2024

afbi AGRI-FOOD & BIOSCIENCES INSTITUTE

Science Impacts 2024

Leading | Protecting | Enhancing

Contents

CEO FOREWORD

Dr Stanley McDowell
AFBI CEO

I am pleased to introduce the sixth in the series of AFBI Science Impacts Reports in which we highlight the key outcomes and impact of our science programmes.

AFBI science is critical to Northern Ireland's long term economic and environmental sustainability, contributing to the protection of our terrestrial and marine environments, leading improvements in our agri-food systems, helping protect animal and plant health, and ensuring the safety of the food that we eat. By delivering essential statutory testing, monitoring and surveillance programmes, research and development work as well as emergency response capability and expert scientific advice, AFBI scientists enable the NI agri-food industry to market products nationally and internationally while ensuring long term environmental sustainability, from soil to sea. The science is critical to the work of our sponsoring department DAERA and contributes significantly to the overall achievement of the NI Executive's programme for government.

This Report highlights the excellence of the work being undertaken across AFBI's three scientific themes and the impact that this work is having in helping Northern Ireland address economic, environmental and societal challenges.

Within the theme of "Enhancing the Natural and Marine Environment", we feature the AFBI science which has provided a substantial part of the environmental evidence-base in relation to Lough Neagh and the algal blooms which occurred during the summer of 2023. Ongoing and future AFBI science will play a vital role in informing the options to manage and commence restoration of the Lough.

The benefits of greater use of genomics in microbiology is highlighted within the theme of 'Protecting Animal, Plant, and Human Health', where AFBI is using whole genome sequencing (WGS) to investigate bovine tuberculosis (bTB) epidemiology and provide vital evidence to inform disease intervention and control policies.

A number of 'Decision Support Tools' for farmers have been developed at AFBI, including the bovine information system 'BovIS', which is featured within the theme of 'Leading Improvements in the Agri-food Industry to Drive Sustainability'. BovIS applications bring multiple data streams together online, including carcass data, breeding data and health data. This allows NI cattle producers easy access to their data and the opportunity to benchmark against other farmers, enabling informed management decisions.

Many of impacts of AFBI science arise from long-term science programmes and data collection studies, such as the ones highlighted above, and it is through these long-term programmes that the maximum impact of our work is often realised.

Ultimately it is the excellence and hard work of our staff which delivers scientific outcomes and impacts. My sincere thanks to the many science teams which have contributed to the work highlighted and to other colleagues involved in producing in this Report.

I would also like to gratefully acknowledge DAERA and the various funding bodies who have provided the funding to support our various scientific achievements.

Dr Stanley McDowell

AFBI Chief Executive

Our Vision

Scientific excellence delivering impactful and sustainable outcomes for society, economy and the natural environment.

Our Purpose

To deliver trusted, independent research, statutory & surveillance science, and expert advice that addresses local and global challenges, informs government policy and industry decision making, and underpins a sustainable agri-food industry and the natural and marine environments.

Who we are and what we do

Statutory and analytical testing

Monitoring and surveillance programmes

Research and development

Emergency response capability

Expert scientific advice

Key Metrics

AFBI science is helping protect the economy, delivering:

over
3.3 MILLION
over the last 5 years

ANIMAL, PLANT & FOOD SAFETY TESTS

supporting sales from the agri-food industry to the value of:

over
£4.5 BILLION
total sales

Department of Agriculture, Environment and Rural Affairs
NISRA

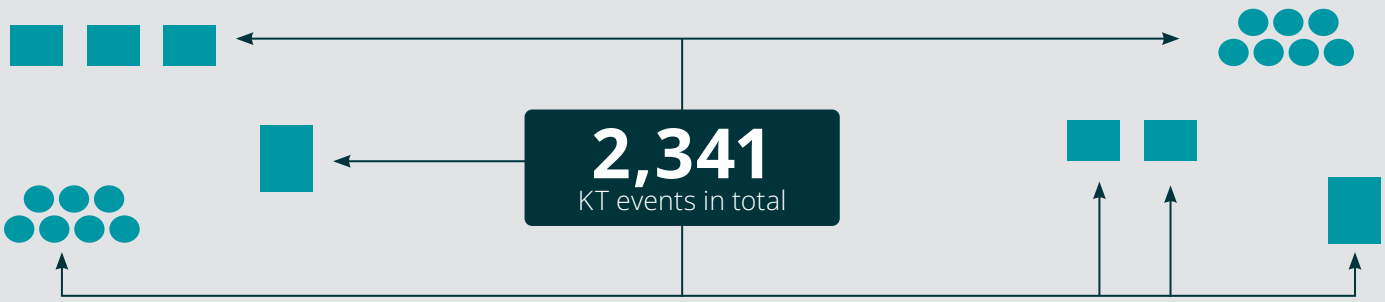
source: NI Food and Drinks Processing Report 2021

£1.7 BILLION

£2.8 BILLION

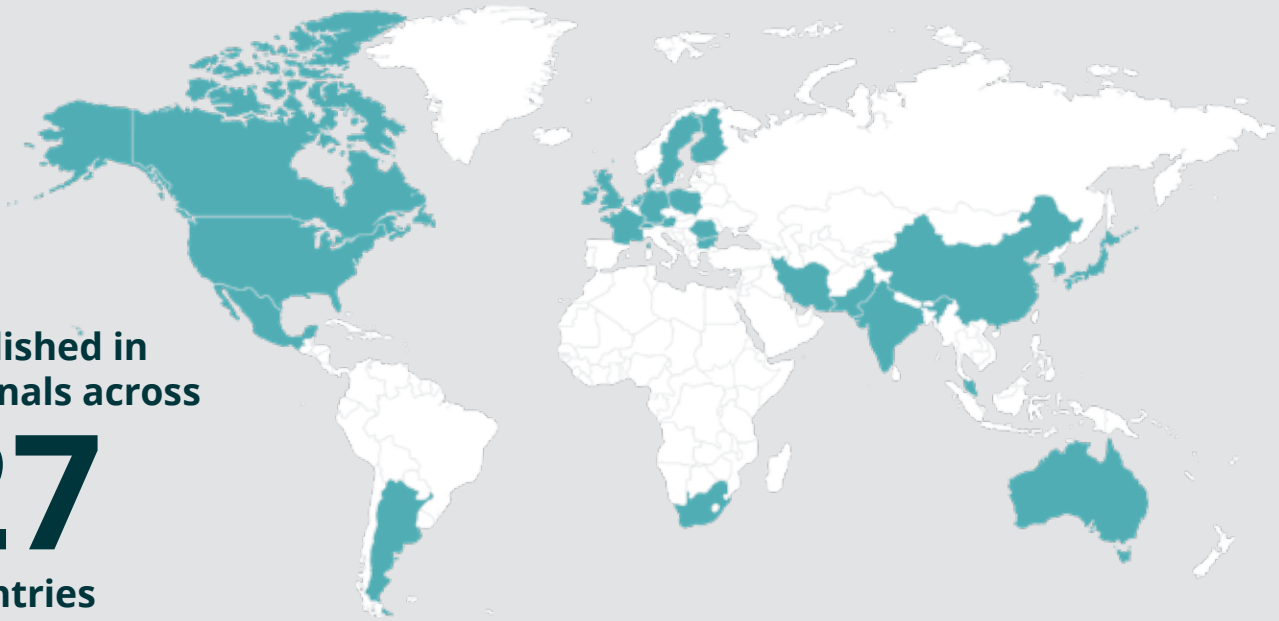
Knowledge Transfer

From 01.01.18 to 31.12.23



Journal Publications

From 01.01.18 to 31.12.23



Published in journals across

27

countries

Leading improvements in the agri-food industry to enhance its sustainability

Improving profitability from multi-cut systems on dairy farms

Dr Aimee Craig and Dr Conrad Ferris

Summary

Offering silage produced within a 4-harvest system improved dairy cow performance compared with silage produced within a 3-harvest system. Despite lower herbage yields and associated higher silage costs (per t DM) with the 4-harvest system, margin-over-feed costs were 8% higher compared with the 3-harvest system.

Background

Given that silage digestibility (D-value) declines by an average of 3.3% for each one-week delay in harvest date, harvesting herbage earlier, or more frequently can improve silage nutritive value. However, few studies have examined the impact of multi-harvest systems on dairy cow performance.

AFBI Science

Grass silage produced within either a 3-harvest or 4-harvest system was offered to 80 Holstein cows during a 25 week feeding study. Increasing harvest frequency from 3 to 4 times during the season reduced herbage dry matter (DM) yield from 13.4 to 12.3 t DM/ha, while increasing silage crude protein content (from 14.3 to 16.4 %, DM basis) and

metabolisable energy content (from 10.7 to 11.3 MJ/kg DM).

The improvement in silage quality within the 4-harvest system increased silage DM intake, which in turn increased milk yield and milk fat + protein yield (Figure 1), compared to the 3-harvest system.

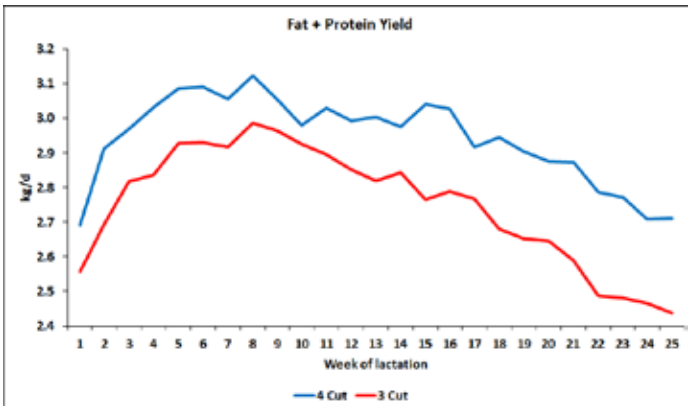


Figure 1. Fat plus protein yield of cows offered silage produced within a 3-harvest or 4-harvest system.

Margin- over feed cost was calculated for the two harvest systems, at November 2023 prices and is presented in Table 1. A higher margin-over-feed cost per cow was found when they were offered silage produced from the 4 -harvest system compared with those offered the 3-harvest system.

Impact of AFBI Science

The economic impact of increasing the number of silage harvests will be largely dictated by the cost of silage production and the effect on food intake versus the value of any additional milk produced. Silage production costs (per t DM) will increase with increasing harvest frequency, but in this study the increase in silage quality and subsequent increase in value of milk produced outweighed the increase in the cost of silage production. Although the actual costs of silage production and milk price vary from year to year, the 8% increase in margin-over-feed costs observed within the 4-harvest system remained stable when costs have been calculated over three consecutive years.

While there has been a trend to increase the frequency of silage harvesting on some farms, this research has provided clear scientific evidence of the potential performance and economic benefits of adopting multi-cut systems.

This project was co-funded by DAERA and AgriSearch

Table 1. Calculated margin-over-feed cost within the 3-harvest and 4-harvest systems.

	3-cut	4-cut
Cost of silage[1] (£/cow/day)	£1.98	£2.38
Cost of concentrates[2] (£/cow/day)	£4.29	£4.19
Total feed costs (£/cow/day)	£6.24	£6.57
Value of milk produced[3] (£/cow/day)	£10.89	£11.60
Margin-over-feed per cow	£6.00	£6.48

[1]Assumed cost of £205 and £229 per t DM for the 3 and 4-harvest silage, respectively.

[2]Assumed concentrate cost of £320 per t DM.

[3]Assumed milk price 32ppl with compositional bonus applied.

