disarm

Disseminating Innovative Solutions for Antiobiotic Resistance Management

Best Practice Guides

Precision Livestock Farming for Early Disease Detection

PROLOGUE


CATTLE


PIGS


POULTRY


SHEEP

This guide is written as part of the DISARM project 'Disseminating Innovative Solutions for Antibiotic Resistance Management', funded by the European Union's Horizon 2020 research and innovation programme under grant agreement 817591.

The DISARM project aims to reduce antibiotic resistance through a focus on disease prevention and animal health, thereby reducing the need for antibiotic use. DISARM has a wide range of resources available via our website and YouTube channel. We also have a vibrant and knowledgeable community within our Facebook discussion group (we welcome you to join, simply click this link and answer some short questions to gain access), and wider social media channels: Twitter, Facebook, LinkedIn.

DISARM also promotes the multi-actor approach – different people (farmers, veterinarians, nutritionists and other advisors) working together towards improved animal health and farm performance. If you want to find out more about this, check out our toolbox to get started!

This guide was based on the information that was gathered during the DISARM project; it should not be considered as a complete reference book. It gives a useful overview with links to practical videos, abstracts, articles, testimonies etc., to facilitate good practices. Not all recommendations will be applicable or suitable for your farm and any interventions should be discussed with your farm advisor(s).

This guide is one of the 10 Best Practice guides made during the DISARM project. The 10 guides all have the goal to inform you about a specific topic in order to reduce the antimicrobial use in the livestock industry.

The other DISARM Best Practice guides can be found here.

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INTRODUCTION

What is Precision Livestock Farming?

Precision Livestock Farming (PLF) uses technologies to monitor animals and/or their environment. Technologies might also make management practices easier on farms, such as automated feeders and other examples as shown in this video. Ultimately, PLF offers useful management support tools which provide insights into production, fertility and health parameters. Most technologies used in PLF aim to capture and analyse data 24/7 and can provide warnings for farmers when there is an issue to prompt early intervention.

Sensor technologies generally measure something about an animal or their environment. This information feeds into a system which analyses the data to automatically perform corrective actions, and/or provide information to the farmer. Various technologies exist on the market to, for example:

- Monitor temperature, relative humidity, carbon dioxide, ammonia, and other emission measurements in animal housing
- Automatically weigh and record growth measurements
- Measure body temperature, heart rate, rumen pH, animal activity and location

Information collected from sensors are analysed to provide **decision support systems** for farmers. These systems can send alerts to the farmer, often via a smartphone app, so that appropriate action can be taken.

Sensors can be used at an **individual animal** level, e.g. accelerometers worn in the ear, around the leg or neck, or applied to **farm infrastructure**, e.g. climate sensors or cameras in animal accommodation.

You might increasingly hear the term "Internet of Things" (IoT). This means that an application uses a network of physical objects – "things" – that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems. This means that multiple datasets can be analysed to provide useful insights about your farm and animals. Networking can be more challenging, depending on the farm infrastructure and farming system, for an overview of technologies for extensive grazed systems and housed animal systems, see this article.

Ultimately, PLF allows animal health and production data to be collected, analysed and converted into clear action points with minimal effort. In this way, PLF can help to inform management decisions.

Why is PLF relevant to animal health and reducing antibiotic use?

PLF aids farmer decision making by providing 24/7 monitoring of the farm and its animals and measuring parameters which cannot be detected by even the best farmers' eye. It can provide farms with **early-warning systems** to alert stockpersons to problems before any clinical signs of illness appear. This helps farmers to detect disease in individual animals (and other issues, such as smothering in poultry flocks) sooner and more easily. PLF can help farmers monitor an animal's performance and **intervene early, and more successfully**, with non-antibiotic treatments, thereby reducing the need for antibiotics.

The use of PLF management tools will be **beneficial to farmers and veterinarians** looking to **reduce disease in their herds and flocks**.

How is PLF applied in different sectors?

