The Future of Precision Livestock for the Cattle Industry—Justin Sexten

Introduction to Precision Livestock Farming

Precision agriculture is not a new idea. Diverse farming and ranching operations have already seen exponential advancement in precision ag within the row crop space. Technology moved us from farm level planning to sub-acre management. Precision livestock farming (PLF) is a more recent application of this similar technological approach to the livestock enterprise.

How one defines PLF will differ depending on the source. Some suggest PLF is the application of process engineering principles to animals (Wathes et al., 2008). In this model animals are monitored continuously by sensors and/or cameras and predictions are made using behavior or trait deviations from normal. Monitoring for deviations from a normal individual's baseline are similar to how equipment manufacturers monitor machines to initiate preventative maintenance. In the livestock space these prediction models tend to focus around event detection, such as estrus, calving, lameness or illness.

A good veterinary friend once told me he has been using a similar model to train future veterinarians. Attempting to learn every disease symptom can be overwhelming, whereas a solid understanding of the normal animal provides a baseline to detect early disease indicators ultimately signaling the need for intervention or further diagnosis.

Another vision of PLF is using technology to automate and simplify data capture to inform production decisions. This model is built on a similar premise to event prediction, informed by massive amounts of sensor data collected around the clock (Berckmans 2017). Machine learning and artificial intelligence continuously evaluate the data to generate an algorithm to make predictions around health, performance and welfare.

This model has greater focus on understanding intervention points around growth and efficiency. Predicting terminal endpoints, making genetic predictions, and automated sorting are outcome examples derived from digitally gathered phenotypes.

The two definitions are not largely different in execution as each incorporates data from the Internet of Things (IoT) using sensor technology coupled with machine learning and AI analysis enabled by cloud-based connectivity. Regardless of the output, PLF is focused on addressing a common challenge: feeding a growing demand for meat and milk products using fewer resources.

Efficient natural resource use is a key metric of operational and financial sustainability. In many areas of agriculture simply increasing operational scale can provide the most effective path to efficiency. As herd and flock sizes increase infrastructure and fixed costs are diluted offering greater margin opportunities. The availability or cost of skilled labor to manage these growing operations often drives producers to increasingly look to technology to curtail any scale related labor and management challenges.

The binary nature of event-based data (estrus, calving, illness) coupled with their labor saving opportunities led to the development of sensor-based solutions for individual animals. Success of these solutions may also be attributed to the limited time the solution is needed, the relative confinement during these periods and the high cost of missing the event. This event focused approach will guide the emerging technology of group management.

Resource Optimization

Berckmans (2017) suggested managing livestock in concert with the animal's genetic potential offers a significant path to environmental sustainability. With that backdrop a question to consider, what percentage of livestock are managed in a way to optimize their genetic potential. Does your answer differ by species? Where is the greatest opportunity to improve? Increase the average genetic potential or provide an environment that optimizes expression?

Innovators will continue to provide point solutions, sensors and algorithms as discussed above. Technology limitations and use will certainly vary across the supply chain as solutions for the ranch will differ widely from that of the feedyard. However the functional challenge to the beef industry as well as the average ranch is finding ways to optimize individual animal performance within a group without sacrificing animal welfare.

No single animal reflects the average of a group (Berckmans, 2017), an example of the paradox of average management. Remove the technology aspect for a moment and consider PLF at the core as managing animals as individuals rather than a group. Group management by rule of math results in half the cattle managed under their potential while half are wasting resources they don't have the potential to fulfill. Rosa (2021) highlighted this individualized approach to optimize future productivity while moving away from traditional management that "pen-alyzes" high production animals fed in a pen.

Precision feeding practices are not a unique approach. Swine and dairy producers implemented phased feeding long ago, grouping animals by nutrient demand. Precision feeding addresses inefficiency in both nutrient supply and demand (Pomar, C. and A. Remus. 2019). By narrowing the window of ingredient supply and animal demand the variation associated with time is reduced. Diet formulations can be changed to narrow the nutrient supply with potential to reduce cost as well unnecessary over formulations and safety margins.

There are few gaps in the knowledge of the average individual animal's nutrient requirements, the gap lies in application of these individual requirements within a dynamic group of animals. If PLF is primarily managing to the individual level future success gets more challenging as operations get larger. Is the average feedlot pen sized to optimize animal production per head? An economy of scale designed to optimize marketing and logistical challenges may impair true enhancements in efficiency. Can precision feeding systems offset the advantages of large group management? Pen size need not limit the ability to apply precision feeding systems if individual animal variation can be minimized.

The use of artificial insemination and estrus synchronization are prime examples where the beef industry solved this challenge. To optimize genetic merit individual matings are carefully considered by seedstock breeders for each cow. PLF solutions emerged to accomplish estrus monitoring that range from chalk to electronics. One may argue detection may still limit technology adoption as estrus synchronization was needed to optimize labor, limiting individual "variation" in estrus timing.

Execution logistics often present the greatest barrier to implementation of good ideas. Breeding cows by appointment continues to improve the uniformity and genetic merit of calf crops across the nation. With a host of options to manage the variation of a cows' reproductive cycle with a high degree of precision producers are able to select the option that addresses their greatest need, ranging from maximum pregnancy rate to most labor efficient.

Another area where logistical challenges can hamper PLF implementation is genetic potential. The ability to quantify genetic potential is well developed for purebred and crossbred cattle. Communicating this potential at logical intervention points is the gap where technology offers possible solutions.