Barriers and Enablers of Long-term Land Leasing in Northern Ireland

Dr Adewale Adenuga and Dr Claire Jack

Summary

The term and type of land leasing plays an important role in the adoption of sustainable land management practices and the uptake of agri-environmental schemes. With no significant tenanted sector in Northern Ireland (NI), access to land via long-term land leasing is limited. Funded by DAERA, this study analysed the barriers and enablers of long-term land leasing in Northern Ireland.

Background

Less than one per cent of the total agricultural land area in NI is offered for sale each year and access to land through leasing is constrained by the type of short-term conacre land rental system predominant in the region. The conacre land rental system is unique to the island of Ireland, and it involves the renting of land nominally for 11 months or 364 days and permits land to be let to other farmers without the need for either party to enter a long-term commitment. Currently, around one-third (about 300,000 hectares) of agricultural land in NI is being farmed under conacre agreements.

Although the conacre system in the past was considered to offer flexibility between a landowner and the farmer renting the land, the uncertainty of tenure linked to the system does not allow for a farmer renting the land to make longer-term investment planning and decisions, particularly around sustainable land management practices and productivity improvements. At an aggregate level, this ultimately impacts on the overall competitiveness of the agri-food sector.

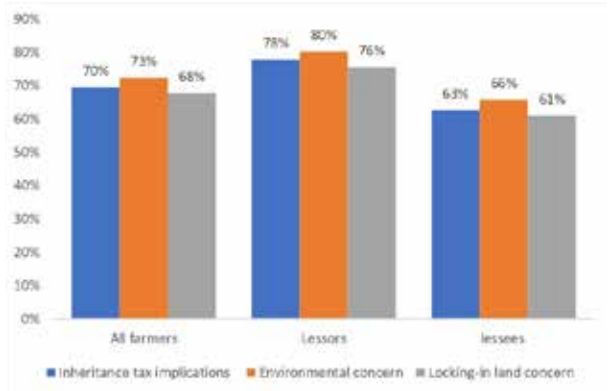


Figure 1: Barriers to long-term land leasing

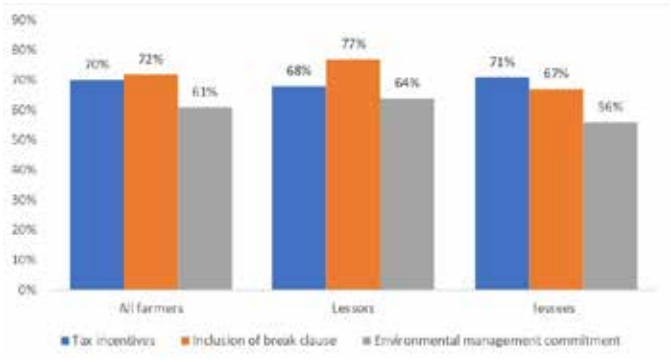


Figure 2: How to encourage long-term land leasing

AFBI Science

This study applied a combination of social-psychology theory of planned behaviour and qualitative and quantitative modelling techniques to explain the barriers and enablers of long-term land leasing in NI. The qualitative aspect of the methodology involved key informant interviews and focus group discussions with important stakeholders within the NI agricultural sector. We were able to obtain and analyse quantitative data from 1,696 farmers in NI through a highly successful survey.

The results of the study identified the following factors as the main barriers to long-term leasing (Figure 1):

- Environmental concerns in relation to how the land will be managed.
- Taxation concerns, particularly in relation to inheritance tax and agricultural relief.
- Concerns around committing to a longer-term land rental and how that may impact on future succession plans for the farm business.

A number of interventions to help encourage long-term land leasing include the inclusion of a "break clause" within land leasing contract, the possible introduction of tax incentives and the introduction of contractual commitments within the lease to ensure that the land would be managed well to deliver environmental improvements. The results also showed that a significant behavioural and attitudinal change would be required to ensure a shift from conacre to long-term land leasing. In particular, it highlighted the role that key influencers such as accountants, land agents and solicitors can play in promoting the adoption of long-term land leasing in NI by ensuring the dissemination of coherent and accurate information (Figure 2).

Impact of AFBI Science

Most agri-environmental programmes now involve multi-year plans (typically three- to five-years contract periods), requiring the operator to have managerial control over the land during the contract term of the support scheme. Informal annual land rental agreements such as the conacre are unsuitable in this new policy context as it cannot support the effective delivery of environmental land management schemes. The results from this research project will help to inform DAERA's strategy in relation to designing policies aimed at encouraging long-term land leasing in NI. The study results are particularly timely, as new agricultural policy is being developed. The results from this study have been shared with important stakeholders in NI including the Northern Ireland Rural Valuers Association (NIRVA) and the Central Association of Agricultural Valuers (CAAV). The study provides evidence to facilitate the development of appropriate land rental agreements for improved economic performance and well-being in the agri-food sector and wider regional economy.

The study was fully funded by DAERA

The importance of valorisation of bivalve shell waste for NI

Dr H Moore, Dr M Service, Dr B Hunter, Hannah Cromie, Gary Heaney, Lizzie Watts.

Summary

The shellfish industry in Northern Ireland, the rest of the United Kingdom (UK) and the Republic of Ireland (ROI) continues to expand with the primary aim of providing a sustainable, high protein food source. This growth has resulted in a significant increase in shell by-product. Currently these shells are considered as waste, this project set out to show the potential of shells as by-products with a wide variety of uses, from low value, high biomass to developing niche markets and showed how circular economy can be achieved by valorisation of these by-products.

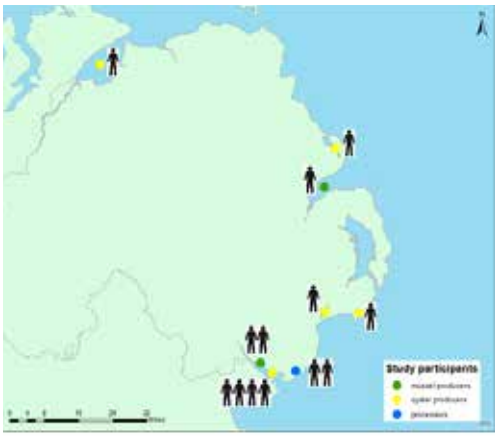


Figure 1. The Shellfish Aquaculture industry in Northern Ireland (NI) located in our five main sea loughs and small bays.

The NI bivalve aquaculture industry produces mainly mussels and oysters (Figures 2 and 3), to a number of export and local markets. Although these are mainly live exports of the whole animal, there are sources of dead shell, mortality on the aquaculture site, resulting from harmful algae blooms (HABs) and disease outbreaks. These have a low incidence in NI at present, but this may increase with the impact of climate change. Interestingly, higher mortality figures have been reported from the Republic of Ireland (ROI) aquaculture sites and they are keen to work with AFBI to look at the benefits from valorisation of the shells.

The other main source of shells in NI, is from the processing of scallops (Figure 4), producing a significant quantity of empty shells, which currently are not re-used.

Figure 2. Live mussels.

Figure 3. Oyster shells.

Figure 4. Scallop shells.

Background

Global expansion of aquaculture to support food security has resulted in more shell material. Examples of the wide variety of established and potential uses for shell material were collated from primary source interviews and existing literature. Not surprisingly the countries producing the largest volumes of shellfish are more advanced in valorisation of shells. For example, Denmark with a large shellfish processing industry produce clean shells which can be readily utilised, in many ways (Figure 5). Whereas the US have moved away from processing shells, but have facilities to collect shells which are weathered, before putting them back in the sea as culch to encourage future shellfish growth.

AFBI Science

Based on the literature review and with local expert knowledge, the most feasible shell valorisation process in Northern Ireland would be for agriculture, aggregates or construction. However, the latter will require further research and development. The scenarios investigated in this project (poultry feed, soil conditioner and shell aggregate) for value chain analysis (VCA) and life cycle assessment (LCA) reflect the fact that the shellfish industry is keen to support

Figure 5. Some examples of different shell fragment sizes and potential uses.

valorisation of shell waste. Chemical analysis confirmed that shell powder from scallop and oyster shells were suitable for these uses.

The system boundary of an LCA outlines the processes involved in the production of the product that are included and those that are not included in the assessment. For this study the primary system boundary will be from "cradle to farm gate" (Figure 6- next page). The study therefore assessed all inputs (e.g., water, electricity, raw materials) and all outputs (e.g., emissions to sea and atmosphere and waste) across the product life cycle.

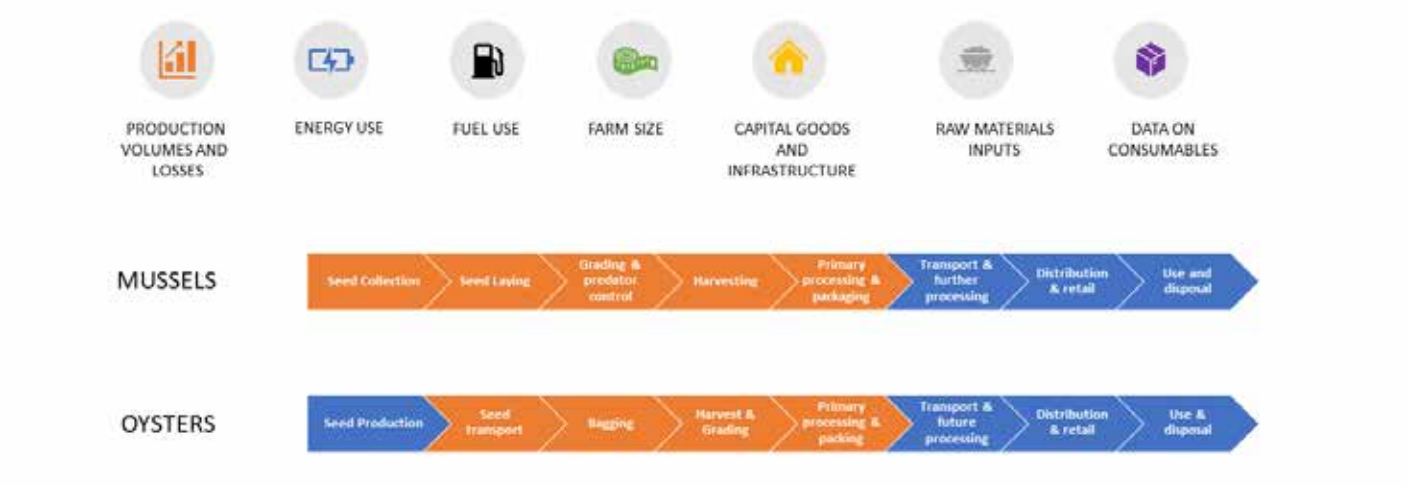


Figure 6. System boundary for mussels and Pacific oysters (activities included within the assessment in orange).

