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The FoodLab

From soil to solution: the latest food systems research from the SEFARI Institutes for Scotland's Strategic Research Programme

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There is more information on the Strategic Research Programme here. For editorial enquiries or to receive a copy of this newsletter, please email michelle.mcwilliams@abdn.ac.uk or emma.agnew@gov.scot

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MEATiCode: Scotland's New Weapon Against Food Fraud

Food crime is estimated to cost the UK anything up to £2 billion a year, and so finding new ways to detect it is of paramount importance. The stakes are especially high for a country like Scotland which has built significant trust in the quality of its culinary exports rooted in heritage and place, including beef and whisky.

Thankfully, ENRA Strategic Research Programme-funded scientists at The Rowett Institute recently added a "robust, reliable and highly sensitive" new weapon with which to defend the safety and integrity of foods.

MEATiCode combines advanced proteomic testing, which examines the individual components of protein in meats, and a bespoke database to accurately identify multiple meat species in a single sample – including the ability to drill right down to a particular breed, such as Aberdeen Angus. Its effectiveness for testing cooked and processed foods also gives it an edge over other techniques which can be unreliable for cooked or complex mixtures such as pies.

Early tests on 19 shop bought meat products underlined the system's value, revealing one kebab product contained none of the 14% lamb it claimed, while another was 60% chicken and 20% lamb, the reverse of the proportions claimed by the label.

The team is now expanding the database to other iconic Scottish foodstuffs such as honey and whisky and exploring the system's potential to detect allergens such as nuts, fish and dairy products, extending its role in food safety.

Food Standards Scotland, with whom the team liaised closely, welcomed the new way to "strengthen consumers' confidence" and "support the credibility of the entire supply chain." National and trade media attention has also inspired commercial interest.

It's a reminder that safeguarding the integrity of our food system is not just a scientific challenge—it's a collective responsibility, and one that matters deeply to Scotland's culture, economy, and global reputation.

Lead researcher: **Jules Griffin**, *The Rowett Institute*

> **"Strengthen consumers' confidence" and "support the credibility of the entire supply chain"**
>
> *Food Standards Scotland*

Cracking the Mycotoxin Challenge: How Research Is Protecting Scotland's Oats

Controlling mycotoxin levels in oats is important not just to protect consumers but to support Scotland's cereal industry – especially with a warmer, wetter climate expected to increase contamination levels at the same time as the EU is introducing stricter limits.

While current evidence suggests most levels remain within safe limits, major data gaps persist around mycotoxin occurrence and the factors that influence their prevalence.

Timely ENRA-funded work is helping to address this. Researchers have, for example, shown that de-husking can remove more than 90% of free mycotoxins present in cereal grains. However, mycotoxins and "masked" mycotoxins remain detectable in oat foods on the market. To help farmers, researchers have identified farming practices - such as organic production and lower intensity crop rotations - that may reduce levels. And they have highlighted the need for more evidence on how sustainable and regenerative systems affect contamination and for better predictive tools to support decision making across the supply chain.

At the same time, an ongoing human study is providing crucial insight into how mycotoxins behave during digestion, while a follow-on project to survey mycotoxin levels in oat products across Scotland has been shaped by close engagement with industry and policy groups, such as the Trade team at Scottish Government and Food Standards Scotland.

Findings from the work have been shared with UK and European food safety bodies to inform ongoing risk assessments to ensure consumer safety.

Lead researcher: **Silvia Gratz**, *The Rowett Institute*

Building a Safer Food Future: Scotland's Push to Understand Forever Chemicals

So-called "forever chemicals" are worryingly present in all parts of the environment – and our food is no exception. Persistent organic pollutants, for example, per- and polyfluoroalkyl substances (PFAS) and polybrominated diphenyl ethers (PBDEs)] don't break down easily, can build up in the environment, and may accumulate in animals and our bodies, where they're linked to a range of harmful health effects.

Building a full understanding of the risks that poses – and what we can do to reduce or eliminate them – is a fast-growing global priority. And thanks to the Strategic Research Programme, Scotland is in the vanguard.

A team of experts at The James Hutton Institute has developed precise methods to detect and measure different types of POPs – enabling them to identify both PFAS and PBDEs in salmon taken from the River Dee. Their attention has since turned to farmed salmon and now Scottish beef, pork, and lamb. This would allow us to understand and assess the potential risks associated with these persistent organic pollutants for Scottish food safety. Emerging Contaminants (ECs) - The James Hutton Institute).

