Advanced Performance Monitoring In Livestock – New Sensors & The Connected Farm.

Dr. Edmond Harty, CEO, Dairymaster (Web: www.dairymaster.com Email: eharty@dairymaster.com)

1 Introduction – The Connected World.

1.1 More information now than ever.

Emerging technologies have radically changed everything we do. We live in an open society where everyone is connected through the internet, social media, smartphones, Twitter, WhatsApp, YouTube, and so on. Never before was there so much information available and accessible. We cannot imagine life without technology anymore. Both new and existing technologies are dominant drivers for our future.

1.2 Megatrends and intelligent sensing mechanisms – Introducing SMART technology.

Megatrends in technology and sensing are currently reshaping the global market. Introducing SMART technologies has played an important role in this. Intelligent sensing mechanisms, big data, cloud servers and two-way data traffic allow us not only to request information anywhere at any time, but also to respond to ever changing situations. For example: breaking news is instantaneously pushed to our phones. If an alarm in our house activates, we know about it immediately and the Satnav in our car makes driving easier and safer. This improves efficiency and makes life easier. Sensors are becoming more popular all over the world. The 'internet of things' has allowed us to include sensor technology in almost every aspect of our lives for example cars that automatically park themselves, climate control in our houses can be adjusted from our phones and there is an explosion of technology in sport and fitness. This 'internet of things' impacts a large number of industries, including the agricultural industry where the introduction of sensing technology has already been done in the form of auto-identification (RFID-eartags were already present since 1993 in the more prominent milking parlours), accelerometers, automated voice commands for in the milking parlour, GIS systems, smart feeding software, hyper spectral imaging, automatic drafting and weighing scales and so on. With these revolutionary technologies herd owners can help manage their farms from anywhere on this planet. Profitability, productivity and the need to have a more effective use of labour are the main drivers for developing these technologies. Attention to detail is key in optimizing any farm and especially in the dairy farm industry the focus can be put back again on the performance of each individual animal but this time with precision like never before.

2 The Connected Farm.

2.1 Global growth demands to face future challenges.

2.1.1 Expanding world population.

In 2011 our world population passed 7 billion people. In 2050 we will have nearly 10 billion human beings living on this planet (UN, 2014). Our population is increasing by 200.000 people a day, which comes down to an increase of 68 million people a year. This is the equivalent population of the whole of the UK each and every year for the next 40 years. If there are not huge changes in agriculture to improve output, the question for many could be: is there food on the table? The World Bank has shown that the world has consumed more food than has been produced in four out of the last five years (Voegele, 2014). Competition for food is growing.

2.1.2 How does this connect to agriculture?

Agriculture is at the moment the number one means for food production and is in many households throughout the world the main source of income. The dairy farm industry forms a main player in this sector. Expectation is that the demand for milk and dairy products is going to increase with 100 billion litres in the next 5 years. But together with increasing world population comes depletion and degradation of natural resources, which has led to a decrease of total arable land for agricultural purposes. Since the year 2012 less than 38% of the land available can be used as agricultural land and with this we are facing considerable challenges in the decades to come considering food production (World Bank, 2012). There is a high need to get the most out of our land, animals, water and people in the most efficient and environmentally friendly way possible. The use of new technologies has become indispensable in this picture. It diminishes workload and physical effort for both operator and manager. This increases work efficiency and reduces risks of farm related injuries and at the same time facilitates working processes. It will also mean a better work environment for staff, helping to make the whole farming processes more profitable, enjoyable and sustainable.

2.2 Sustainable food production – Driver for good farming practice.

2.2.1 Pillars of productivity.

Sustainable food production and longevity of stock goes hand in hand with optimal herd management. Healthy cows have greater reproductive performance and produce more milk of better quality than cows in suboptimal condition (Bareille, et al., 2003). Also, antibiotic usage is significantly less in well-managed livestock and the better the facilities and housing environment, the less stress the animal will experience. Moreover, better quality feed and water and improved heat detection rates will also increase milk production (Challis, et al., 1987; Beauchemin, 1991). Nutrition, reproduction, health, infrastructure and staff management are key focus points for optimal productivity and good farming practice.

2.2.2 Nutrition.

From the moment a calf is born it needs to get optimal care and the right amounts of high quality colostrum. This gives that calf a good foundation in life and improves growth rates in the months to follow. This is of major importance since onset of puberty is rather weight rather than age dependant. Also, introducing the correct weaning protocols on farm will improve feed conversion and growth rates (Pallisé & Rushen, 2012). Optimum dry cow management and a high-fibre diet will prevent many production related metabolic disorders after calving (Doyle, 2013). Cows in peak lactation require a diet, high in energy to counteract the effects of negative energy balance. Ever improving smart feeding technology together with auto-identification and cloud computing have now made it possible to plan the most beneficial diet for each individual animal from birth to old age regardless of herd size.