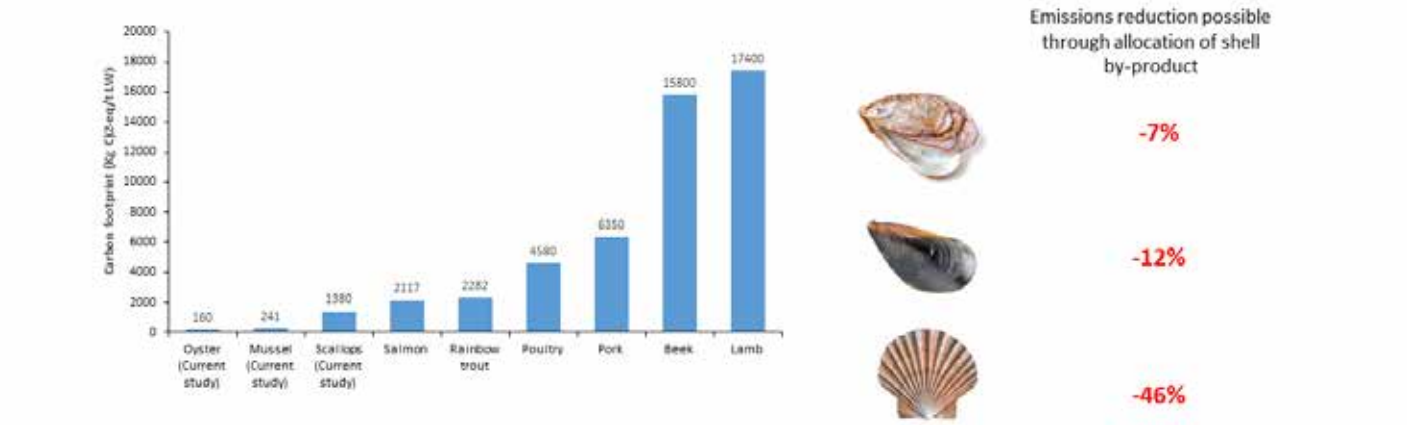


Figure 7. Graph showing the bivalve emissions from our study compared with the carbon footprint for other UK animal production. Graph adapted from McGoohan et al (2021)

Impact of AFBI Science

Life cycle analysis was used to evaluate the environmental impact of a product through its life cycle. This analysis provided a quantifiable reduction in costs and losses. Improved sustainability by reduction of "waste" was included in the LCA and VCA, estimating the reduction of environmental impacts and reduced carbon footprint of the industry by valorisation of shells.

Applying LCA, we estimated the environmental impact of 1 tonne of live weight bivalve produced in NI. Results showed that 160 kg CO2-eq is needed to produce 1 tonne of oysters and 241 kg CO2-eq for 1 tonne of mussels (Figure 7). This highlights the low environmental footprint of bivalve aquaculture in NI. A potential scenario for shell valorisation was also modelled and estimated that 124 kg CO_2-eq would be required to produce 1 tonne of processed crushed shell for market. We also estimated that the allocated emissions to seafood production (bivalves) could be reduced from between 7- 46% through shell valorisation, resulting from the allocation of a portion of emissions from shell production to other industries that would benefit from the use of shell by-products. The re-use of waste shell will reduce the carbon footprint of the shellfish industry as it minimises production of waste that is subsequently sent for landfill. Additionally, the use of shell waste instead of other man-made materials with higher carbon outputs will provide further benefits in, for example, the construction industry.

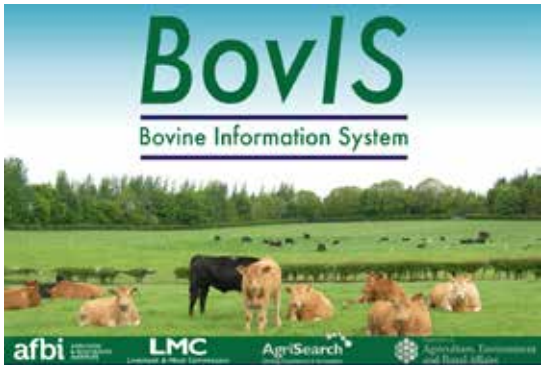
The study was co-funded by Seafood Innovation Fund (SIF)

Bovine Information System: BovIS- data driven decisions for cattle enterprises

Frances Titterington, Prof Steven Morrison and Dr Francis Lively

Summary

AFBI, with support from DAERA and Agrisearch, developed the bovine information system, BovIS. BovIS collates individual animal slaughter records from seven high throughput abattoirs. It connects this data with the genetic and health information from APHIS. This information is used to model market trends and to provide a range of decision support tools designed to help NI cattle farmers.



Background

Multiple data streams, including carcass data, breeding data and health data, are required to successfully manage a cattle farm. This often entails reviewing farm notes, dockets from the abattoir and meat inspector records and trying to link them. However, this data has been brought together in one place for the NI farmer to access free of charge. The BovIS online decision support tool applications are available to every registered cattle owner through the online Government Gateway.

AFBI Science

AFBI have designed a suite of decision support tools to help NI cattle producers meet the challenges of running an efficient cattle enterprise. These tools give producers a detailed insight of their cattle's performance, including meeting growth targets, health information and carcass characteristics at slaughter. Powerful modelling tools allow the farmer to predict how adjusting cattle management to produce more premium, in spec carcasses can impact their income. There is also a detailed breakdown of meat inspector reports allowing the farmer to measure incidence of disease and the impact of disease on cattle performance. Farmers can compare their cattle's performance, on a herd or individual animal basis, against other cattle of similar type to determine whether there is room for improvement.

Impact of AFBI Science

The suite of BovIS decision support tools allows the NI cattle producer easy access to their data and the opportunity to benchmark against other farmers. This allows every producer to gauge their performance and understand where improvements can be made. These informed management adjustments will help their cattle achieve key performance indicators, such as growth targets and fertility measures set out in the future agricultural policy. These increases in efficiency will reduce the GHG emissions on farm and the data held on the BovIS database is integral to the genetic improvement of the NI cattle herd.

The study was co-funded by DAERA , LMC & AgriSearch

Towards climate-smart sustainable management of agricultural soils

Dr Suzanne Higgins, Dr Jonathan Holland, Dr Elaine Groom

Summary

AFBI led a collaboration with 26 partners across Europe to assess the potential for harmonisation of fertilisation guidelines between European countries.

Background

AFBI is the UK partner in a European Joint Programme (EJP) project called EJP Soil, funded by the European Union (EU) Horizon 2020 research and innovation programme. Commencing in 2020, the 5-year project has created a roadmap towards climate-smart and sustainable agricultural soil management across Europe.

This roadmap identified activities and knowledge gaps that would form a platform of research collaborations across the 26 participating European partners, to be conducted throughout the lifetime of EJP Soil, and with six clear expected impacts:

- Fostering understanding of soil management and its influence on climate change mitigation and adaptation, sustainable agricultural production and environment.
- Understanding how soil carbon sequestration can contribute to climate change mitigation at the regional level and accounting for carbon.
- Strengthening scientific capacities and cooperation across Europe including training young soil scientists.

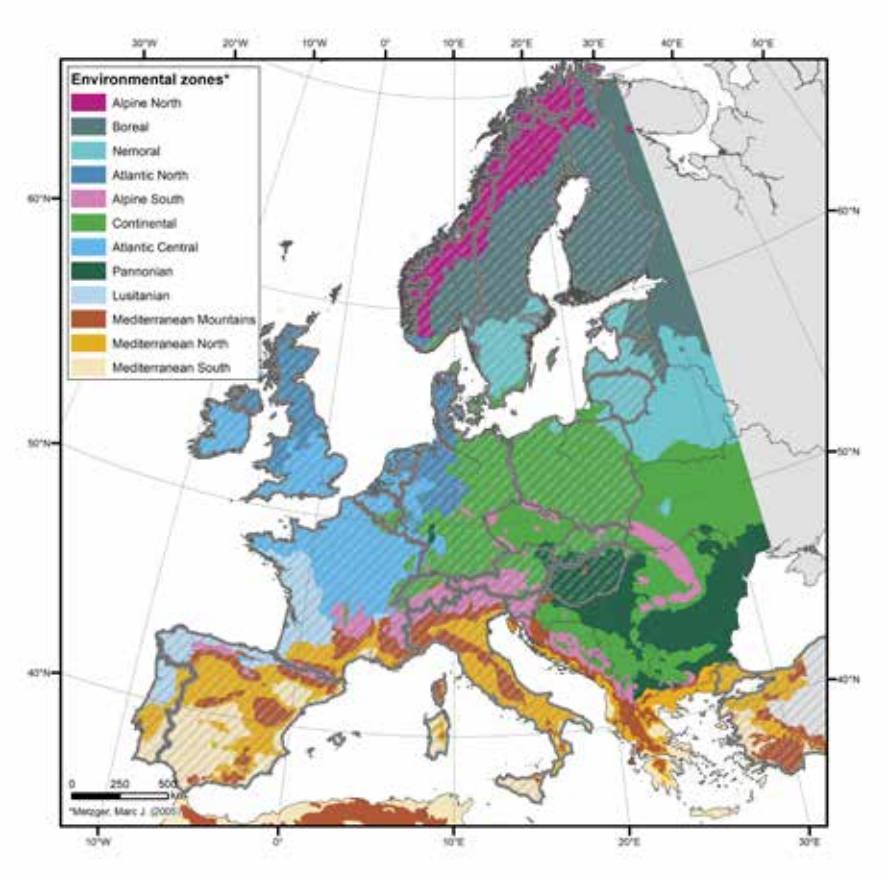


Fig 1. Countries participating in the EJP Fertiliser Stocktake Study led by AFBI

- Supporting harmonised European soil information, including for international reporting.
- Fostering the uptake of soil management practices conducive to climate change adaptation and mitigation.
- Develop and demonstrate region- and context-specific fertilisation practices (soil, water and pedoclimatic conditions).

AFBI Science

AFBI scientists have a contributing role across all work packages within EJP Soil. As the UK's representative, AFBI's role is to provide input and feedback to the EJP Soil programme, including information on UK region-specific soil management practices, challenges and policy needs, along with fostering UK soil stakeholder engagement through local events. AFBI also conducts research within a number of EJP sub-projects under the main themes of

- **Sustainable Soil Management:**
  i-SoMPE
- **Climate Change Mitigation:**
  CarboSeq; MIXROOT-C
- **Assessing & Monitoring:**
  SensRes
- **Fostering Adoption:**
  PRAC2LIV

Impact of AFBI Science

Through leadership of a stocktake study of fertilisation recommendations across Europe, in 2023 AFBI has published two peer reviewed articles in European Journal of Soil Science, which discuss the importance of harmonised European soil information, including for international reporting. As a result of their impact, Suzanne Higgins has been invited to present at an International Workshop on Fertiliser Recommendations in The Netherlands in April 2024. This work has contributed to two of the six expected impacts of EJP Soil:

- Supporting harmonised European soil information, including for international reporting
- Development and demonstration of region- and context-specific fertilisation practices (soil, water and pedoclimatic conditions).

SURVEY ARTICLE

Stocktake study of current fertilisation recommendations across Europe and discussion towards a more harmonised approach

Fig 2. AFBI publication in European Journal of Soil Science

These topics have been recognised by the European Commission and have been included in the EU Mission "A Soil Deal for Europe". The study completed by AFBI assessed the potential for harmonisation of fertilisation methodologies as a strategy to reduce nutrient loss and improve overall soil health. By generating a side-by-side comparison of fertilisation practices across European countries, the data gathered can provide a baseline for the development of scientifically based EU policy targets for nutrient loss and soil fertility evaluation.

The study was funded by the European Union Horizon 2020 research and innovation programme (Grant Agreement NO. 862695) with 50% co-funding from DAERA.

THIS PROJECT HAS RECEIVED FUNDING FROM THE EUROPEAN UNON'S HORIZON 2020 RESEARCH AND INNOVATION PROGRAMME UNDER GRANT AGREEMENT No: 862695

Evaluation of the use of MultiSpecies swards within beef production systems.