Lead researcher: **Zulin Zhang**, *The James Hutton Institute*

Informing Tomorrow's Food Safety Rules: Cell-based Assays Improving Detection of Hidden and Emerging Toxins

A separate strand of work has made advances in the detection of mycotoxins – showing potential advantages of cell-based assays. Crucially, this can pick up "masked" mycotoxins – hidden forms that slip through conventional screening – and reveal the combined impact of exposure to several toxins. Researchers found early warning genes in cells switch on sharply when multiple toxins are present, offering a way to detect risks that don't show up when each toxin is measured in isolation.

By tracking how cells change their gene activity in response to contamination, scientists can pinpoint the moment toxins begin to have a measurable effect. That threshold is vital for governments and food safety agencies, helping them set exposure limits and decide how much of a toxin can safely be consumed each day. The hope is that this work will ultimately strengthen food safety rules and reduce risks to public health.

One of the biggest advantages of cell based tests is their ability to flag new or previously unknown toxins. As the climate warms, harmful organisms – including toxin producing algae – are spreading into new regions. At the same time, industry continues to introduce new chemicals whose long term effects are often poorly understood.

For regulators, these assays offer a way to keep pace with emerging threats. They are now recognised internationally as part of a new generation of safety testing tools, giving authorities a better chance of spotting problems early and protecting both people and the environment.

Lead researcher: **Andreas Kolb**, *The Rowett Institute*

Securing Scotland's Food Future? Hemp as a home-grown alternative to Palm Fat and Soya

ENRA-funded research at the Rowett Institute has already established strong health and environmental credentials for hemp. These findings helped leverage funding from BBSRC for the next stage of research, which has found that hemp could also play a meaningful role in strengthening Scotland's food security at a time when global supply chains feel increasingly fragile.

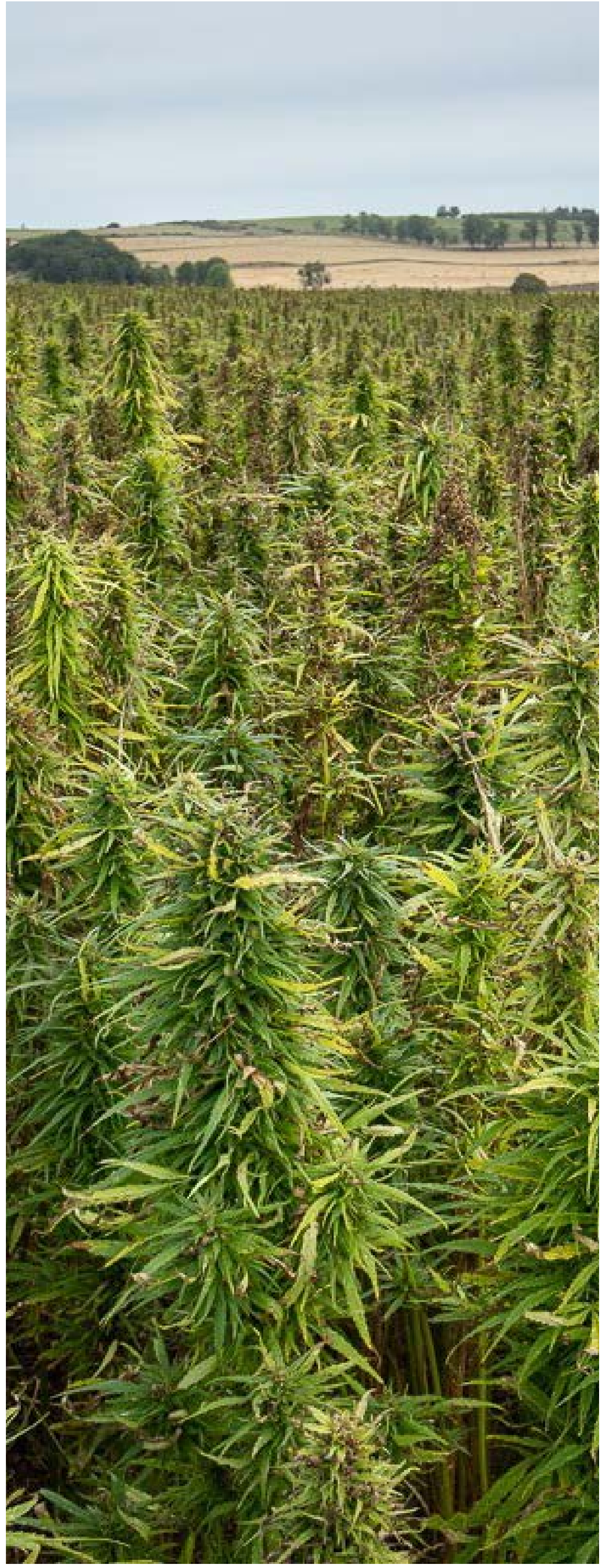
Take palm oil. The UK imports hundreds of thousands of tonnes each year, mostly from Southeast Asia, where production is often linked to damaging deforestation. Palm fat is also high in saturated fat, contributing to raised LDL cholesterol and obesity and associated diseases (costing the NHS £31B per annum). For bakers, finding responsible alternatives has become a growing challenge. Working with Scottish bakers Murdoch Allan, a major supplier of UK supermarkets, researchers have been reformulating everyday staples by replacing palm fat with hemp hearts. The result is a noticeable reduction in saturated fat and substantial increase in omega-3 fatty acids, fibre and micronutrients without compromising taste or texture.