PLF is being used across multiple livestock species around the world. This next section will summarise examples of best practice in the cattle sectors (dairy and beef), sheep and goats, followed by the pig and poultry sectors, pulling material from DISARM's State of the Art database, best practice abstracts, links and articles shared on the online Community of Practice (CoP) and the DISARM website.

DAIRY CATTLE

Selecting PLF Tools

There are many different applications for PLF in dairy farming (see here and here for some examples). Every farm is different so it is worth considering which technologies and systems will have the best outcome for your herd and farm. Independent advisory services can help maximise the strategic use of sensor-derived data, for example Cow Coach aims to address specific challenges around using robotic milking systems and other sensor technologies.

Using Data Systems to Optimise Health and Production Performance

There are many tools available to help you to **review your activities** by providing useful **insights** into your farm and herd **performance**. For example, ZLTO's OPTIcow in the Netherlands.

Using integrated technology systems to collect and analyse data is a great way to inform decisions and identify points of action. You can easily monitor:

- Animal health
- Environment within the shed
- Fertility and reproduction
- Milk production
- Breeding and genetics

Multi-sensor monitoring can be used to get an overview based on different aspects of your farm/herd management. It is important to check that technologies are compatible before investing as not all products will be interoperable. When it is possible to

integrate multiple sensors, they can be very effective, offering more comprehensive insights.

Using technology for earlier interventions

Elevated temperature and humidity negatively affect feed intake, resulting in poor rumination, milk yield and fertility. Using sensor systems, it is possible to assess the environment within your cow shed to see patterns relating to animal health and production. For example, the SMART Zoo Tech system offers **24/7 monitoring of microclimate parameters** within the cow shed: temperature, humidity, dew point, carbon dioxide, ammonia and dust particles. Information is stored in a database and when parameters exceed permitted levels, an alert is sent via mobile phone so immediate action can be taken.

There are also tools which can support decision making relating to **fertility and health management**. For example, Connecterra's Intelligent Dairy Assistant (IDA) provides actionable insights based on data from sensors mounted on neck collars. It measures cow activities including eating, rumination, walking, standing, lying, and chewing. Using this system can help you to act sooner resulting in **increased production** and fertility efficiency and **reduced antibiotic use**.

The Happy Cow project showed that using cow activity sensing and machine learning technologies can:

- Improve farm productivity and better understand your herd
- Detect health issues at an early stage e.g. milk fever, rumen acidosis, lameness
- Gain insight into potential solutions e.g. optimising feed intakes

Automatic Feeding

Automatic feeding systems, such as the GEA MullerUp system, provide cows with regular meals of freshly mixed feed which has both health and production benefits. The managers and staff at the South West Dairy Development Centre in the UK cite automatic feeding as the technology that they value the most (see here). Feeding more frequently leads to increased dry matter intake, and increased pH in the rumen and a consistent diet optimises the rumen microbes. Feeding bouts and amounts can be scheduled to leave no waste, so the system increases feed palatability and reduces waste.

Automatic feeding can contribute to:

- The convenience of automation and reduction in labour cost
- Less stress and disease in your herd resulting in better animal welfare and reduced antibiotic use
- Increased feed intakes and feed efficiency
- Improved body condition score and fertility
- Regulating and increasing rumen pH which reduces metabolic diseases
- Improved milk yield and constituents and thereby increasing milk income
- Increased profit and sustainability through reduction in waste feed

Metabolic Disorders

This study showed that in the two weeks before calving, cows later diagnosed with metritis had reduced lying time and fewer lying bouts compared to healthy cows. In the 3 days before clinical diagnosis, cows that developed metritis ate less, consumed fewer meals, were more frequently displaced whilst feeding and had fewer, longer lying bouts compared to healthy calves. Using sensors to assess these behaviours in transition cows can provide early warnings for metritis and other metabolic diseases.