Dr David Patterson, Dr Denise Lowe, Dr Aurelie Aubry, Dr Naomi Rutherford & Dr Francis Lively

Summary

Dairy-origin beef calves grazing multi-species swards (MSS) exhibited improved liveweight performance and a reduced worm burden in comparison to those on a grass clover sward. However, there was a high occurrence of bloat with clover swards.

Background

There is growing interest into the potential benefits of increasing plant diversity in swards. The suggested benefits from incorporating a mix of grass, legume and herb species into grazing platforms includes improved soil health, reduced need for artificial fertiliser and improved drought tolerance. However, knowledge gaps exist on the impacts on animal health and performance, particularly that of cattle.

AFBI Science

A grazing trial involving dairy-origin beef calves grazing either MSS or grass clover swards was conducted in the summers of 2020 and 2021. All swards received 75 kg N/ha in spring. Calves were rotationally grazed. Calf liveweight, faecal egg count (FEC) and trace element status (year 2 only) were monitored.

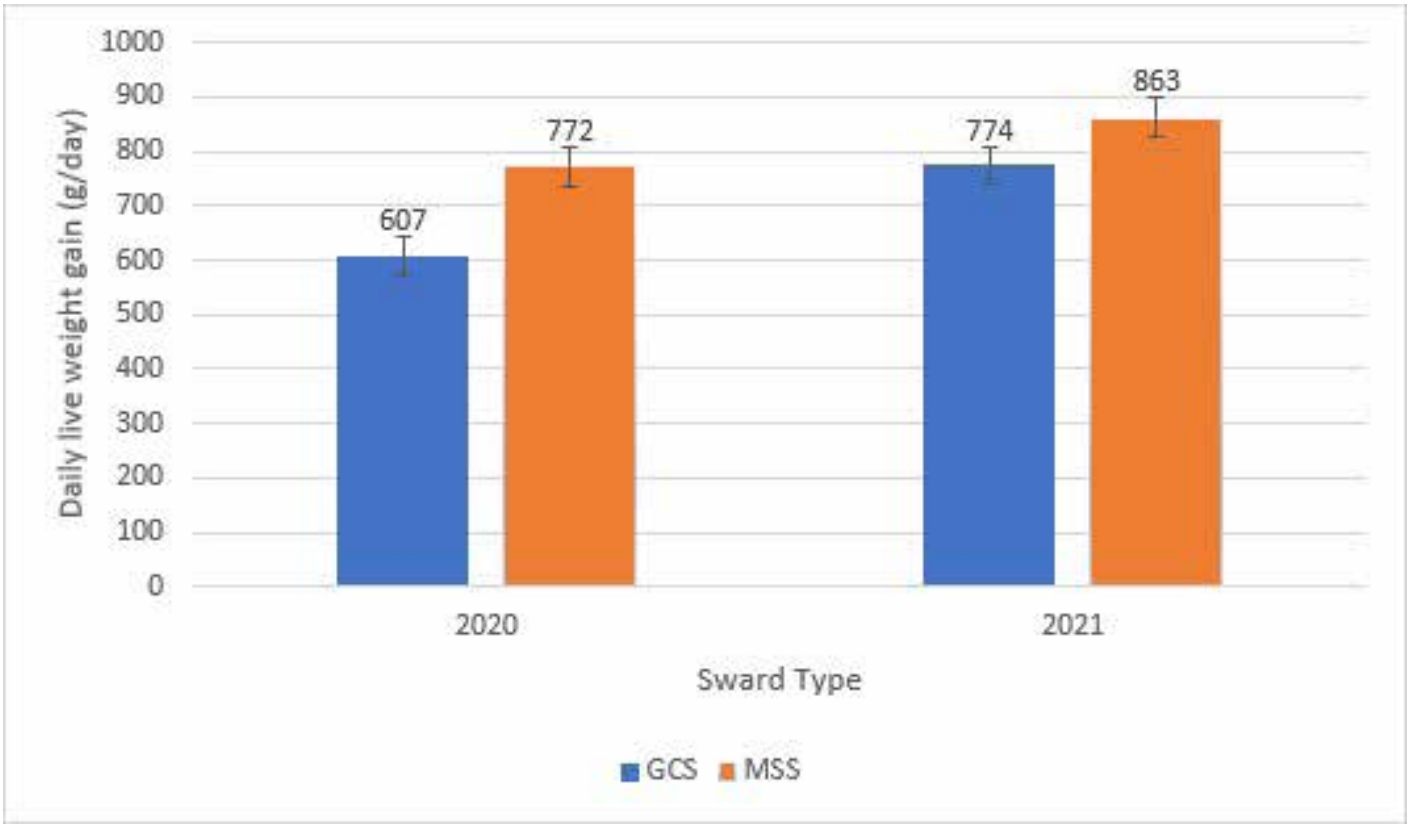


Figure 1: Live weight gain of dairy origin calves grazing either grass clover sward (GCS) or multi species swards (MSS) during 2020 and 2021

Calves grazing MSS had a higher daily live weight gain during both 2020 and 2021 than those grazing grass clover (Figure 1). FEC was consistently lower throughout the grazing season for calves grazing MSS compared with those grazing grass clover, while the trace element analysis showed no difference between treatments. However, across both sward types in this study there was a high occurrence of bloat in calves due to the clover content of the swards. Measures were taken in year two to reduce this risk, however bloat still occurred when the sward was lush in early autumn.

Impact of AFBI Science

Results show that MSS swards have the potential to maintain or even enhance animal performance. The reduced FEC in this study demonstrated that MSS also have the potential to reduce anthelmintic requirements, primarily due to the condensed tannin content of the herb species in the sward.

Therefore, MSS could play an important role in minimising the development of anthelmintic resistance on farm. MSS and clover-based swards also have the benefit of having a lower fertiliser requirement in comparison to conventional perennial ryegrass swards, which can bring both economic and environmental benefits. However, the inclusion of clover did lead to a high occurrence of bloat, highlighting both a need for additional research on the matter and the need for a holistic assessment of grazing systems.

The study was co-funded by HORIZON 2020 project *Super-G* & AgriSearch/CAFRE (EIP)

THIS PROJECT HAS RECEIVED FUNDING FROM THE EUROPEAN UNON'S HORIZON 2020 RESEARCH AND INNOVATION PROGRAMME UNDER GRANT AGREEMENT No: 774124

Feed into Beef Nutrition: Precision Nutrition for beef cattle

Dr Francis Lively, Dr Tianhai Yan, Dr Denise Lowe, Dr Edward Garcia and Dr Chen Xianjiang

Summary

Feed into Beef Nutrition (FIBNUT) is a collaborative research project (with AFBI working in partnership with CIEL, Scotland's Rural College (SRUC) and an industry advisory group) to improve the accuracy of the nutrition guidelines for rationing beef cattle within the United Kingdom.

Background

There was strong evidence that the nutritional guidance for rationing beef cattle in the UK (AFRC, 1993) was inaccurate and outdated. This could be due to changes in the feeds, management systems and the genetic base of the UK cattle population since the guidelines were published. The FIBNUT consortium was established to update the nutritional guidelines based on more recent scientific data using typical beef production systems currently adopted within the UK.

AFBI Science

This project aimed to deliver new guidelines for predicting beef cattle performance and feed requirements by:

- Engaging with industry to clearly define needs and priorities
- Developing new equations to provide improved predictions of feed intake for main types of beef cattle

- Developing new models for predicting growth and composition of modern beef genotypes according to both category of animal and the feed they are offered and consume
- Revising models for rumen microbial protein synthesis and metabolisable protein requirements to better predict the effect of dietary protein on animal performance
- Revising feed values for major feed categories fed to beef cattle in the UK – particularly filling gaps in information about new feed types
- Modelling the effects of feed interactions on feed values. The current system does not consider such interactions
- Developing prediction models for methane emissions of beef cattle to help carbon footprinting of beef cattle production systems

The project utilised available data within AFBI and SRUC to validate a range of internationally available prediction models for rationing beef cattle to test their suitability and accuracy for UK conditions. Where new data was available, new prediction equations were developed. Where new data was not available, engagement with industry led to modifications of existing models. Collectively, a range of new nutritional guidelines were developed and are being evaluated by an industry advisory group.

Impact of AFBI Science

Accurate guidelines for rationing beef cattle are critical to ensure the nutritional requirements of beef cattle are met and desired levels of performance are achieved in a cost effect and efficient manner. This research will benefit those offering nutritional advice to beef farmers as well as the farmers themselves. It will also benefit the red meat industry as more accurate predictions of cattle flows to the meat plants can be made; and additional carcases should meet market specification in terms of age at slaughter, carcass weight and fat classification. This research will indirectly benefit Policy with improved knowledge of cattle nutrition being closely aligned to beef cattle's contribution towards greenhouse gas emissions. The outcomes of this project will be available for future modelling to determine beef nutrition regimes or farm management practises which have the minimal environmental footprints.

The study was co-funded by AHDB and an Industry Advisory Group in conjunction with CIEL.

Delivering Ecosystem services from Permanent Grassland

Frances Titterington and Dr Francis Lively

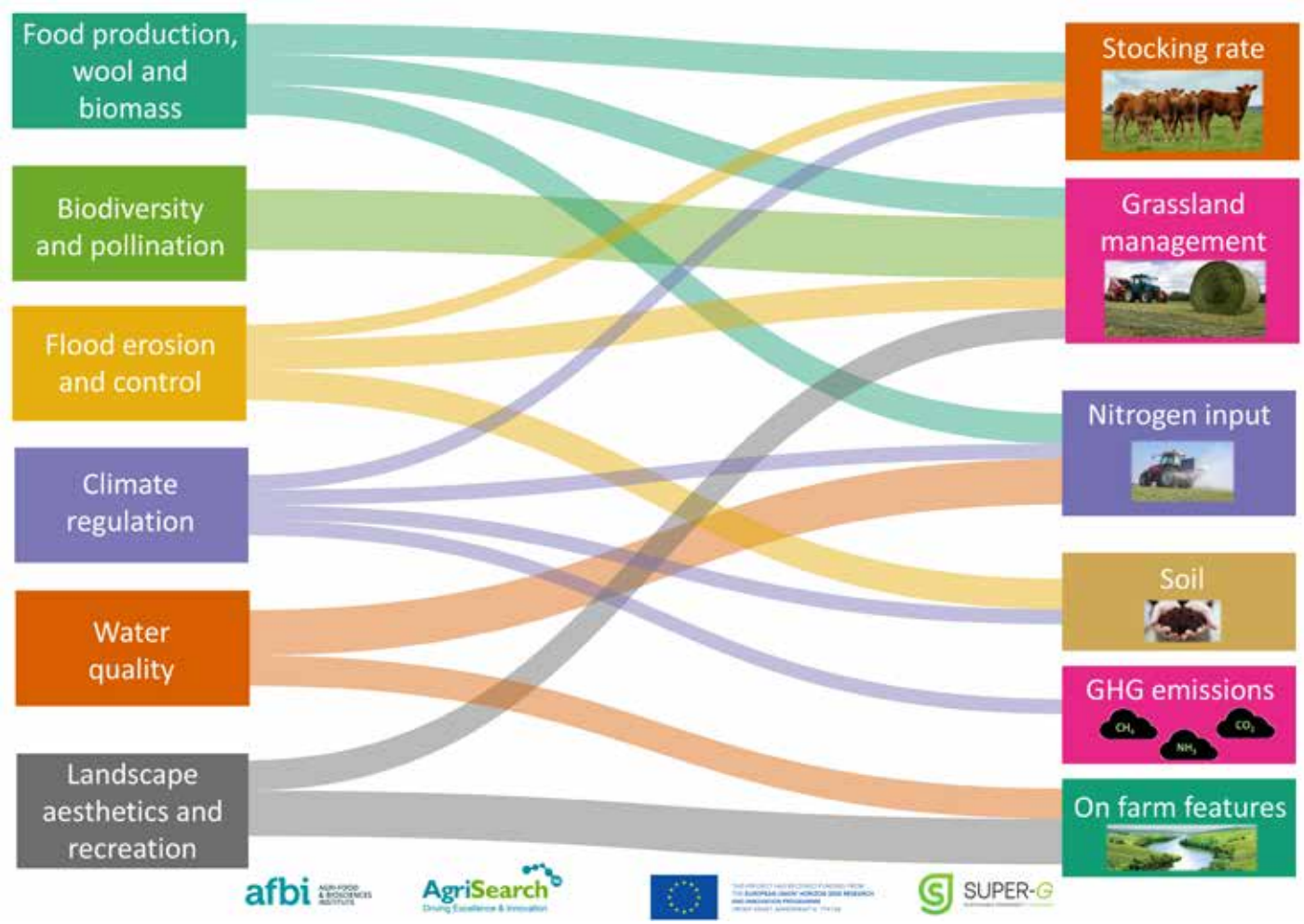
Summary

The SuperG farmer decision support tool has been designed to give farmers a better understanding of the Ecosystem Services (ES) provided by their farm. The tool includes six ES, which are all intrinsically linked. The farmer answers a series of questions about their farm and then they are presented with an overview of ES provided by their permanent grassland (PG), how they can improve each ES, and the possible trade-offs involved in changing their management.