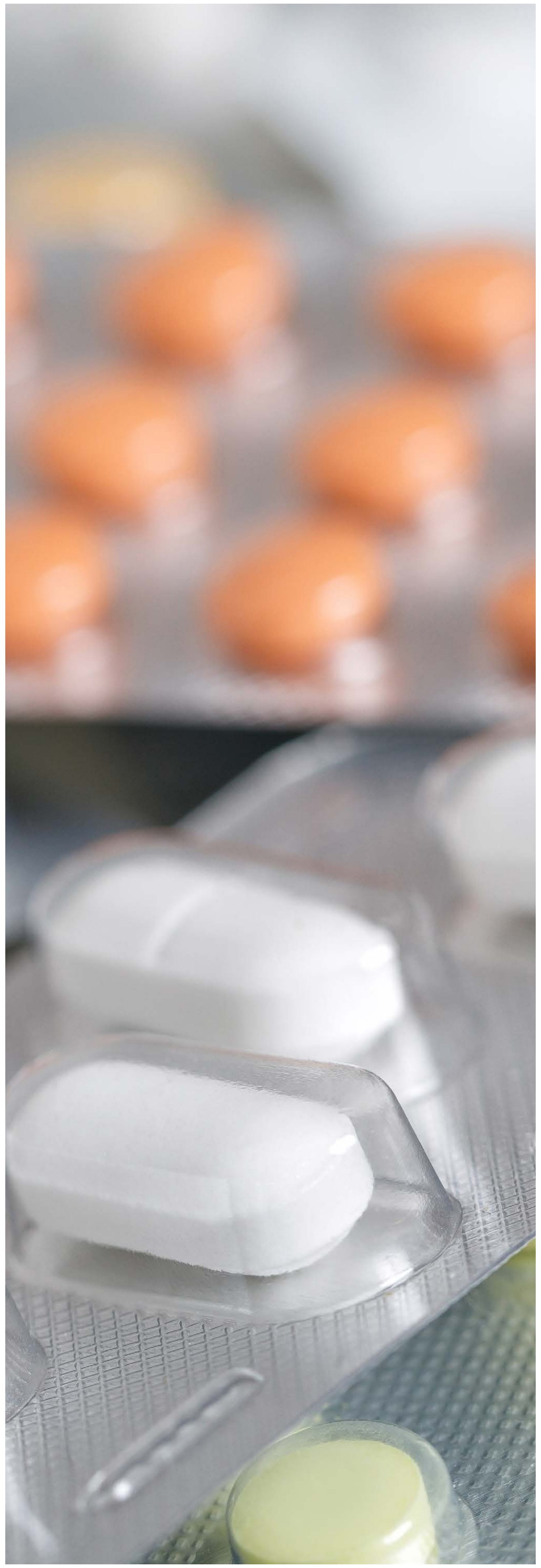
A similar story is unfolding in livestock feed. The UK relies heavily on imported soya cake, with Scotland's poultry and pig sectors particularly exposed to price swings, political instability and environmental concerns tied to global soya production. In a trial involving 19,000 chickens, the Rowett team showed that hemp could replace a significant portion of soya in feed without affecting bird welfare or the flavour of the eggs. In fact, the eggs became richer in key nutrients, offering a meaningful boost to dietary quality while lowering the carbon footprint of production.

With these promising results, researchers are now turning their attention to pig and cattle feed, exploring whether hemp could offer the same resilience and nutritional advantages for dairy and meat systems.

