The future of technologies for cattle fertility and calf health

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The Future of Technologies for Cattle Fertility and Calf Health

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- The cattle industry is a key provider of food-produce globally through both meat and milk production
- Technologies are increasingly being used to improve both animal welfare and productivity of cattle systems in general, however, the fertility of cattle and survival of calves is still an area were large economic losses occur
- Whilst a wealth of technologies capable of combating fertility and cattle health-related issues exist, there is a significant lack of farm-level validations and a lack of focus towards calf monitoring in general

Introduction

Globally meat production demand has more than quadrupled in the last 50 years. The "Beef and Buffalo" meat sector constitutes the third-highest level of meat production (behind pig meat and poultry) worldwide, as such, this sector requires continual innovation to meet demands.

Whilst a significant amount of innovation has been achieved, through intensification of systems via improved mechanisation and genetic manipulation during the agricultural 'green revolution', more stress is being placed on animal health and welfare and individual animal level controls. Many technologies are being aimed at improving core aspects of the cattle industry, including cattle health monitoring and improved management. This article aims to highlight key technologies that are in commercial use, could be adapted from other applications and those which are in the research and development stages in this sector.

Cattle Health Technologies

Cattle are a high cost per animal production system, this may be why this sector has had higher levels of research into innovative technologies compared to other livestock sectors (Figure 1). Whilst technology is becoming more common within this industry, for instance with automated milking parlours, there are still key areas where advancements could be beneficial. Two key areas of note are in cattle fertility as well as calf health monitoring and management.

Cronfa Amaethyddol Ewrop ar gyfer Datblygu Gwledig: Ewrop yn Buddsoddi mewn Ardaloedd Gwledig
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Fertility and pregnancy are key factors in cattle management, as fertility in sucklers is specifically related to the economic productivity of the animal and pregnancy is a time of high risk for deaths and treatment costs (between £100 and £400 per calving depending on difficulty) of both heifers and calves. Figures from AHDB's "GB Cattle Health & Welfare Group" (2012) noted that calf mortality is an issue with around 8% of all calves either born dead or dying within the first 24-hours, with a further 14% of dairy heifers dying before their first calving. These issues cost the industry as a whole, with noted impacts of around £60 million a year. Technologies which can improve pregnant heifer health, and labour monitoring, could also improve initial calf survival and health. Calves are at highest risk during their first 6 months of life, demonstrating high mortality rates, therefore, monitoring early calf health could improve management and productivity reducing economic losses in the sector.

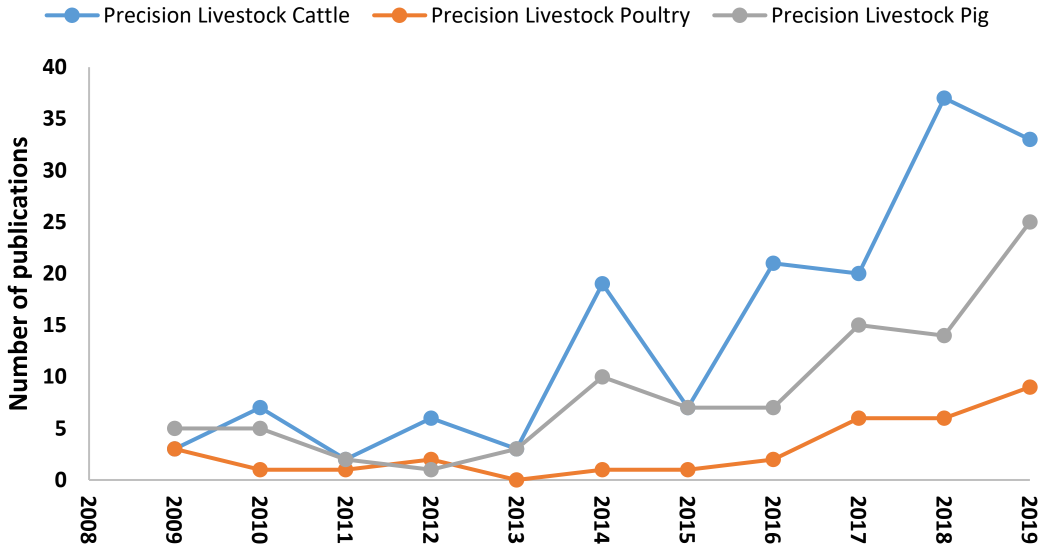

Figure 1. Publications for the three largest meat production sectors globally over time (webofknowledge.com)

Automation systems

Automation systems offer important innovations in the ability to both monitor and impact on animal management, often on a 24/7 basis, with minimal or no labour input. 24/7 monitoring is important as previous studies have noted that manual observations, on a weekly rota, often miss a high proportion of health-related issues. Automated milk feeder uptake for rearing young calves is becoming increasingly common as these systems provide the farmer with a wealth of information towards calf management.