PLF technologies that identify **changes in feeding, social and lying behaviour** in transition cows, and those that **monitor rumination** can provide early warning health alerts for cows at risk of **metabolic diseases**.

This **early diagnosis** leads to a wider range of potential treatments, many curative, thereby **reducing the need for antibiotic use**. Cows experience **less severe symptoms** and have a much **quicker recovery**.

Ultimately, these systems can help to save time, reduce stress for you and your animals, increase production and improve animal health and treatment outcomes.

It is now common for neck collars and eartags to measure rumination, as well as activity, in automatic heat detection systems. Several technologies e.g. the Cow Manager ear tag and rumen boluses from SmaXtec and Moonsyst also include temperature in the health alert algorithm. Cows are monitored 24/7 and notifications are sent to the stockperson when a problem arises, allowing time to be focused on animals that need attention. Monitoring rumination can identify early stages of ketosis, acidosis, mastitis and even the time of calving in individual animals, and at a herd/group level it can identify Sub Acute Ruminal Acidosis, suboptimal dry cow transition diets, and even poor forage quality.

Examples from the South West Dairy Development Centre in the UK showed the Smartbow eartag identified reduced rumination at 3 days post calving, prompting a vet diagnosis of a dilated abomasum - the first stage of a displaced abomasum (DA). Appropriate treatment avoided the need for an operation - and the corresponding antibiotic use - and resulted in a quickly recovered cow. Remotely monitoring rumination rate can also indicate if a treatment has been successful.

Mastitis

Mastitis is one of the main causes of antibiotic use on dairy farms. PLF includes several tools and data management systems that can help you to investigate udder health in your herd. Typical mastitis diagnostic methods are based on somatic cell counts (SCC) and plate-culture techniques.

On-Farm culture systems to test milk samples for mastitis-causing pathogens were suggested as a useful tool on our CoP to speed-up informed mastitis treatment decisions. Some plates focus on identifying Gram-negative or Gram-positive bacteria to guide antibiotic choice. Others like the New Zealand

Mastatest® system and Accumast® plates give more accurate indications of causal pathogens within 24 hours. Plating can also indicate where the cause of mastitis is not bacterial so antibiotic treatments are not required. These tests can provide dairy producers with a quick, simple and inexpensive way to identify the likely bacterial cause of clinical mastitis. A word of caution though – culturing means that you produce billions of germs! On-farm culturing must include a strict biosecurity protocol to avoid introducing cultured pathogens back into the herd e.g. culturing should be done in a specific, separate area, gloves should be used and were disposed, along with the plates, into a specific bag for disposal.

However, these on-farm culture systems do not provide insights in real-time, which is what is needed to speed up the choice of treatment to obtain better treatment outcomes. Biosensors are automated and portable diagnostic devices that can convert the presence of biological particles into an electric signal. This review article highlights (future) approaches for on-farm diagnosis of mastitis-causing pathogens to direct treatment decisions quickly and easily.

Sensor systems can be used to monitor udder health and support the management of clinical and subclinical mastitis. Using technology to achieve earlier mastitis diagnoses allows for:

- Early application of non-antibiotic treatments, such as the application of UDDERMINT® and increasing the frequency of milking, which can effect a self-cure.
- Higher cure rates in cases where it is decided that the best course of action is to use intramammary antibiotics due to greater treatment success.
- More milk per cow being sold (less "treated" milk and less milk reduction due to sick cows), offering a financial benefit.

Robotic milking systems can aid early mastitis detection and reduce antibiotic use both from reducing the number of cows that need antibiotics, and having better cure rates in those that do – see here for a brief summary. Robotic milkers, such as the GEA monobox used at the South West Dairy Development Centre in the UK, measure milk conductivity, temperature and colour from each quarter - there is now also an option to install somatic cell count detection per quarter. Data is collected at each milking and analysed by comparing previous data from that individual cow (rather than generic averages), providing a much more accurate system. When there is a significant change in a specific quarter, the system issues an alert, allowing a much earlier diagnosis of mastitis.