What emerges from this work is a picture of hemp that could help Scotland reduce reliance on vulnerable imports, support healthier diets, and build a more sustainable food system for the future.

Lead researcher: **Wendy Russell**, *The Rowett Institute*





Strengthening Defences: The One Health Research Guiding Scotland's AMR Response

Antimicrobial resistance (AMR) is among the world's biggest public health and development threats – risking many of the gains linked to modern medicine and is estimated to have directly caused 1.27 million deaths and contributed to nearly 5 million deaths in 2019. By 2050, it is predicted to be a bigger killer than cancer or diabetes.

Although AMR occurs naturally, the overuse and misuse of antimicrobial drugs (for example, the use of the antibiotic, colistin, as a growth promoter in meat production) has accelerated AMR to the point where clinical cases of infection with resistant microorganisms, no longer susceptible to the antimicrobials previously used to cure them, have drastically risen.

SEFARI research teams are collectively taking a One Health approach - sustainably balancing and optimising the health of people, animals and ecosystems – and feeding into both the UK National Action Plan for AMR and the Scottish One Health Antimicrobial Use and Antimicrobial Resistance (SONAAR) programme.

Here are some of the leading ideas being researched by the institutes:

01: Harnessing Good Microbes to Fight Antimicrobial Resistance

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UNIVERSITY OF ABERDEEN
The Rowett Institute

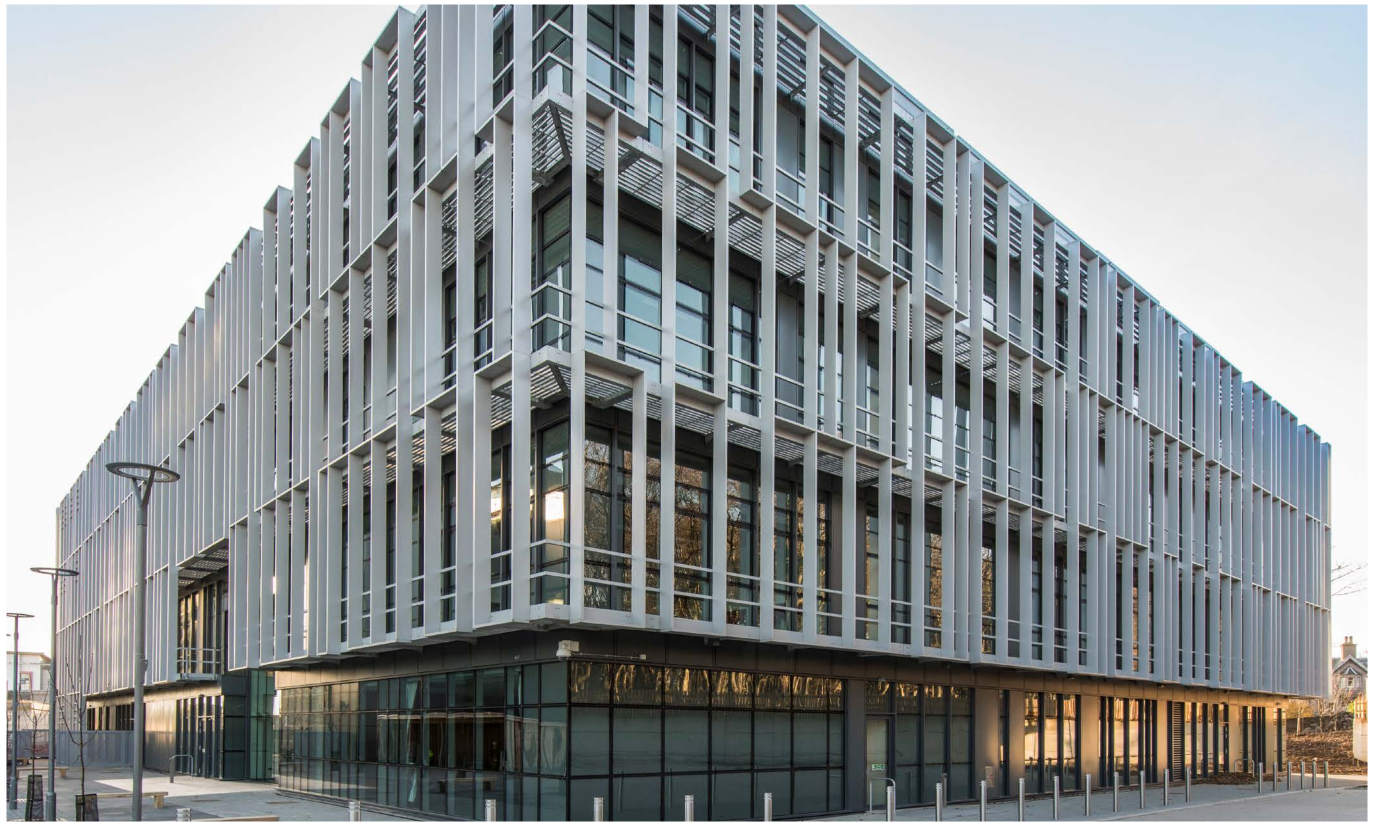
ENRA funded research is exploring a simple but powerful idea: using beneficial microbes to keep harmful ones in check. By finding natural alternatives to antimicrobials, we aim to reduce the spread of foodborne pathogens and cut antimicrobial resistance across the whole food chain.