2.2.3 Reproduction.

Poor fertility is one of the main reasons of prematurely culling cows. A calving interval of 365-375 days, calving to conception interval of 85-90 day, submission rates of 70% (90% for block-calving) and a non-return rate in excess of 75% are targets for optimum fertility. These are achievable targets. Selection for 'high production' traits has caused fertility to decrease in the last decade (Boichard & Brochard, 2012). Optimizing reproductive performance on farm goes hand in hand with accurate heat detection. Sensing technology is not only able to identify cows that are in heat, but also cows that are non-cycling or cystic. These animals can be picked out sooner and presented for veterinary inspection. More advanced devices such as the MooMonitor include onset of heat, making it possible to calculate the optimum time for insemination and so increasing conception rates (Stevenson, et al., 2014).

2.2.4 Health.

Most diseases of dairy cows happen around the time of calving so proper dry cow and fresh cow management is vitally important. High producing cows are prone to typical health issues such as (sub-acute) ruminal acidosis, (sub)clinical ketosis, retained foetal membranes, abomasal displacement, endometritis and (sub)clinical milk fever (Mulligan & Doherty, 2008). It is crucial to identify these animals and treat them as soon as possible, in order to promptly get them back in production. Other diseases with a high prevalence in dairy farms are mastitis and lameness. Both decrease productivity if present on farm (Warnick, et al., 2001; Fourichon, et al., 1999) However, an American study showed that true prevalence of certain conditions are 2.5 times higher than the estimation done by herd managers (Wells, et al., 1993). This means that a lot of health events on conventional farms are missed. These animals are not performing to their potential, which results in reduced production and profits. If potential health events are better managed, there are improvements in reproductive performance and consequently in productivity.

2.2.5 Infrastructure.

Dairy farm infrastructure includes areas such as milking parlour and facilities, housing and ventilation, walk ways and staff access points, adequate number of cubicles and feed space, feed storage and slurry handling. A well-designed housing system has a positive influence on productivity. Optimal cow flow maximises milking time, reduces injuries and facilitates adequate time for feeding and resting. Increased resting allows up to 30% greater blood flow through the udder which can increase milk yield, because 400-500 litres of blood need to pass through the udder to produce 1 litre of milk (Metcalf, et al., 1992). Sensors that measure resting behaviour help to improve cow house management and design. Keeping the cow house clean is important to reduce mastitis, lameness and other diseases.

2.2.6 Staff management

As herds increase in size, the demand for labour also increases. There is limited availability of well-trained staff. Technology can help attract staff to a particular farm as a first step in the process of locating, educating and motivating a team. Introducing technology improves time-management and increases objectivity. With improved time-management, there is reduced firefighting and more time for training and forward planning. Typically this results in a better working environment and higher job satisfaction.

2.3 PERFORMANCE MONITORING FOR THE INDIVIDUAL ANIMAL & THE ENTIRE HERD.

It is important to remember that herds are made up of individual animals. And for the reasons mentioned above it make sense to continuously measure the animal's behaviour. The Dairymaster MooMonitor is a wireless wearable sensor which measures rumination, resting, feeding and fertility related behaviours 24 hours per day. Each year this sensor makes over 15 million measurements and over 210,000 measurements are transferred to the cloud for detailed analysis. If normal behaviour is known, data of cows showing abnormal signs can be identified and action can be taken much sooner. Early identification of the onset of disease is often identified earlier by sensing technologies, whereas visual observation alone is often inadequate. In much the same way as news alerts can appear on a smartphone in real-time, these health alerts can be seen on the herd manager's phone.

Sensing technology is proven to have a positive impact on calving interval (Stevenson, et al., 2014). Using the sensing device as a heat detector, more heats can be picked up and more animals can be submitted for insemination. This leads to more pregnancies and calvings per year and an overall greater life production due to more peak lactations in this period. Watching parameters such as rumination, feeding and resting time increases the knowledge about the individual animal. It also gives indications when she is sick or recovering from a certain problem. It identifies problems in early stages due to due to a continuous information flow. This often allows the herd manager to intervene with supportive therapy only and so reduce the use of antibiotics. In regards to the animal's digestive system, monitoring parameters such as rumination and feeding can give the farmer an indication about intakes, food conversion and digestibility of the diet. The performance of each individual cow can be compared with the group and individual adjustments can be made.

2.4 MORE TECHNOLOGIES FOR THE CONNECTED FARM

Smart feeding technology can improve transition cow management by feeding each individual cow according to their requirements based on their condition at dry off for example body condition score, health status, days to calve, presence of twins, lactation number etc. This system ensures that each individual animal follows their specific nutritional plan and if feeds are missed alerts are sent to the herd manager.

In vehicles satellite navigation systems use speech to communicate important information to the driver at the appropriate time. VoiceAssist technology is similarly used to communicate important information to the operator at milking time. For example fresh or treated cows can readily be identified and any drops in production or potential health events can be effortlessly highlighted.