Background

Permanent grassland is key to the delivery of multiple ES including food, wool and biomass production; climate regulation; biodiversity; landscape aesthetics; flood and erosion control; and water quality. As part of the SUPER-G project, AFBI have developed a farm level decision support tool.

This tool aims to provide the farmer with an overview of the ES delivered through the management of PG within their farm and to offer guidance on management strategies which could enhance the delivery of each ES.



AFBI Science

AFBI and AgriSearch coordinated a series of expert forums to agree the questions and calculations required to assess each ES. AFBI scientists developed a 'Simple Additive Weighting' model to calculate a score for each ES and an intuitive reporting system which offers advice. The tool is being built by ADAS and AFBI are currently undertaking user acceptability testing and a sensitivity analysis to assess the calculations.

Impact of AFBI Science

Once launched, this tool will allow farmers to score the ES provided by their PG whilst considering the synergies and potential trade-offs by implementing new management. This will allow the farmer to model how management changes will impact both the production levels and ES on farm and make informed decisions on how to balance productivity and environmental considerations.

The study was co-funded by HORIZON 2020 project *SUPER-G*

THIS PROJECT HAS RECEIVED FUNDING FROM THE EUROPEAN UNON'S HORIZON 2020 RESEARCH AND INNOVATION PROGRAMME UNDER GRANT AGREEMENT No: 774124

InnoVar: Next generation variety testing for improved cropping on European farmland

Dr Lisa Black, Dr Adam Gauley, Dr Paul Cottney and Hazel Brown

Summary

As coordinator of EU project InnoVar, AFBI is at the forefront of international innovations in plant variety testing. Incorporation of new science into traditional plant testing processes and including traits that support sustainability and resilience, has the potential to made real impact to sustainable agricultural production across Europe.

Background

Work on plant variety testing for statutory testing of breeders' candidate varieties has been ongoing in AFBI since the 1950s. Such work relies on expert knowledge and detailed manual measurements comparing different crop varieties in field-grown plots. The methodologies have changed little despite advances in technology and there is a need to keep pace with the challenges growers face because of changes in climate. Funding from the European Union's Horizon 2020 Programme for the €8M InnoVar project, led by AFBI, has looked at much-needed change in this area by harnessing developments in genomics, sensors and data analytics.

AFBI Science

AFBI has expertise in plant variety testing and coordinated the 84 trials in the pan-European-wide trial series. Data from images, manual measurements, soil and weather and the genomic sequences of the varieties have all been brought together with machine learning to examine the potential of a digital approach to managing the evaluation of new plant varieties across Europe. This has put AFBI staff at the forefront of proposed changes in their field and given them opportunities to discuss their work with national, EU and world bodies (CPVO, UPOV) for plant variety protection.

InnoVar trial at AFBI Crossnacreevy

Impact of AFBI Science

InnoVar has sought to identify varieties that can maintain performance with lower agro-chemical inputs and under more extreme climatic conditions. AFBI has trademarked a new "High Performance Low Risk" (HPLR) recommendation tool to allow selection of varieties for specific growing conditions with more sustainable levels of chemical treatment. The HPLR brand is being trialled by the AHDB through a consultation with UK growers on potential changes in the recommended list system in the UK. The ultimate impact of the project will be to re-focus plant breeding and variety testing to encourage more sustainable and resilient agriculture.

HPLR™

THIS PROJECT HAS RECEIVED FUNDING FROM THE EUROPEAN UNON'S HORIZON 2020 RESEARCH AND INNOVATION PROGRAMME UNDER GRANT AGREEMENT No: 818144

The study was co-funded by EC Horizon 2020 and DAERA

AFBI's Food Quality Research programme

Dr Linda Farmer, Dr Colin McRoberts, Dr David Farrell, Mr Terence Hagan and Dr Janeen Speers

Summary

The Agri-Food and Biosciences Institute (AFBI) has a long and successful history in the area of food quality research. The programme has assisted a wide range of commercial companies in the development of their products by improving their health attributes, eating quality and overall consumer acceptance. This research has used cutting-edge technologies and state of the art methodologies, such as hyperspectral imaging for the measurement and prediction of composition and quality and high-pressure processing and active packaging to extend shelf-life.

Background

Northern Ireland's economy is heavily dependent on food production and the remit of the food quality research programme has been to understand the eating and nutritional qualities of food, supported by strong expertise in analytical chemistry, meat science, spectroscopy and sensory evaluation.

The consumer expects a product with consistent eating quality and factors affecting this consistency need to be underpinned with sound science. Furthermore, the association of certain diseases with diet in western society (such as obesity, diabetes and cardiovascular disease) has highlighted the importance of improving the nutritional quality of food.

Impact of AFBI Science

Quality food to meet consumer requirements

Food production is a key driver of economic growth in Northern Ireland. Northern Ireland is net exporter of food to the rest of the UK and further afield, with additional transport costs to recoup, the quality of the product is of paramount importance. The final arbiter of that quality is the consumer. Every penny that reaches the farmers' and processors' pockets is ultimately derived from the consumer.

A unique combination of sensory, instrumental chemistry and statistical techniques have enabled us to elucidate the science underpinning eating quality. Several projects have been conducted for the UK meat industry to increase our understanding of the factors affecting consumers' perception of palatability.

Our work has:

- Shown that Northern Ireland produced lamb can be bought with confidence throughout the year, since eating quality matches imported "spring born" lamb from New Zealand.
- Elucidated the factors affecting the eating quality of Welsh lamb.
- Demonstrated that meat from ram lambs can have as good sensory quality as that from castrates.
- Highlighted that different sources of chicken vary markedly in their composition and eating quality.
- Indicated that beef that meets the sensory standards of Northern Irish and Irish consumers also meets the expectations of consumers in Great Britain.
- Developed an understanding of what drives consumer flavour perception of beef and how this can be related back to the farm and processing (Figure 1).
- Provided evidence that skatole has a greater effect on the eating quality of pork than androstenone.

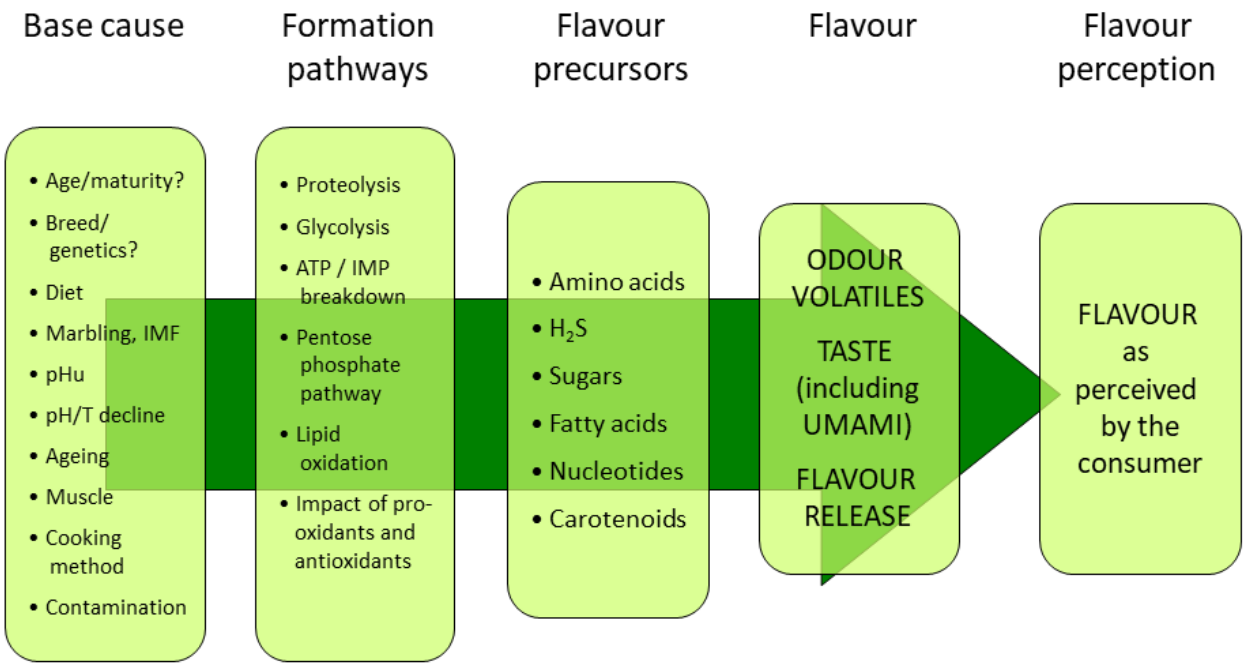


Figure 1. Schematic diagram illustrating the factors driving flavour perception

Balsamic lamb with aubergine salsa. (Photo courtesy of LMC)

Maximising the nutritional quality of our food

The health of western society is facing several challenges. Whilst people are living longer, there is also an increasing incidence of obesity, diabetes, cardiovascular disease and these diseases are also associated with the over-consumption of unhealthy food. It is becoming increasingly evident that other diseases of the young and old alike are associated with diet. The increases in such diseases are expected to place an even greater pressure on the National Health Service. In addition, many people ingest sub-optimal quantities of essential dietary components such as Vitamins D and E, iron, zinc and omega-3 fatty acids.

Northern Ireland produces a wide range of potentially healthy food. Our role has been to investigate ways to make it even more healthy. We have shown the benefits of UV light as a promising technology for increasing Vitamin D content in meat and dairy products and for improving animal welfare. Our work with the Welsh lamb commission proved that total fat, fatty acids, minerals and Vitamin D are influenced by aspects of lamb production that may be managed through the rearing regime. We have also highlighted that grass-based diets increased omega-3 fatty acids and reduced n6/n3 fatty acid ratio in beef, when fed at the finishing stage, but not at the grower stage.

New technologies for processing and measurement.