For example, *Campylobacter*, commonly carried by chickens, is the leading cause of food poisoning in the UK and Europe. Using beneficial microbes identified in the lab to reduce the infection on farms could mean fewer people getting sick, less pressure on the NHS, and a healthier environment. And because these solutions don't rely on antibiotics, they help slow the global rise of antimicrobial resistance.

The team has already discovered a number of helpful bacterial isolates and tested them in a wide range of conditions - from different gut environments to varying soil pH - to make sure they stay effective. Analysis of genome sequences confirms they don't carry any unwanted or harmful genes. Early trials with an industry partner show they perform as well as commercial products—and may offer extra advantages. We've also teamed up with Red Rocket Labs Ltd and IBioIC to test new sensor technology that can monitor microbial communities in real time.

These findings can help policymakers make the case for reducing the use of antimicrobials while offering practical alternatives that help farmers protect animal health without relying on antimicrobials. This work supports Scotland's contribution to the UK's national AMR action plans.

Lead researchers: **Karen Scott and Alan Walker**, *The Rowett Institute*



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02: Understanding AMR Risks across the agrifood system

The James Hutton Institute

Eulyn Pagaling and Lisa Avery at The James Hutton Institute are developing a new risk assessment model that will help pinpoint where changes in farm management could most effectively reduce foodborne AMR risks across the agrifood system.

It is based on information gathered through extensive consultation with farmers – who mostly recognised the risks AMR poses to their animals, but less so how it might affect them, their families, or workers - or how practices like slurry spreading or waste milk disposal could contribute to wider environmental spread – of both resistance genes and resistant bacteria.

On six dairy farms, scientists analysed antimicrobial resistance genes (ARGs) across soil, water, faeces and other materials. When ARG patterns were compared with soil chemistry, heavy metals and nutrients such as carbon and nitrogen emerged as key drivers of ARG diversity—supporting existing evidence that metals can boost AMR and nutrients can fuel bacterial growth.

One unexpected finding may reassure farmers: their personal AMR levels were similar to those of people living in urban areas, suggesting that using antimicrobials on farms doesn't automatically mean higher AMR in farmers themselves. Still, many livestock farmers have already cut antimicrobial use significantly and feel they're reaching the limits without compromising animal welfare. Understanding their perspective is essential for exploring whether changes—like new slurry management practices—are realistic, or even possible in day-to-day farming.

Lead researchers: **Lisa Avery and Eulyn Pagaling**, *The James Hutton Institute*

03: New Evidence on Gene Flow Across Livestock Systems

SRUC

Research by SRUC has studied how AMR moves through livestock systems and the environments connected to them.

Spanning pigs, cattle, sheep and poultry, as well as grazing land, manure treated fields and nearby natural habitats, the project has produced a world-leading dataset on AMR gene diversity across the Scottish livestock system. Researchers have also now identified plasmids - mobile genetic elements that help AMR genes spread - within livestock samples, highlighting the potential for gene flow between livestock, soil and the wider environment.

Another major focus is the risk to people through fresh produce, such as salads, grown with irrigation water that may contain antibiotic resistant bacteria. The team developed and tested a risk assessment model to estimate the likelihood of AMR carrying *E. coli* being transmitted from contaminated water to consumers – which showed a high probability of ingestion when produce is contaminated. While the health consequences of ingesting AMR bacteria remain uncertain, this work highlights a plausible route contributing to the broader AMR burden.

Lead researcher: **Lesley Smith**, *SRUC*

04: Fertilisation Practices and the Spread of AMR on Pastureland

Moredun

Researchers at the Moredun Research Institute have been exploring whether different pasture fertilisation practices influence how antimicrobial resistance (AMR) develops and spreads in livestock farming environments.