Lameness

Lameness is accepted as causing the biggest loss of income on dairy farms and is second only to mastitis as the leading cause of antibiotic use. It is also widely reported that lameness is under-diagnosed - in many studies only 25% of lame cows are identified. Observational detection is subjective, requires skill, and is time consuming so the low detection rates are understandable. Technology can monitor cows 24/7, conducting automatic, objective lameness scoring, resulting in a much higher detection rate.

A project in Ireland has created an application to monitor cattle in real-time using a range of sensors to identify lameness at an early stage and send alerts to the farmer. The on-farm trial on a 150-cow herd indicate that lameness can be detected 3 days before it can be visually captured by the farmer with an overall accuracy of 87%.

Mobility sensors can be mounted on a cow's neck or leg, but foot sensors are more sensitive. The use of mobility sensor systems provide simple alerts on a phone or computer. These alerts mean that:

- Lame cows are identified sooner
- Early non-antibiotic treatments, such as foot trimming, can be used
- Early intervention improves cure rates
- The need for antibiotic treatments is reduced
- Animal wellbeing is improved and milk loss is reduced, granting financial gains

The use of thermal imaging to validate the lameness alerts from monitoring systems (e.g. Cow Alert) can also direct and motivate appropriate treatments at the earliest possible opportunity. In response to alerts, thermal imaging cameras can be used to investigate the cause of lameness on the affected cows. Thermal imaging can differentiate between foul infections that require antibiotic treatment, and the majority of causes that don't. Furthermore, thermal imaging can enable foot trimmers to be more precise, using the hoof-knife in the correct location to reach ulcers or white line disease that would otherwise not be found. Thermal imaging can even identify the lame foot, or establish that the cause of lameness is not in the foot at an early stage. This improves animal wellbeing, reduces milk loss, and reduces the amount of antibiotics used.

Calf health management

Calves are particularly vulnerable to disease due to their immature immune systems. Calfhood illness, particularly bovine respiratory disease (BRD) and diarrhoea, can have lifelong consequences – calves experiencing pneumonia or enteritis go on to produce less milk and have shorter lives than their healthy peers. Early detection and intervention are essential for treatment success and protecting the future health of your animals.

One of the first things you can do to ensure your calves are healthy is to ensure you provide adequate colostrum. Using a Brix Refractometer to measure the immunoglobulins present in the colostrum can provide an idea of its quality. You can also use the Brix Refractometer to measure the immunoglobulins in blood samples to monitor rates of passive transfer (absorption of enough antibodies from colostrum into the calf's bloodstream to protect it from pathogens) – as shown in this video on Facebook. This allows you to assess whether your colostrum management practices are working or need refinement.

Computerised feeders for calves can issue alerts for any calves that are slow to drink their milk allowance or are consuming less than usual. This can be an early

sign of illness and allows the stockperson to check on the calf.

The TempVerified calf tag from Fevertags includes a thermometer which sits within the ear canal to continually monitor calf body temperature. The TempVerified software monitors every 15 minutes. When a calf has a temperature above 39.7°C for 6 hours or more, a red flashing LED light will alert the stockperson to take action: verify temperature with rectal thermometer and proceed with established treatment protocol.

Early and automated identification of calf illness can:

- Reduce the economic cost to farmers
- Reduce antibiotic medicines used to treat calf disease
- Improved wellbeing of animals as calves and as adults
- Improved sustainability as healthy calves live longer and achieve greater milk production as adults

A more high-tech ear tag system for calves which has recently come on the market is Smartbell. This sensor comes with a free app which can not only alert farmers to sick animals, but can also track calf health history. Another project is using thermal imaging to reveal various stages of BRD. Although manual scoring systems exist to aid early identification of the disease, they are time consuming and rarely used in practice.

BEEF CATTLE

Animal activity monitoring systems are also available for beef cattle. For example, the Allflex SenseHub Beef system monitors behaviour and rumination to offer insight into reproduction, health, and nutrition.