Data collected includes; feed intake, the number of feeding visits, attempted feeds and feeding-time patterns and have potential in predicting and alerting illness. Automatic milk feeders also offer a static location for incorporation of further sensors, including the incorporation of automated weighing scales providing further information, without significant labour and animal stress associated with manual weighing. Growth trends of each animal produced can lead to the detection of abnormalities that may be associated with disease and health risks.

Other automation systems with potential for fertility management include automated milking parlours and associated automated pen systems. High success can be achieved with inline milk analysers in these systems which allow the determination of cow fertility status', including oestrus (with 100% efficiency), and detecting successful insemination and pregnancy, or lack of this, within 25 - 32 days. There is also potential to pick up fertility complications, including cysts, as part of the same analysis. Automated detection of fertility status is already incorporated into sorting systems (such as Afisort systems) where animals in oestrus can be automatically separated for insemination, reducing animal stress and labour inputs.

Precision livestock technologies

Precision livestock technologies include sensors involved in collecting data as well as computational software/algorithms used to analyse this data. In fully integrated systems this may include technologies which then act upon the data collected and analysed by the previous systems. Whilst calving monitoring/prediction has been a focus of these technologies, it is interesting that specific calf monitoring is lacking, despite issues of high mortality. In this article, several systems aimed at adult cattle will be highlighted where these could be adapted for calf applications in future, as well as specific calf technologies which are under development.

Movement or acceleration technologies have been employed across the cattle industry to date (IceRobotics, SCRdairy, Afimilk, CowManager) to monitor animal behaviours using changes from "normal" patterns to signify events which include;

- Feeding – High specificity achieved (>90%) for adult grazing cattle, in future changes could be used to detect illness and adapted for grazing calves
- Behaviour changes – Walking, lying standing times (up to 98% accurate) with patterns shown to be linked to detection of illness particularly lameness and specific work ongoing to adapt systems for improved calf health monitoring
- Oestrus – Changes in movement patterns particularly associated with oestrus with up to 93% sensitivity and >10 km transmissions (using LoRaWAN) for units costing $25 per 100, improving timely insemination and overall fertility

- Detect calving – accurately detect and predicted calving to reduce potential risks associated with dystocia, including calf deaths
- Feed intake – For calves specifically, accelerometer devices are in current optimisation (with up to 95% accuracy) towards detecting feed intake from bucket-fed systems, automated feeding systems and in general to observe suckling behaviours (as these are directly linked to health and wellbeing)
- Nutritional regime analysis – changes in behaviour can be analysed when changing calf nutritional regimes to assess their associated health effects

Acoustic sensors offer another route to detect changes in animal wellbeing and health status and have found huge success in pigs (Fancom- pig cough health monitor). In cattle this area has been limited, however, investigations into evaluating acoustics to detect chewing/feeding behaviour, potentially determine individual animal intake (to better manage pasture grazing/stall feeding) and detect age and welfare issues in calves are in development.

Image analysis sensors offer alternatives to the labour involved with stock person direct observations, they can achieve constant monitoring and observe spectra outside of human ranges (such as infrared light). 3D imagery has been assessed to visualises changes in cattle gait or conformation to detect lameness or perform body condition scoring. Systems could likely be re-purposed to assess calf growth patterns for improved management. Furthermore, infra-red imagery has demonstrated applicability in illness detection through localised temperature changes in cattle udders (udder health/mastitis), with further optimisation, this technology could provide constant non-invasive calf temperature monitoring towards early detection of illness.