A big part of the work involved testing *E. coli*, a common gut bacterium used as an indicator of AMR, from across the farm—soil, water, sheep faeces, organic fertilisers like slurry and manure, and even septic tanks—to see how they responded to a wide range of antimicrobials. The team found some clear differences in soil. Fields treated with slurry had a higher proportion of non-wildtype bacteria, suggesting slurry use may contribute to more resistant bacteria in the soil.

The good news is that only a small number of bacteria carried a specific type of resistance that allows them to inactivate important antibiotics such as penicillin and cephalosporins. These strains, known as ESBL-producing *E. coli* were found only in water samples from one farm. This points to the limited spread of this particularly important resistance mechanism, with water acting as a possible local reservoir.

The team also used genetic analyses to study the "resistome"—the full collection of resistance genes present. By tracking both resistance genes and mobile genetic elements (the bits of DNA that help these genes move between bacteria), researchers could see how resistance traits are distributed across fields, grazing animals, and different parts of the farm environment. They also monitored how these patterns shift over time in response to fertiliser use and land management practices.

Together, these findings help build a clearer picture of how AMR circulates within agricultural systems and where interventions might make the biggest difference.

Lead researcher: **Nuno Silva**, *Moredun Research Institute*

The Science Behind Scotland's *E. coli* Risk Management

Per head of population, Scotland experiences more cases of illness caused by Shiga toxin producing *E. coli* (STEC) than anywhere else in the UK. Research led by SRUC, in collaboration with the Moredun Research Institute, has resulted in a major improvement in our knowledge of which STEC strains are present in three important Scottish livestock sectors.

Working with the Scottish *E. coli* O157/STEC Reference Laboratory, the project team has used whole genome sequencing to identify the STEC strains circulating in Scottish dairy cattle, sheep and farmed deer, and compared them with isolates from Scottish human cases. This has helped to determine where the greatest risks might lie. Encouragingly, the team confirmed that the non-O157 STEC that were found in the sample of Scottish sheep which they tested were not a source of human infection.

At the same time, the research highlighted vulnerabilities that remain. The STEC strains discovered in faeces from Scottish dairy cattle could be transmitted to humans, if raw milk became contaminated with faeces, This reinforces a longstanding but essential truth: simple interventions like pasteurisation continue to be among our most powerful tools for protecting public health.

The genome data generated through this project has supported real world human outbreak management in Scotland, including an O157 incident. The findings will also help industry partners to update their Hazard Analysis and Critical Control Points (HACCP) plans with more accurate risk assessments.

Another aspect of this research is looking at how we can benefit public health by improving our ability to both detect and identify which STEC strains are present. For example, the team has shown that there are molecular markers that could identify a specific strain of O157 STEC that is associated with fresh leafy produce, while other studies are looking at both improving traditional culture and isolation methods and the use of modern sequencing technologies.

Lead researcher: **Sue Tongue**, *SRUC*

Investigating *Toxoplasma* and *Campylobacter* in Scotland's Livestock

Scientists at the Moredun Research Institute have investigated the role of Scottish livestock and their environments in the transmission of important foodborne pathogens, *Toxoplasma gondii* and *Campylobacter spp.*, to humans.

In Years 1 to 3, scientists assessed a blood-based technique for determining the strain of *Toxoplasma* infecting livestock and humans, to better understand the diversity of strains circulating in the environment. Although the test shows promise, a larger number of control samples would be required for reliable validation. Given the difficulty in controlling transmission of *T. gondii* in food animals, thorough cooking or freezing of meat is currently the best option for reducing human infection. Now, researchers are further refining the optimum cooking and freezing conditions.

In the first three years of the project, scientists collected samples containing *Campylobacter* bacteria from different livestock farms and used whole genome sequencing to read their DNA. This allowed them to compare different strains to better understand how they circulate in the environment and animal reservoirs, and how factors such as farm management practices can influence risk of transmission to food

Some *Campylobacter* strains can grow using a wider range of nutrients than others. Being able to "eat" more types of food may help these strains survive better in the guts of farm animals. If they thrive more easily, they could become more common on farms and may also spread antibiotic resistance genes more widely. This ability might also make certain strains more capable of causing severe illness in people.

To investigate this idea, the team selected a set of DNA sequences linked to different ways *Campylobacter* can use nutrients to understand how these traits might influence the bacteria's behaviour in animals and humans and will be reporting on the results next year.

Lead researcher: **Clare Hamilton**