Following production it is important to store milk so that milk quality is maintained using the least amount of energy. Sensor technology means that cleaning, storage and collection are continuously monitored and again any anomalies can be readily identified. For example following milk collection cleaning of the milk tank should commence. If this process is not initiated the farmer is made aware of the situation. Because temperature is monitored constantly, both the milk storage conditions and cleaning conditions can be verified in real-time and maintains a continuous watch on the valuable end product. This technology allows farmers to better manage and will allow processors to have a more secure higher quality supply base which is monitored 24 hours a day.

3 THE FUTURE…

In the years to come our knowledge of technology will expand and more advancements in technologies will be achieved. Imagine that due to technology we are able to breed animals that show more overt oestrus signs with regular cycles and little or no calving difficulties. Imagine that we could phenotypically select cows with more positive health characteristics (less lameness & mastitis as well as higher reproductive performance and feed conversion efficiency). These possibilities are clearly within view and data from sensor technology will be the basis that allows this to take place.

4 CONCLUSIONS.

There is no doubt that sensors make sense. Essentially we have more eyes and ears on the things that are important to the successful management of farms.

With a growing population food safety and security is becoming increasingly important and the consumer has more interest in their source of food now than ever before.

Farmers are adopting technology and are seeing the huge benefits first hand – better lifestyle, better health, improved reproductive performance and higher productivity.

Individual care for each animal is the new way of farming and sensors allow this level of detail, making farming more profitable, enjoyable and sustainable.

5 References

Bareille, N. et al., 2003. Effects of health disorders on feed intake and milk production in dairy cows. *Livestock Production Science,* Volume 83, pp. 53-62.

Beauchemin, K., 1991. Effects of Dietary Neutral Detergent Fiber Concentration and Alfalfa Hay Quality on Chewing, Rumen Function, and Milk Production of Dairy Cows. *J. Dairy Sci.,* 74(9), pp. 3140-3151.

Berry, D. P., 2013. *Breeding the dair cow of the future - What do we need?.* s.l.:Irish Cattle Breeding Federation.

Boichard, D. & Brochard, M., 2012. New phenotypes for new breeding goals in dairy cattle. *Animal,* 6(4), pp. 544-550.

Challis, D., Zeinstra, J. & Anderson, M., 1987. Some effects of water quality on the performance of high yielding cows in an arid climate.. *The Veterinary record,* 120(1), pp. 12-15.

Doyle, M., 2013. Dairy cow nutrition in the transition period. *Veterinary Ireland journal,* 3(9), pp. 493-495.

Fourichon, C., Seegers, H., Bareille, N. & Beaudeau, F., 1999. Effects of disease on milk production in the dairy cow: a review. *Prev. Vet. Med.,* Volume 41, pp. 1-35.

Gerber, P. et al., 2013. *Tackling climate change through livestock – A global assessment of emissions and mitigation,* Rome: Food and Agriculture Organization of the United Nations.

Malthus, T. R., 1798. An Essay on the Principle of Population: Library of Economics. In: *Library of Economics.* s.l.:Liberty Fund Inc..

Metcalf, J., Roberts, S. & Sutton, J., 1992. Variations in blood flow to and from the bovine mammary gland measured using transit time ultrasound and dye dilution.. *Res. Vet. Sci.,* Volume 53, pp. 59-62.

Mulligan, F. & Doherty, M., 2008. Production diseases of the transition cow. *The Veterinary Journal,* Volume 176, pp. 3-9.

Pallisé, A. & Rushen, J., 2012. Adjusting the weaning age of calves fed by automated feeders according to individual intakes of solid feed. *J. Dairy Sci. ,* Volume 95, pp. 5292-5298.

Stevenson, J., Hill, S., Nebel, R. & DeJarnette, J., 2014. Ovulation timing and conception risk after automated activity monitoring in lactating dairy cows. *J. Dairy Sci.,* Volume 97, pp. 1-13.

UN, U. N., 2014. *Development DESA.* [Online]
Available at: http://www.un.org/en/development/desa/population/

Voegele, J., 2014. *Keeping pace with global food trends.* Naas, Ireland, Agricultural Science Association.

Warnick, D., Janssen, D., Guard, C. & Grohn, Y., 2001. The effect of lameness on milk production in dairy cows. *J. Dairy. Sci.,* Volume 84, pp. 1988-1997.

Wells, S., Trent, A., Marsh, W. & Robinson, R., 1993. Prevalence and severity of lameness in lactating dairy cows in a sample of Minnesota and Wisconsin dairy herds.. *J. Am. Vet. Med. Ass.,* Volume 202, pp. 78-82.

World Bank, 2012. *Data Agriculture and Rural Development.* [Online]
Available at: http://data.worldbank.org/topic/agriculture-and-rural-development