Technological developments are providing new opportunities for both the processing of foods and their measurement. The food quality research programme has focused on the use of high-pressure processing and active packaging to extend shelf-life and hyperspectral imaging for the measurement and prediction of composition and quality. With thanks to AFBI's Statistics and Data Science Branch, the development of advanced data handling tools for very large data sets has provided new ways to interpret and model the resulting very large data sets. The practical application of such tools in the food industry provides new opportunities to add value and manage quality.

Hyperspectral Imaging is a novel and rapid non-destructive tool for measuring quality throughout the food industry. Our research has shown that this technology can be used as a measurement and prediction tool of meat quality. We have successfully used hyperspectral imaging to identify colour defects in beef and to measure the post-mortem ageing and aspects of meat quality in chicken meat. This technology has also been used in a number of CAFRE final year student projects. We have developed algorithms for authenticating culinary oils, differentiating nitrate and nitrite levels in locally produced bacon (Figure 2), measuring the quality of locally produced fruits and vegetables, measuring the colour of locally produced beef and classifying microplastics.

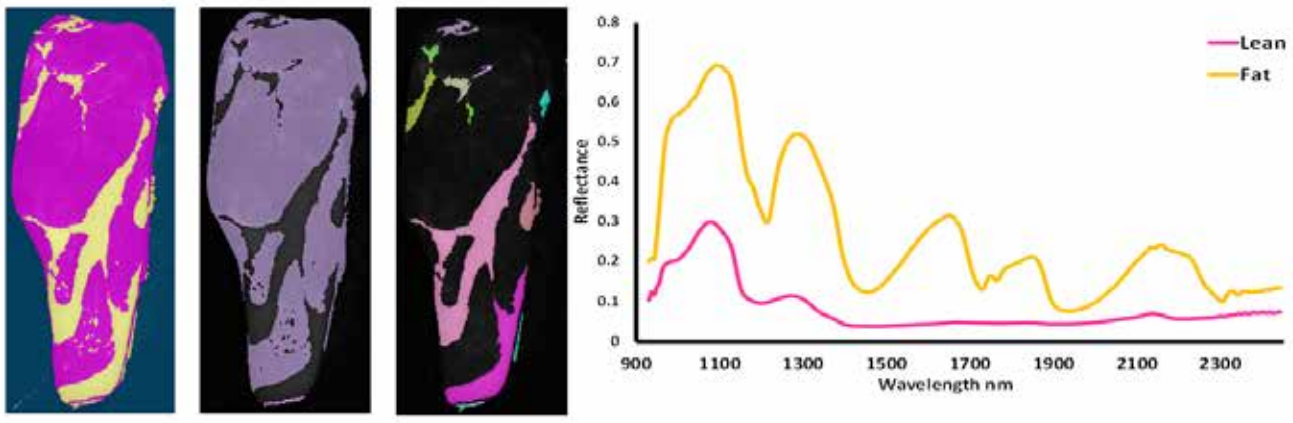


Figure 2. Differentiating nitrate & nitrite levels in locally produced bacon using hyperspectral imaging

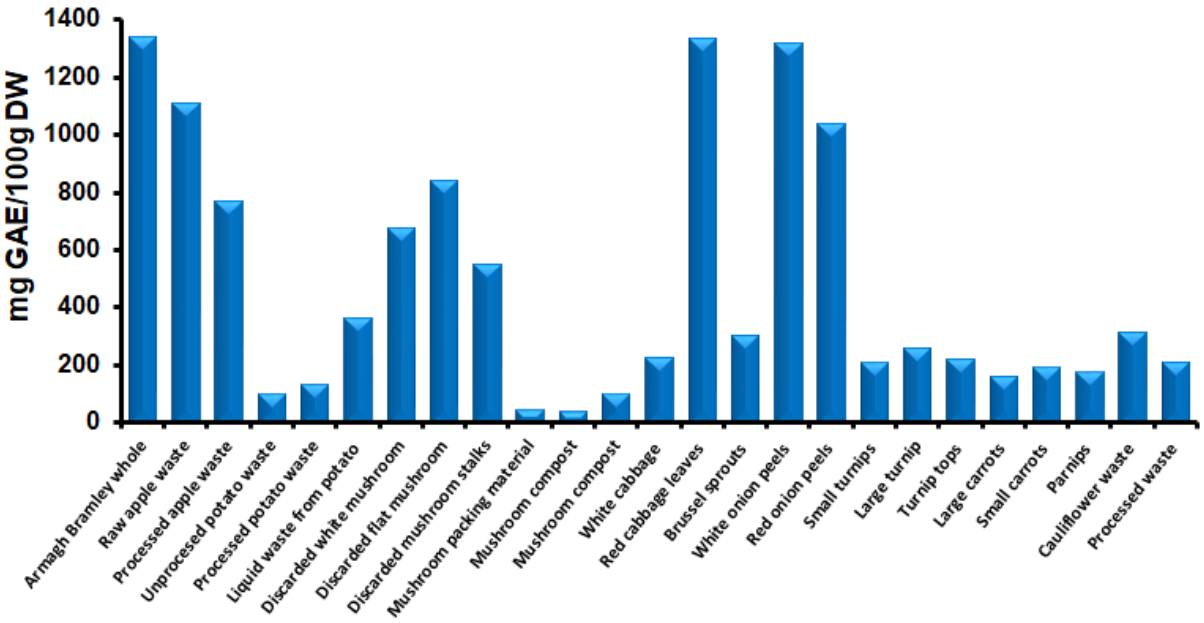


Figure 3. Antioxidant status of locally produced fruit and vegetable waste streams

Better use of co-products of food production

In the forward to the "ReNEW" report into the circular economy in Northern Ireland, Mark H Durkan (MLA Minister for the Environment) in 2015 wrote "A circular economy will encourage innovation, deliver job creation, improve resource efficiency and productivity; thereby driving economic growth, and helping local businesses to remain competitive in the global market".

Northern Ireland produces a wide range of meat, dairy, seafood and fruit/ vegetable products. Many of these products are of very high quality and these underpin Northern Ireland's reputation for fine food.

However, there are also lower value products for which the value and profitability could be increased. In addition, there are many co-products from all these industries that are not used optimally. For example, co-products from the vegetable and fruit production are a valuable source of natural antioxidants, anti-microbial compounds and coating materials, and there has been little exploitation of these products in Northern Ireland. This provides an opportunity for Northern Ireland to add

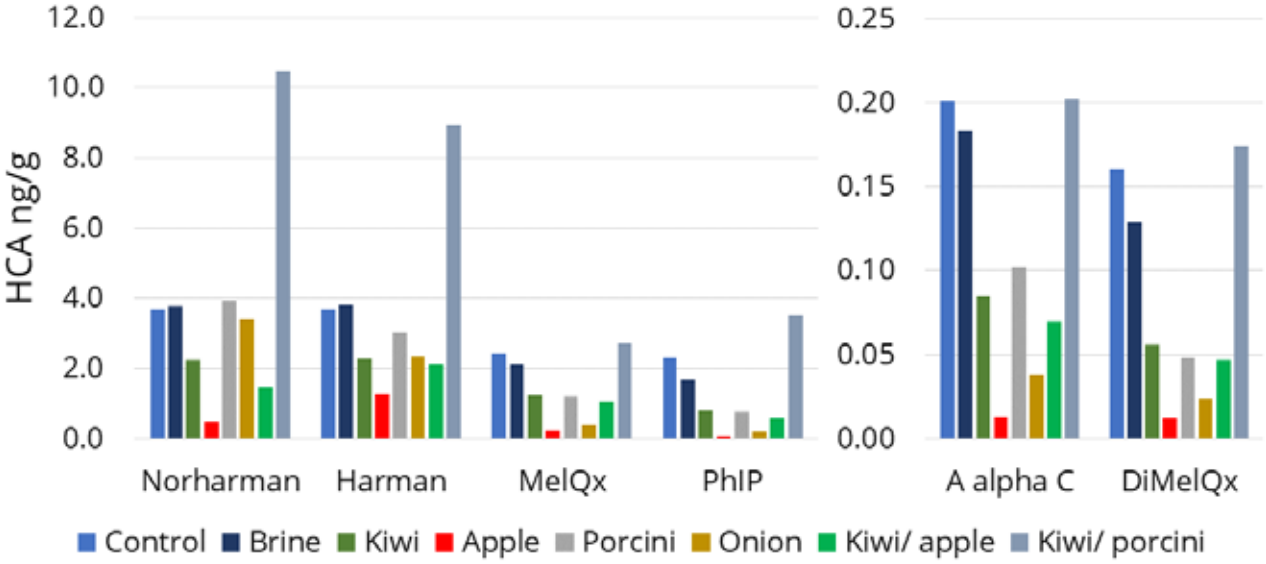


Figure 4. Co-products can reduce mutagen formation on meat cooked at high temperature

quality and value to its food and make better use of all its resources.

The food quality research programme has conducted preliminary research that demonstrated the potential of this approach. Our research highlighted the high antioxidant status of waste material especially from the local Armagh Bramley apple and mushroom industries, as well as the smaller volume onion and cabbage production (Figure 3). Further work showed that dried apple products can both enhance the quality of lower valued beef cuts and reduce the formation of mutagen compounds that form with meat is cooked at higher temperatures (Figure 4).

Knowledge transfer

The food quality research programme has been involved with knowledge transfer to scientists, to industry and the next generation of food scientists. Most of the research has been undertaken in partnership with the agri-food industry in Northern Ireland or further afield.

The results of our research have therefore been transferred directly to those who need to utilise these findings to improve the quality of their products. In addition, the local agri-food industry has commissioned investigations to solve specific problems. On occasions we have saved them or made them considerable sums of money, but these examples are always confidential.

Over the past seven years, the food quality research programme secured £3.1 million of non-DAERA income and has completed 47 projects reporting results and advice to 25 customers. Internationally, the programme has collaborated with food scientists from 30 countries worldwide and organised 6 international conferences and events.

The programme has also supported both undergraduate and postgraduate education for CAFRE, Queen's University Belfast and University of Limerick students, with many of these students now playing an important role in the food industry and are now AFBI customers.

Figure 5. Food Research Branch Key Customer Day (Belfast, April 2018)

Protecting animal, plant and human health

Water Quality Prediction Models Impact DAERA Schemes (WQPMIDS): SWIM NI

Dr Heather Moore, Dr Elaine Mitchell, Cathy Brooks

Newcastle, Co. Down.

Summary

Good water quality is the foundation of good health for both humans and animals. The Department of Agriculture Environment and Rural Affairs (DAERA) seeks to prevent deterioration and improve surface water quality in Northern Ireland through the implementation of the Water Framework Directive (WFD). AFBI have been developing models to predict when identified bathing waters and shellfish waters are likely to be contaminated with faecal bacteria. The daily bathing water quality predictions are communicated to the public through electronic signage and a webpage and mobile phone app, hosted by Keep Northern Ireland Beautiful (KNIB), called SWIM NI. Access to water quality predictions may reduce the risk of exposure not only to pathogenic organisms but potentially antimicrobial resistant organisms and should inform remediation projects by DAERA and Northern Ireland Water.