A thermal imaging camera can also be a useful diagnostic tool to detect health issues not visible to the naked eye in a quick, non-contact, non-invasive way. It can be particularly useful for identifying the cause of lameness, informing treatment decisions – including whether antibiotics are required or not.

Using PLF in beef production has many benefits:

- Early alerts for action related to reproduction, health and feed management
- Easy monitoring of medicine use, growth rates and grazing offer useful insights into cattle health, production, and treatments
- Improved pasture management can ensure cattle are provided adequate nutrition to keep them healthy
- Insights gained through easy-to-use technology saves labour time so attention can be focused where it is most needed
- More information allows farmers to run more efficient, productive cattle resulting in financial benefits

Another focus is on liveweight gain and market requirements for beef cattle. As an example, Breedr is a cloud-based app for weighing livestock, accessing markets and collating production and medicine use data.

For cattle in extensive systems, grazing is an essential part of nutrition. Technology can help you to make the most of the land you have. For example AgriWebb Grazing Management analyses the data that you collect to generate useful reports to inform your decisions. Check out this simple summary of various options for measuring pasture from no action to drone and satellite imagery.

SHEEP

There is growing interest in the application of PLF technology for small ruminants. This article discusses various technology options for dairy sheep in Mediterranean EU countries, including electronic identification systems such as ear tags, ruminal boluses and sub-cutaneous radio-frequency identification; on-animal sensors such as accelerometers, global positioning systems and social activity loggers; and stationary management systems such as walk-over-weights, automatic drafter, virtual fencing and milking parlour-related technologies. Auto-weighing sheep can allow more targeted anthelmintic and antibiotic treatments according to individual animal size.

TechCare (Integrating innovative TECHnologies along the value Chain to improve small ruminant welfARE management) is an EU-funded project running from September 2020 – August 2024. The project will focus on the development of novel, appropriate technologies that can enhance productivity levels and reduce costs by improving welfare management at individual or flock level. The project aims to create and validate demand-driven and innovative welfare solutions at all stages of small ruminant production. Find out more from their press release.

Black Sheep Technology in the UK offer solutions focused on pastoral farming, making tracking, recording and selling animals easier for farmers. Their Flock Finder tool streamlines livestock movements, medicine use data and tracking of animals and can be used with or without an electronic identification reader. FlockMarket focuses on remote selling of livestock to provide better insight for buyers and offers a virtual marketplace available 24/7.

PIGS

Early disease detection

PLF technologies can enable real-time health monitoring in pigs. For example, the degree2act app can be used as part of your routine daily observations to monitor the temperature of pigs without having to restrain them. This case study with a Spanish farmer demonstrates the added value of using this technology.

Another example of technology which allows tracking of pig health is the FITPIG ear tag which monitors activity and heart rate. This forms part of an Internet of Things system which includes tools which also measures environmental conditions like dust and ammonia levels within the shed. Learn more by reading this article or watching this webinar.

Respiratory disease

Several PLF technologies aim to monitor respiratory disease in pigs using sound, for example, this video shows early iterations of the Fancom® Cough Monitor. A similar technology is SoundTalks® which uses sound analytics and Artificial Intelligence to detect respiratory diseases before clinical or behavioural signs of illness were visible. Using the system allows treatments to be given at an earlier stage of infection, resulting in better cure rates and a reduction in amount of antibiotic used. See more in this article.

Sound-based PLF techniques have significant advantages over other technologies, such as cameras. Besides the fact that microphones are contactless and relatively cheap, there is no need for a direct line of sight and large groups of animals can be monitored with a single sensor in a room/building.