Long generation intervals continue to drive investments in genetic testing by seedstock and progressive commercial breeders. The value of time and need for continual progress will continue to drive genetic PLF solutions. Purebred and commercial cattlemen want to understand the genetic potential of an animal early in life. The value proposition for this technology is clearly defined for those making long-term selection and mating decisions.

For the short-term manager of the products of genetic improvement the communication of performance potential downstream is largely unrealized. Breeders have established a currency of communication amongst themselves using EPD's and genomic results yet the conversion of these results to other aspects of the supply chain are limited to group level badges and certifications. The goal of implementing precision feeding systems appears unattainable when genetic potential cannot be communicated to the next owner.

An equal challenge is communicating genetic potential so that managers can act on the information. Whether at purchase or initial processing the need for technology solutions to enable real-time communication across operations. If individual animal management is the goal for optimal resource use, then communication of individual data must evolve beyond current industry practices.

Currently precision management beyond the ranch is limited to biometric sorting as well as strategic implant and feed additive use. These solutions are valid PLF management approaches applied to imperfect groups. The ability to deploy technology at an animal level is limited by group size or chute sessions. If group size is determined by logistics and marketing then solutions should seek opportunities for prescriptive management at chute intervention points. Pen monitoring and algorithm predictions, while useful, ultimately require additional operator intervention. Processing cattle using real-time information is a first step to PLF implementation.

Chute sightings provide key opportunities for passive phenotypes collection that remain a premium in powering PLF predictions. The digital capture of visual phenotypes was first used in carcass evaluation (Fernandes et al., 2020) with increasing use in dairy and swine systems. The evolution of computer vision systems with integration into PLF ecosystems offer opportunities to provide data to the market and production segments. Use cases where both production and marketing needs are met can lead to wide-scale adoption.

Future Considerations

Technological

Connectivity is a key enabler of PLF solutions. The ability to move data across devices, operations and people is key. What good is data locked in a single device or platform? Data management challenges are not a unique problem to PLF. In areas of poor or slow connectivity, data transfer challenges are exacerbated. Berckmans (2017) suggested PLF applications should use local algorithm development to minimize the need to manage data and the associated energy and transactions costs. This factor is increasingly important in developing regions where infrastructure may lag (Rosa 2021).

Connectivity offers reduced deployment costs when enabled by agnostic on-farm sensors and processors provide infrastructure to deploy technology. How many are using a high cost or outdated system due to the high cost of switching? Switching costs are expressed in many forms. The first and most painful is data entry, for many getting data into systems the first time is bad enough making re-entry worse.

Real-time updates enabled by connectivity provide frictionless software deployment from basic operations to farm level algorithms. Technology providers are well served to ensure components are agnostic to current upgrades or amenable to the new components to promote early adoption. Early adopters provide key feedback to the marketplace and developers. While rapid product evolution and iterations are key to product improvement, early adopters should not be punished with outdated prototypes.

Optionality is a key to the success of technology adoption. We have no idea how devices, hardware or service providers will change and adapt over time so consider platforms where data portability is a core focus. John Deere® provides a row-crop example where they actively promote across company development to ensure system compatibility. https://developer-portal.deere.com/#/. If history provides an example, those solutions focused on keeping producers or data locked into a program or offer limited integration opportunities will be challenged by open source or flexible platform models.

Production

Limiting individual and group disruptions to normal behavior is a key barrier to address (Rosa, 2021). For beef production systems where most management occurs in extensive environments the application of spatial sensors, video cameras and other monitoring technologies are limited. The nature of converting large areas of unimproved forage to beef mandates the need for off-line or intermittent communication solutions.

For those systems that are successful in these environments, battery life and size becomes the next barrier to overcome. While battery technology will continue to advance, passive technology offers the greatest solution in the near term. Sensor activation near key gathering points (water, mineral, or gates) will provide check in opportunities to capture and sync data.

Several sensing technologies have clearly demonstrated predictable outcomes overcoming the barriers above, however, they require a timely sensor application. These solutions will remain a point solution (solve a singular problem) or incorporate within a long term sensor. Here is where the cow's ears proves to be a key asset to PLF applications.

Any discussion of future applications of PLF that ignores data privacy issues would be incomplete. Producers increasingly understand the value of their data. Data in exchange for value has been a swap people are willing to make thus far. Whether auto insurance, family genetic history or soil productivity, consumers continue to share data in exchange for improved solutions. Data is the currency of PLF, effective consumer protections that incorporate across operation sharing will provide additional value beyond performance predictions.

Ethical considerations related to PLF pose a unique challenge. PLF solves for the growing list of sustainability metrics suppliers increasingly demand. Yet the consumers may view the solution as compromising welfare and converting the care and monitoring of animals over to the machines (Wathes et al., 2008). Consumers seek technological solutions in every aspect of life yet the food system is increasingly pressured to maintain the historical context of red barns and upright silos.

While PLF systems offer an increasingly wide range of monitoring and predictive management opportunities, the most useful aspect of PLF may lie in the primary requirement for execution, individual identification in a connected ecosystem. The ability to provide digital, on-line practice verification across the supply chain may be the most valuable by-product of precision livestock management.

PLF offers the beef industry the opportunity to improve animal productivity, and address growing labor issues while fulfilling consumer demand for increased food system traceability and sustainability. The technology to accomplish the production goals exists in a number of current solutions. When the marketplace is willing to pay for adoption, producers will rapidly solve for the execution barriers.

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