarking services, you can identify areas of improvement by comparing your herd against other herds with a similar ranch makeup.<sup>19</sup> The data you collect and share about your cattle might be used in the future as justification for higher prices at weaning or justify the need to retain ownership to harvest. As traceability evolves and more information is available, price signals will also guide producers in respect to changes in production practices, genetic improvement, and compliance with process verified and Beef Export Verification programs.<sup>1</sup>

### **Advances in Marketing**

The proposed requirements for a National Animal ID System could yield new opportunities for livestock producers. These opportunities will only be available to producers interested and willing to put the effort out to comply with the programs.<sup>1,20</sup> Potential applications of animal identification, product traceability, and source verification in the livestock and meat industry may include:

- Determination of ownership and deter theft
- Surveillance control and disease eradication
- Biosecurity of the nation's livestock population
- Compliance with international requirements for export
- Improvement of supply management, distribution, and inventory control
- Facilitate value based and value added marketing
- Isolation of problems with quality control and food safety

- Reduction of product recalls and improve effectiveness of product recall management

The financial incentives of source and process verified programs are associated benefits with a national ID system because of the overlap in requirements.<sup>1</sup> For example, cattle can be marketed under USDA Process Verified Programs (PVP), Quality System Assessment (QSA), and Beef Export Verification (BEV). All of these classifications assist with preservation of product identity and differentiation from commodity product.<sup>1</sup> In a PVP program, you could make certain claims based on your production practices or breed makeup. As an example, a PVP program specifies a specific breed percentage (i.e., 50% Angus or higher). For you to qualify for the program or sell your animals under their label claims, only animals with a certain breed percentage would be eligible.<sup>1</sup> Some cattle breed associations use this approach to differentiate their product in the marketplace and help their participants claim a higher price. Both the U.S. Red Angus and Black Angus breed associations are implementing PVP programs to enhance the value of their breed. In the requirements for the American Angus Association program, RFID tags and visual tags with the program name and logo are listed as an accepted form of ID.<sup>21</sup> The same is true for the American Hereford Association's Hereford Beef program.

A few states are developing systems to comply with the proposed national animal ID system and simultaneously enhance the value of their cattle. South Dakota has developed a state-wide program named South Dakota Certified Beef ([www.southdakotacertifiedbeef.com](http://www.southdakotacertifiedbeef.com)).<sup>22</sup> The program requires cattle to be born, raised, and harvested all in South Dakota. Additional requirements involve source and age verification and the use of RFID technology. The Montana Beef Network (MBN) is another example of a state-wide program that incorporates many positive benefits of an animal ID program (<http://www.mbn.montana.edu>). The main goals of MBN are focused on beef quality assurance practices, voluntary certification of calves that meet specific health requirements, and traceability and information feedback from buyers. This information is used to educate producers about ways to improve their product.<sup>20</sup>

## Summary

Animal ID technology will continue to evolve with advances to existing technology and the entry of new

competition in the marketplace. New technologies, such as biometrics, high frequency RFID, and DNA ID analysis, will continue to mature and develop a stronger presence among livestock producers. Therefore, livestock producers should continually evaluate their existing animal ID system and consider new technology if the technology improves profitability by enhancing production efficiency or accessing new markets.

## Information Resources

- Livestock Marketing Information Center, [lmic.info/memberspublic/animalID/AnimalID.htm](http://lmic.info/memberspublic/animalID/AnimalID.htm)
- International Livestock Congress, [www.livestockcongress.com/](http://www.livestockcongress.com/)
- USDA Process Verified Program, [processverified.usda.gov/](http://processverified.usda.gov/)
- USDA Export Verification, [www.ams.usda.gov/lsg/arc/bev.htm](http://www.ams.usda.gov/lsg/arc/bev.htm)
- USDA Quality System Assessment Program, [www.ams.usda.gov/lsg/arc/qsap.htm](http://www.ams.usda.gov/lsg/arc/qsap.htm)

## Company Pages

- Optibrand [www.optibrand.com](http://www.optibrand.com)
- Biogenetic Services, Inc. [www.biogeneticservices.com](http://www.biogeneticservices.com)
- Bovigen [www.bovigen.com](http://www.bovigen.com)
- Genaissance [www.dna.com/products\\_services/bovine\\_id.html](http://www.dna.com/products_services/bovine_id.html)
- Igentiy [www.igenity.com](http://www.igenity.com)
- GeneSeek [www.geneseek.com/index.sp](http://www.geneseek.com/index.sp)
- ImmGen [www.immgen.com](http://www.immgen.com)
- MMI Genomics [www.mmigenomics.com](http://www.mmigenomics.com)
- UC Davis Veterinary Genetics Laboratory [www.vgl.ucdavis.edu](http://www.vgl.ucdavis.edu)

## Acknowledgements

The authors and University of California Cooperative Extension committee would like to thank the California Department of Agriculture for providing the funds to develop this fact sheet and educational materials for Animal Identification. In addition, the committee appreciates the contributions of the Western Extension Marketing Committee.

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