Radio-frequency identification (RFID) systems are already utilised to improve aspects of cattle fertility. This includes MooCall heat which detects when heifer ear tags come into contact with bull collars during mounting. RFID is a common component of legal identification tagging and tracing of cattle and has been integrated into several whole-farm systems, linking data from multiple sensors to specific animals (automatic calf feeders detect RFID tags of individual calves at the feeder). A unique application with RFID is the inclusion of RFID identification with automated brushing devices as barn enrichment for calves, allowing observations relating to animal wellbeing and improving management for overall health.

Positional data (via GPS or other signal triangulations) either indoor or outdoor has been demonstrated previously, through using algorithms to be able to monitor the overall health of cattle and observe changes in behaviour associated with illness. Systems have been suggested which would facilitate the same health monitoring benefits directly in calves, particularly concerning respiratory disease diagnosis.

Biosensors

Biosensors describe sensors which either detect changes occurring directly to an organism or having an organic component integral to their functionality (pregnancy test strips use enzymes and bound antigens). Biosensors with possible roles in calf health evaluation, based on their suggested roles in cattle, are rumen boluses. Ingestible wireless sensors (bolus') allow for accurate measurement of core body temperatures non-invasively and constantly, with algorithms being developed to link changes to disease onset, detecting drinking behaviours and detection of heat stress (to improve health and reduce milk losses). These boluses look to use long-range transmission technologies such as low-power wide-area networks LPWAN to monitor cattle across pastures or whole farms.

Other technologies looking to asses animal temperature including tail-mounted temperature sensors which achieve stable consistent results (relative to rectal temperatures, but don't require stressful invasive thermometer use) in calves. Changes detected can be associated with respiratory disease, allowing earlier treatment. Equally, ear tag devices inclusive of ear temperature probes have been effective in monitoring cattle health and particularly have potential in predicting calving in heifers up to 10 hours in advance.

Heart rate analysis is a useful non-invasive measure of stress in calves and cattle and has been incorporated into multiple systems to date. An interesting development, currently being tested in mice and chickens is a subcutaneous injectable capsule which can combine core body temperature, movement, heart-rate and breathing into a single device with 15-years of battery life, though future iterations intend to be rechargeable wirelessly.

Wearable biosensors are becoming increasingly developed in the realms of human health, however, for these to be approved safe for humans they are often initially tested on animals. As such, there is a wealth of data demonstrating that these sensors work on animals, for example, tear sensors to check sugar levels (tested on goats before human use in contact lenses). Other sensors along this vein tested on animals or which could be repurposed include smart tattoos (can detect lactate level) and RFID 'bandaids' (Adhere to the body transmitting information about electrolytes in sweat). Data collected from such sensors would improve the overall picture of animal health, though would likely need significant optimisation first.

Barriers to Technology use

A wealth of technologies exist, however, there are barriers to their increased use within farming systems. A major issue (other than costs and understanding of their correct use) is the lack of validated evidence of their benefits. Throughout this article where figures were found, they are presented, as such, it is clear that most technologies have only been proven in concept, with little practical farm-level data available and less long-term data available. This lack of information acts as a barrier to farmers who require evidence that the cost of purchase will lead to gains, in animal welfare and directly into productivity and economic success. Furthermore, in outdoor farm practices, many of these devices falter, due to a lack of range through which they can transmit data when farms may be several 10s of hectares in size. Some technologies already look to counter this achieving long-range transmission such as LPWAN. The positives about LPWAN transmitters and receivers (such as the popular LoRaWAN systems) are they could easily be incorporated into any of the above technologies, and in open spaces allow transmissions up to 20-50 km distances, depending on geography. LPWAN systems are receiving significant development in India, Africa and

China towards tracking animals over large distances, setting up invisible 'geo-fencing' and to combat cattle theft. Importantly LoRaWAN frequencies are free to use and the technology is already being supported and developed by the Welsh Government for use across Wales, this could facilitate farmers utilising this technology in future.

Summary

There is increasing use of technologies within the cattle industry towards improving productivity, reducing costs and improving animal welfare. Whilst several commercial technologies now exist and several more concept technologies are in development there is a significant lack of research towards calf health and monitoring, a key area linked with production losses. However, many of the current systems could easily be re-optimised towards monitoring directly of calves with some evidence of this already occurring. Technologies may well hold the answer to increased productivity with lower inputs and costs within the cattle sector. However, a significant amount more farm-level and long term studies will be required before farmers feel secure in investing in these innovative technologies.

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Note to editors:
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