Futuristic Farming

Dr Nicolas C. Friggens

FUTURISTIC FARMING

Dr Nicolas C. Friggens, head of research at MoSAR discusses his technological approach for the 21st century farmer

Could you describe your academic background and tell us what got you interested in precision farming technologies?

I did a BSc in Animal Physiology and Nutrition and followed that up with a PhD looking at the way lactating females used their body reserves to support lactation. In that PhD I was extremely lucky to be in a department of the Scottish Agricultural College that included researchers, farm advisors and lecturers. If you had an idea that spoke to all three of these then it was a good one! Since body reserves are a key factor underpinning good health and reproduction, studying these reserves naturally led to health and reproduction research, which I did during 12 years at the Danish National Institute for Agricultural Research. In this domain, a key factor is early-warning, i.e. identifying animals that are at risk before problems get serious, and precision livestock technologies have really opened the door for monitoring of individual animals. Throughout the above, I have approached the issues from a modelling perspective. I am now head of a research unit at INRA called "Systemic Modelling Applied to Ruminants" (MoSAR in French).

Is this project the first of its kind, or does it expand on previous work that has been undertaken in this area?

The recent projects we have been involved in build on a significant number of precision farm technology projects. A good example of a prior project is Herd Navigator (www.herdnavigator.com) which uses biosensor technology in milk to measure key indicators of reproductive status (progesterone) and health (LDH for mastitis, BHB for ketosis). In that project, we provided the biological and statistical modelling expertise to turn the data into meaningful information for end-users.

In today's world, farmers have a tough time balancing sustainable farming with efficient farming methods that maximize profits. How does this technology benefit farmers?

This type of technology provides reliable information on animal status to the farmer. In a situation where one solution to today's economic pressures is to scale-up farm sizes, the monitoring provided by these technologies is an important factor for keeping track - to not lose sight of the individual in ever larger herds. This not only frees up valuable time, but also provides the farmer with real-time diagnostics, allowing earlier and thus more effective intervention.

Using genetics and models to manage cows sounds quite futuristic; what are the applications in terms of herd management — how can farmers apply the technology on their farms?

Mathematical modelling serves two functions: 1) It is a way to structure existing knowledge and data about complex systems, which often yields simplifying insights of value to animal science; 2) It is a way to develop predictions — what will happen next, what will happen if I make a change? Both of these elements are needed if we are to make good use of precision farming technologies. Technologies such as accelerometers produce multiple measurements per second, i.e. huge piles of data that are quite useless unless models are applied to distil this into the biologically relevant information and present it to the farmer in a user-friendly way. With multiple technologies, the models become even more crucial since there is not only distillation, but also combining of information, and we all know how crucial the blending process is to produce a quality product! Combining information is especially important for complex characteristics such as resilience and efficiency, which are by their nature combinations of underlying physiological mechanisms.

How does the project contribute to animal science in general, and do you foresee any future multi-disciplinary research being undertaken in this field?

In addition to providing better tools for farmers to monitor their animals, i.e. better models to distil the data from farm technology, my research unit is increasingly involved in using modelling to move from a monitoring perspective towards a predictive phenotyping perspective. We have the models needed to predict genotype x environment interactions both at animal-and herd-level, and are working to bring them together with information from precision technologies for phenotyping efficiency and resilience. This is important as it allows these general 'animal biology' models to be calibrated for specific production environments. This then allows prediction of the long-term consequences of, for example, a change in farm management or a change in genetic selection. The work of building such predictive frameworks requires close collaboration between modellers, nutritional physiologists, geneticists, and scientists studying farm systems.

PRECISION FARMING TECHNOLOGY

Animal scientist Dr Nicolas C. Friggens is using modelling to develop precision livestock technology that will give farmers the tools to allow them to move with the times and adapt to the challenges of the future.

With the global human population expected to reach 10 Billion by 2060, there is growing competition for space between livestock and crop production to provide food to feed the ballooning human populace. As a result, livestock are likely to be pushed into less favourable environments in the future to make arable land available for crop production, posing a unique challenge to livestock farmers.

Automated technology can play a key role in helping farmers manage their livestock in these difficult conditions, ensuring that farms continue to operate efficiently and productively, and that the welfare of the animals is maintained. Using precision phenotyping, this technology allows us to readily identify specific traits, such as adaptive capacity and robustness, that will be advantageous in the future, and apply them in our management strategies to selectively breed animals with the desired characteristics.

However, it is essential that we fully understand the complexities of these traits; for example, how they change over time as the animal ages, or how they trade-off with production. We also need to understand and be able to predict how these attributes can contribute to the overall resilience of the farm system, and how they will evolve in the future. Biological modelling offers a powerful tool that not only gives farmers a much more precise view of how their herd and farm are performing, but also addresses these more complex questions to ensure that livestock farming is sustainable in the future.

Addressing Climate Change & Food Security

Climate change and food security are two key areas of concern today. Precision farm technologies are developing to measure some key factors relating to the environmental footprint of livestock farming; things which were until recently impossible to measure outside of research stations, such as methane production by ruminants, or components of animal efficiency. As these developments mature to become commercially available, they will allow farmers to adjust their management to local environmental conditions.