Background

The Bathing Water and Shellfish Water Directives fall under the umbrella of the WFD. There are 26 identified bathing waters in Northern Ireland and 10 shellfish waters, which are marine protected areas. Bathing waters and shellfish are tested for the presence of faecal indicator bacteria. Sources of faecal contamination in the environment are combined sewer overflows or septic tanks located close to rivers, or runoff of slurry or faeces from farm animals. Heavy rainfall is one of the most important drivers of poor water quality and DAERA advise bathers not to enter the water for up to 2 days after a rainfall event. An INTERREG funded project called EU SWIM (2014-2020), which was a collaboration between AFBI, UCD and KNIB, developed water quality prediction models

for six identified bathing waters in NI and three in ROI. The legacy DAERA funded Evidence and Innovation project, WQPMIDS (2019-2024), seeks to develop models for a further six bathing waters and two shellfish waters in NI.

AFBI Science

Meteorological and hydrological data is used to inform the model development and how these variables impact the water quality at each location is unique. AFBI owned instrumentation such as weather stations, river level sensors and rain gauges are installed and monitored at relevant locations. Water samples are collected and tested for faecal indicator bacteria to validate the results of model predictions at Castlerock, Portrush, Waterfoot, Ballyholme, Ballywalter and Newcastle. Water samples have also been taken at Ballycastle, Carnlough, Ballygally, Brown's Bay, Crawfordsburn and Millisle beaches, and shellfish beds at Dundrum and Belfast Lough, to inform further water quality prediction model development at these locations.

Impact of AFBI Science

Water Quality Prediction models have already assisted bathers in NI to make informed choices about when and where to enter the water visit Swim NI on the (keepnorthernirelandbeautiful.org page). For example, the SWIM model predicted poor water quality at Newcastle bathing transect on 19th June 2023 and was validated by same day water quality testing, for concentrations of faecal indicator bacteria *Escherichia coli* and Intestinal *Enterococci* measuring 460 colony forming units per 100 ml (cfu/100 ml) and 635 cfu/100 ml respectively. Individual sample results for Intestinal *Enterococci* exceeded the threshold typical of a sufficient classification. The development of models for a further six beaches and two shellfish waters should mitigate the risk of illness through exposure to contaminated shellfish or bathing waters, thus protecting the health of the public.

The study was co-funded by DAERA

Spillover of Highly Pathogenic Avian Influenza virus into local mammalian wildlife - laboratory response and future perspectives

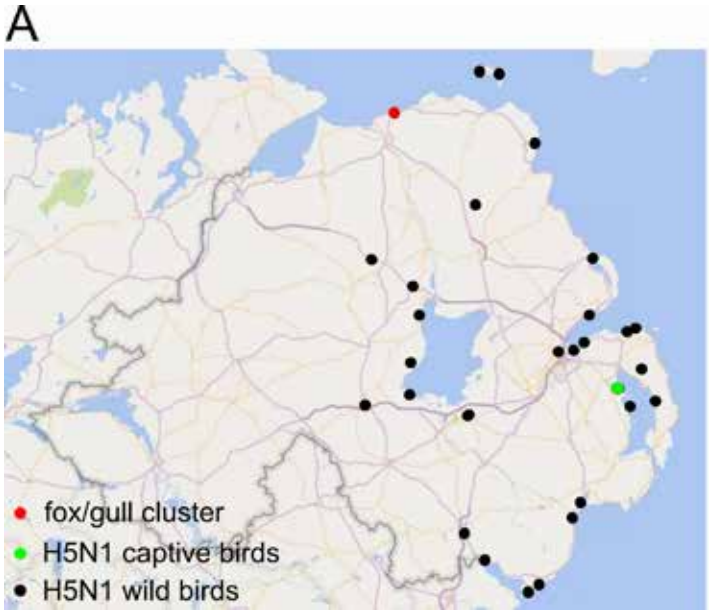
Dr Ken Lemon

Summary

The global spread of highly pathogenic avian influenza (HPAI) has resulted in an unprecedented number of spillover events to wild and domestic mammals, leading to public health concerns over the increased zoonotic risks posed. In July 2023, AFBI confirmed the first cases in Northern Ireland, in two red foxes. Genetic analysis of the viral sequences obtained from the foxes identified mammalian adaptations, one of which was highly novel.

Background

During the autumn/winter of 2022/23, scientists at AFBI VSD confirmed the presence of HPAI H5N1 in numerous wild *Anatidae* species (ducks, geese and swans) and birds of prey. Over the summer months, a significant increase in detections occurred in seabirds of the *Laridae* family (black-headed gulls, kittiwakes and terns) found dead around the coastal regions. On 25 July, DAERA was notified of two gulls and two red foxes found dead in sand dunes near Portrush. Carcasses were collected and submitted to AFBI for post-mortem examination and diagnostic testing.



AFBI Science

AFBI scientists determined that all four carcasses were positive for HPAI H5N1, with the highest viral loads present in brain tissues. Histopathological examination revealed the presence of viral antigen in brain tissues and associated lesions. Whole genome sequencing identified a small number of mutations unique to the fox sequences, two of which were determined to be mammalian adaptations that enhance HPAI replication in mammals. One of these mutations had not been described previously.

Impact of AFBI Science

AFBI is working closely with DAERA and reference labs in GB and the EU to monitor the situation closely and respond appropriately. Expanded surveillance in local mammalian wildlife is planned to determine the prevalence of infection and monitor the evolution of HPAI in mammalian hosts. This information will be used to better understand the role of mammals in the spread of HPAI and will help to safeguard the NI poultry industry. These data will contribute to the ongoing One Health – All Ireland for European Surveillance (OH-ALLIES) project.

The novel mammalian adaptation identified by AFBI has subsequently been identified in HPAI outbreaks in Finnish fur farms.

Our findings have been published in the European Centre for Disease Prevention and Control (ECDC) journal, Eurosurveillance (https://doi.org/10.2807/1560-7917.ES.2023.28.42.2300526).

The study was co-funded by DAERA (AWP)

Integrated pest management of leatherjackets

Dr Archie K. Murchie, Dr Florentine Spaans, Dr Stephen Jess, Ms Jillian Hoy

Female cranefly, which lays its eggs in the soil at the base of grass plants giving rise to leatherjacket grubs.

The leatherjacket

Summary

Leatherjackets are the larval stage of craneflies and an important pest of grassland in Northern Ireland. They were previously controlled by insecticides but following withdrawal of chlorpyrifos, farmers have been left with no clear options. This project assessed the leatherjacket problem through a questionnaire survey and on farm sampling. We then proposed an integrated pest management (IPM) framework, which seeks to minimise leatherjacket populations through a combination of measures acting in a coordinated incremental process. IPM requires farmers to take a multi-season approach to create conditions disadvantageous to the pest, but with minimal effects on the environment.

Background

Leatherjackets are the larvae of the crane fly, commonly known as “daddy long-legs”. They feed on grasses and cereals and can cause significant loss of yield and even sward destruction. Previously, leatherjackets were controlled by application of the organophosphate insecticide chorpyrifos but this was withdrawn in 2016 due to health concerns about the potential genotoxic and neurological effects on the unborn child. Leatherjackets are associated with damp climates and farmers in the west of NI are particularly vulnerable.

Farmers have no chemical means of controlling leatherjackets and need advice on how to manage this pest.

AFBI Science

An online questionnaire survey found that 67% of NI farmers (n = 335) reported issues with leatherjackets. This figure was highest in the west, with 93% of farmers in Fermanagh and 74% in Tyrone having problems with this pest.

The economic damage caused by leatherjackets was updated using data from the scientific and technical literature.

Impact of AFBI Science

The current cost of leatherjacket damage is estimated at £153 per ha for every million leatherjackets. Leatherjacket sampling on farms in Fermanagh gave leatherjacket populations averaging 470,000 per ha (2021), 930,000 (2022) and 1.13 million (2023), corresponding to potential losses between £72 to £173 per ha. The greatest level of infestation was 5.5 million per ha.

Recognising the problem with leatherjackets, AFBI scientists and AgriSearch constructed an integrated pest management framework for leatherjacket management on Fermanagh grassland farms. Practical advice was sought from four farmers as part of the project but also involved general discussion through presentations to farming groups, webinars and demonstrations. The majority of management measures proposed were good agronomic practice including drainage, reseeding, liming and use of break crops, such as forage brassicas. One innovative measure that came from farmer discussions was the use of tight grazing in late summer / autumn to reduce cranefly egg laying sites and early larval survival. This is a practical measure that could be implemented on farm with minimal disruption to farming practice or additional expenditure. The key to an IPM approach is prevention rather than cure.

The study was co-funded by the European Innovation Partnership (EIP) Scheme in Northern Ireland: funded by the European Agricultural Fund for Rural Development (EAFRD) and DAERA.

Leatherjacket damage is evident by yellowing of grass and bare patches

Leatherjacket grubs

The increasing threat of midge-borne disease to the livestock industry

Dr Archie K. Murchie & Dr Michael McMenamy

Inset: Gravid female biting midges. Only female midges bite, to get blood protein to develop their eggs.

Engorged midge with blood meal clearly seen through the abdomen

Summary

Bluetongue virus causes a serious disease affecting cattle and sheep. The virus is transmitted by biting midges. AFBI entomology has demonstrated that NI has high populations of biting midges coupled with high densities of naïve livestock hosts. This means that NI is at high risk of bluetongue disease spreading rapidly if an incursion occurs and weather conditions and temperatures are suitable. The current finding of bluetongue serotype 3 (BTV-3) in southern England in November 2023 has raised alarm levels and AFBI Virology are heavily involved in testing imported livestock for the virus. As there is currently no vaccine for BTV-3, early detection, restrictions on movement and targeted vector control are essential for preventing disease spread. Consequently, DAERA advise that producers should not import susceptible livestock unless it is essential for their business needs.

Background

Bluetongue is a viral disease of ruminants which is transmitted by biting midges of the genus *Culicoides*. In 2006, bluetongue virus was unexpectedly found affecting cattle and sheep in northern Europe. Initially, considered an African and Mediterranean disease, the bluetongue virus had 'jumped' from its native vector *Culicoides imicola* to northern European *Culicoides* species.

The disease spread rapidly throughout northern Europe, including to Great Britain, severely disrupting livestock production and trade. In 2008, bluetongue was detected in NI in imported cattle but as this was during the winter no onward transmission took place. Since then, bluetongue has been detected in other imports, but these findings were also in the winter, were isolated quickly and the disease did not spread.

Examining midge samples – Entomologists study the prevalence, distribution and timing of midge flight to determine the risk of bluetongue virus transmission.

UV light trap mounted in a cattle shed. At dusk and during darkness, midges are attracted to the UV light.

The situation, as of November 2023, is such that various bluetongue serotypes have continued to circulate in Europe despite ongoing vaccination programmes. In November 2023, bluetongue serotype 3 was detected in a cow in Kent, England. Subsequently, the virus has been detected in other livestock in Kent and Norfolk. As November is at the very end of the midge flight season, the risk of the virus circulating in the midge population during the winter is low.

AFBI Science

After the initial outbreak in 2006, AFBI entomologists conducted an extensive midge trapping programme to determine the prevalence, distribution and flight activity of biting midges. Up to 36,000 midges could be caught in a UV light trap during a single night and their flight period ranged from April through to December. This demonstrated that cattle could be subject to over 20,000 midges attacking them during the night. We demonstrated that pour-on insecticides would not stop midges biting but would kill them afterwards preventing onward transfer of the virus. We found the surprising result that the repellent DEET could actually attract midges to light traps.