PLF tools can offer great benefits to pig producers:

- Monitor animal-based health and welfare indicators e.g. respiratory disease or sow/weaner aggression.
- Detect technical problems like a blocked feeding line or incorrect climate parameters.
- Alerts allow for immediate action before health and performance are negatively affected.
- Preventive actions help to prevent the spread of disease, reducing the need for antibiotic treatments

Farm level health management

This article proposes some ways in which biosecurity on pig farms could be further improved through the objective data provided by PLF technologies. For example, could monitoring the walking lines of farm workers highlight a mismatch between biosecurity protocols (theory) and what happens in practice? Once identified, any problems could be addressed. In terms of external biosecurity, using an electronic visitor book can be more useful than a paper-based one as it is easier to review the data.

An Internet of Things application in the pig sector is being trialled to reduce boar taint across European pig production. The project aims to provide management information that enables continuous improvement and sustainable production. The project has created over 2000 pig records, involves 5 farms and pulls together data covering genetics, information about the farmer, the slaughterhouse, processor and retailer, right through to the end consumer.

The goal is to develop early warning systems on several group-level daily data streams and report back boar taint presence to farmers and link with preventive measures. It is also hoped this IoT PLF application will improve feed efficiency, animal welfare and lower the carbon footprint of the product.

In France, there are three connected tools which approach the issue of health protection in pig production: PorcProtect, Bâtisanté and Porcisanté. PorcProtect focuses on biosecurity.Bâtisanté assists with management of buildings and livestock equipment, including issues including climate, ventilation, access to food and water, quality and type of floors, and cleaning protocols.

Porcisanté helps monitor animal-based interventions including colostrum intake, care of piglets, management of sow feed and breeding management etc. Read more here.

GVET is another tool from France which provides an electronic records system for veterinary treatments in pigs for easy data entry. Find out more here.

POULTRY

Another sector that has embraced PLF is poultry, particularly broiler farming. Production, transport and processing of poultry have been optimised using automated ambient temperature monitoring, control and data analyses. Frequent real-time data can be fed back to farmers on the health of their birds and any early signs of disease, as well as environmental parameters.

In this video a farmer shares his top tips for antibiotic reduction in broiler farming, the third tip includes monitoring health, welfare and technical results using a digital system: “With antibiotic reduction, the trick is not to lose sight of animal welfare and technical results. We have a digital system to monitor and graphically display various parameters (e.g. temperature, water and feed intake, animal weight). We can combine this data with for example vaccination schedules, treatments, or information from slaughterhouses. We then discuss this together with the feed advisor and the veterinarian”.

This video explains the role of big data in optimising production and early warning systems in poultry management. For example, the Smart Farm Assistant from Porphyrio offers you to choose the solution(s) best fitted to your business, with a range of options including flock management and early warning systems, production planning and customised reporting.

In broiler farming, one example of technology to bring better visibility and performance to the industry is FLOX. FLOX uses a series of cameras to provide continuous remote monitoring of your flock, day or night. This visual data is used to produce actional insights about bird activity, performance and weight which can alert you to smothering, hockburn and pododermatitis. The Spoutnic NAV and Octopus XO are examples of robots which stimulate the movement of broilers whilst aerating the litter.

This helps to prevent aspergillosis, pododermatitis, hock and breast injuries, and can even reduce ammonia by interrupting the fermentation process. Another example of technology in broiler farming is Chickenboy, a ceiling-suspended robot that autonomously monitors thermal comfort, air quality, proper equipment function, and health and welfare of the birds at flock level.

How has PLF helped reduce the need for antibiotics?

PLF allows farmers and advisors to use comprehensive data to inform management decisions so we can detect disease and sick animals earlier, and if necessary, treat with better outcomes. Prompt disease detection also allows management of animals with non-antibiotic interventions, thereby reducing the use of antibiotics. PLF and the capabilities of machine learning and artificial intelligence has enabled complex data sets to be reduced to actionable and simple steps for farmers and advisors, avoiding the need for laborious and skilled analysis. The different ways of capturing data at the farm level using various sensors means there are many applications specific to different farming systems.

More from the DISARM Best Practice Guide Series

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