The push for global food security will reduce the use by farm animals of cereals and other foods that can be directly used by humans. Farm animals will increasingly exploit marginal land and by-products of human food and biofuel production. These resources will be more variable in nature and quality; the same applies to the marginal environments that will be exposed to the increasing climate variability that climate change is bringing. In this situation we need animals that are resilient, i.e. that have an in-built adaptability. We also need farm management systems that can respond rapidly and appropriately to fluctuating conditions. Technology to monitor how animals are coping, how the available feed and water supply is holding up, etc. will be of considerable value.

The models can help us understand which combinations of mechanisms confer the right balance of resilience and efficiency for different environments. This is highly important information for breeding animals that are better adapted to future conditions. Data from precision technologies, when treated with the appropriate models, will provide much more precise phenotypic information on these complex traits for the geneticists who today have genomic information.

Contribution to Animal Welfare

The public is generally becoming more aware of animal welfare issues and many people are concerned about the welfare of farm animals, particularly those farmed intensively, and consumers often take these factors into account in their purchasing decisions. But will precision livestock technology mean a better life for farm animals?

The answer is yes, if used properly, it will definitely improve the well-being of farm animals. If you can identify an animal that is going to get sick at a very early stage, then you have a much better chance of taking preventive action to avoid it becoming really sick. The time gained in early identification can be used to better target treatment. For example, different strains of mastitis require different antibiotics, and a significant proportion of mastitis should not be treated with antibiotics. Traditionally, typically, when the signs of mastitis are detected things are sufficiently serious that immediate treatment is needed with no time to culture the bacteria to find out which type they are. But with precision technology, cases can be detected several days earlier, allowing time to type the bacteria and thus target treatment. This results in better cure rates, and reduced use of antibiotics. The other key area where these technologies will really come into their own is when animals are kept in extensive conditions, e.g. grazing on difficult to access rangelands. Precision technologies in these conditions will be a huge help for early detection of animals that need attention, but which are often difficult for the farmer to keep an eye on.

Applications

Precision farming technology is not limited to managing cattle, it is already in use in a range of farmed livestock, with applications in pigs and poultry already well advanced. There are also initiatives to use it in aquaculture. The main issue is not the technology, but rather its cost relative to the value of the individual animal. In some situations, e.g. dairy cows, it is frequently worth monitoring at the level of the individual animal, in others, e.g. broiler chickens, monitoring is often at the level of groups of animals, either through measures of group behaviour etc., or using a few 'sentinel' animals.

As the technology becomes more and more sophisticated and the associated costs continue to fall, we can increasingly access measures considered virtually impossible a decade or two ago. Today there are commercial on-farm systems measuring real-time progesterone levels in milk — this reproductive hormone is present in nanogram concentrations. Twenty-five years ago it required a lengthy lab-based method using radio-immuno assay, with turn-around times of days or weeks.

Implementation of the Technology

While there is already a significant amount of precision farming technology being made available to farmers, including accelerometers to measure activity and thereby assess if a cow is in heat, or is getting lame, or is going off-feed, the key issue is that the information is reliable and that it is condensed and presented in a useful user-friendly format that a farmer can readily interpret. Maximising the farmer utility of such technology requires not only statistical modelling to filter data and biological modelling to achieve context-sensitive interpretation, but also an on-going interaction with the farmers themselves in order to build software that responds to their needs and fits with their user practises. We have clearly seen that when we have engaged with the farmer from the start, i.e. from the design stage, we have produced tools that have a significantly higher uptake potential. There is also a

need for some of these technologies to provide the advisors with the information to propose more strategic changes to farm management. The above mastitis example is a case in point; if vets have herd level information about pathogen types and seasonal variation in mastitis, they can propose broader preventive strategies rather than just treating individuals as they become sick.

The second issue for implementation by farmers is how to reconcile information from different systems. Although some companies — in the dairy sector, typically the milking machine providers — offer bundles of technologies, e.g. accelerometers with in-line milk measures and in-line weighing of cows, the farmer is often confronted with different brands and software. This can considerably increase the time needed to monitor one's animals, and it represents a missed opportunity. Typically, the individual technologies are sold for monitoring the one or two types of event that the technology is best at detecting. However, these technologies could provide useful elements of other more complex quantities. Two highly relevant quantities are animal resilience and efficiency; there is no direct real-time measure of either of these and yet they are increasingly important to future sustainable breeding and management of farmed animals.

It would be highly useful if a farmer could make his breeding decisions (which animals to re-breed and which to cull) according to some ranking of his animals on their worth for resilience (ability to cope) and their efficiency. Today, in cattle breeding, sexed semen has become available, which means that the dairy farmer can use sexed semen on his highest worth cows to get milk breed daughters, freeing up the rest to produce cross-bred animals that will give extra value as meat-producing offspring. Such ranking tools will require the combination of genetic information with multiple farm technology measures to assess the phenotype at point of breeding. Modelling is the key to developing such tools.

Meet the researcher

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