Impact of AFBI Science

AFBI has the benefit of having virologists and entomologists working in close collaboration with DAERA. As the risk of bluetongue has increased due to greater circulation of the virus in Europe and the findings in England, the work of AFBI Virology and Entomology is essential for early detection of the virus in imported livestock. Knowledge of the vector (the biting midges) is then important to determine the risk of onward transmission, which is determined by the extrinsic incubation period (the time it takes for the virus to replicate in the vector), temperature and midge dispersal and host-seeking behaviours. The livestock sector is by far the largest component of NI agriculture and an outbreak of bluetongue would have serious economic implications. Unfortunately, the risk from midge-borne diseases such as bluetongue, African horse sickness and epizootic haemorrhagic disease will increase with climate change and globalisation.

Interactive Visualisation of Pathogen Genomic Epidemiology Data

Dr Adrian Allen, Dr Ryan Devaney, Dr Purnika Ranasinghe, Dr Robin Skuce, Dr Tom Ford, Dr Tara Ardis.

Summary

AFBI uses genomic data for disease source tracing for multiple pathogens. Visualising this data for veterinarians and public health professionals can however be challenging, but there are solutions.

Background

AFBI Stormont's Epidemiology, Molecular Biology and Immunology cluster have produced an interactive web application that trace sources of infection by comparing data from a chosen sample to archived genomic data. It is initially being used for bovine tuberculosis (bTB). We call it i-MAGE: interactive MycobActerium bovis Genome Epidemiology. It is written in the R programming language using the package 'Shiny'.

AFBI Science

At log in, users are met by the front-end page (Figure 1A). The first interactive page is the 'Map' tab (Figure 1B). Here, the user selects the sample name from a drop-down menu. The map then displays the locations of other closely related *M. bovis* outbreaks. The relatedness of the outbreaks is defined by how genetically related the bacteria that cause the disease are at different locations. The default setting is to present cases which are within 25 genetic mutations or fewer of the chosen sample. The user can then set a mutation distance threshold using a sliding scale to find more closely related samples which could be the infection source.

Generally speaking, the smaller the number of mutations difference, the more closely related the outbreaks are – fewer than 5 mutations is typically seen to suggest outbreaks could be linked by recent transmission. The phylogenetic context of the sample chosen, and its closest relatives can then be displayed in the 'Phylogeny' tab (Figure 1C).

Impact of AFBI Science

iMAGE is helping us to demonstrate the benefits of AFBI's genome epidemiology work by providing downstream users with an easy-to-use platform that informs disease control decisions. While it is currently being used for bTB, the underlying architecture is easily adaptable for use with any pathogen for which genomic and location data are available.

The study was co-funded by DAERA

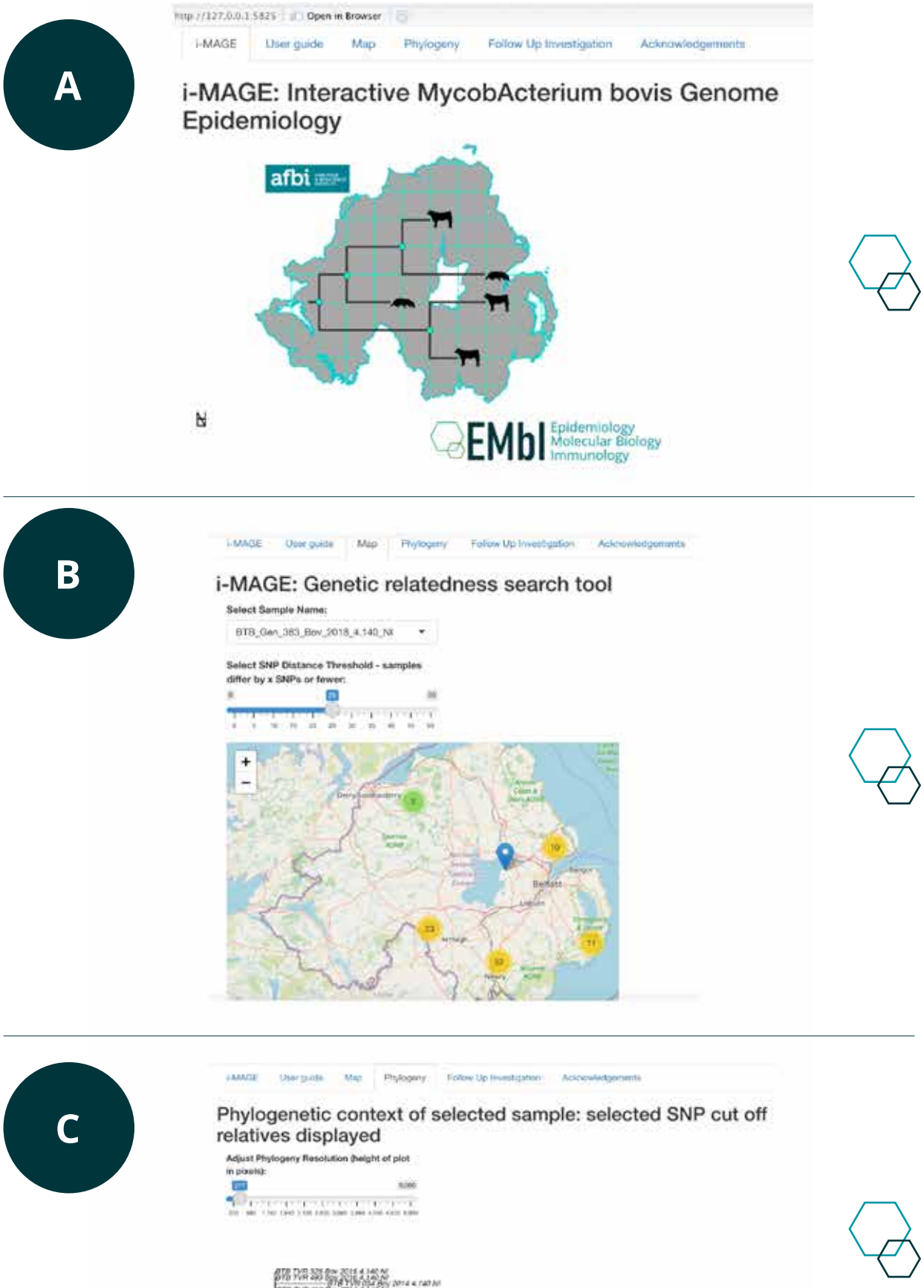


*Figure 1: i-MAGE: **i**nteractive **M**ycob**A**cterium bovis **G**enome **E**pidemiology*

Whole-Genome Sequencing for routine *Mycobacterium bovis* epidemiology.

Dr Adrian Allen, Dr Robin Skuce, Dr Ryan Devaney and Dr Purnika Ranasinghe

Summary

Using the genetics of pathogens to trace epidemics came of age with the SARS-CoV-2 pandemic. AFBI now uses whole genome sequencing (WGS) to investigate bovine tuberculosis (bTB) epidemiology.

Background

Genetically fingerprinting bacteria like the one that causes bTB (*Mycobacterium bovis*) using a small number of variable genomic sites is something AFBI has a long-standing pedigree in, and has informed much of what we know about this multi-host system. Such data are useful for epidemiology but lack the resolution to inform finer scale epidemiological inferences. In contrast, WGS permits reading of the entire genome of M. bovis - a huge increase in resolution.

AFBI Science

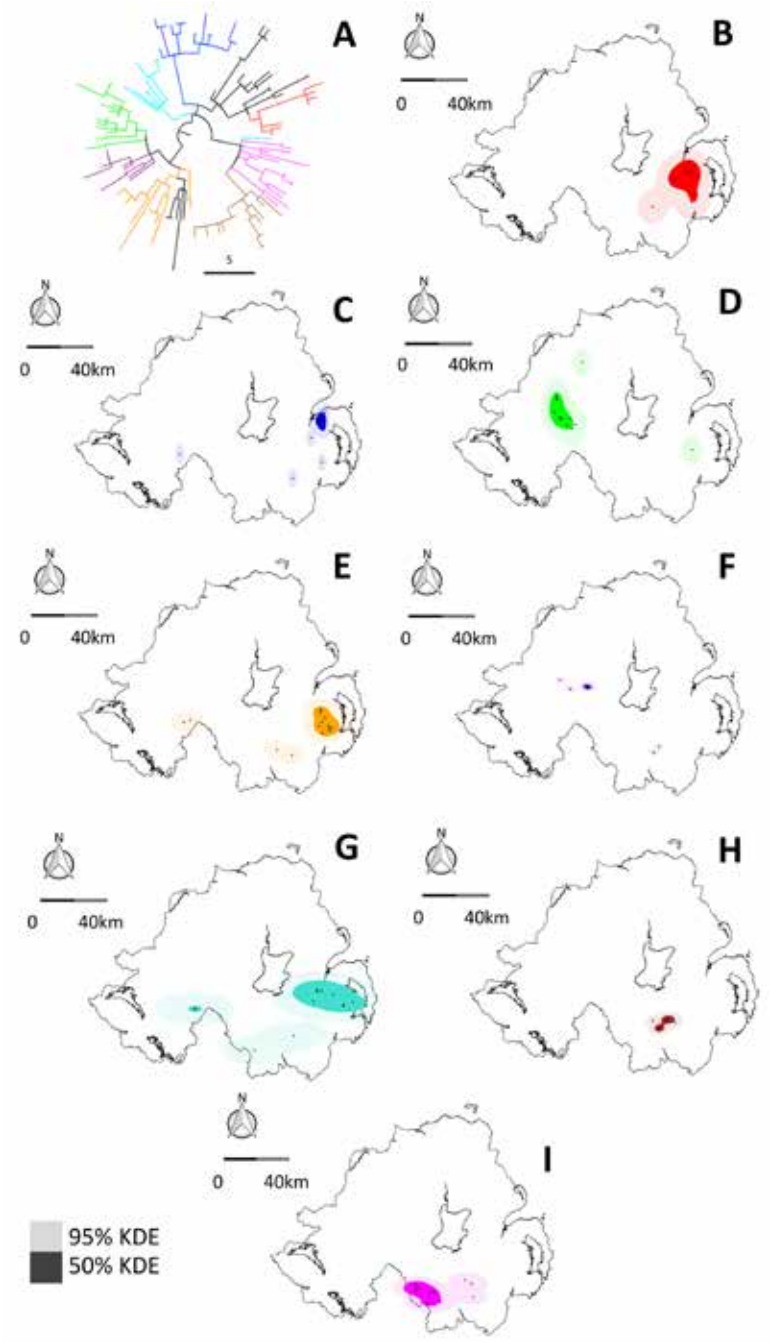
We have applied WGS to *M. bovis* isolates from cattle and badgers to ascertain which transmission routes predominate in this epidemiological system. The latter has been useful, but there are more everyday uses of WGS data for veterinarians on the ground. *M. bovis* clusters in the landscape such that specific branches of the bug's family tree are associated with specific locations (Figure 1). Higher resolution WGS data makes these core ranges more accurate, which aids epidemiological precision. Genomic data also permit monitoring of epidemic dynamics, control measures and the success of interventions by enabling us to follow fluxes in bacterial population sizes and reproduction number (R_e) (Figure 2), a measure that became very important in the COVID pandemic.

Impact of AFBI Science

With the application of pathogen genomic methodologies, AFBI are producing insights that are helping to shape disease intervention / eradication policies, ultimately aiding DAERA and DAFM to eradicate bTB.

As we modernise how we do microbiology in AFBI, by making greater use of genomics, we will continue to reap the rewards of these higher resolution analyses across multiple pathogens. They will not only tell us something about their epidemiology, but also tell us about their evolutionary histories and phenotypes. The latter will give us greater insight into the mechanisms underpinning antimicrobial resistance, pathogenesis and virulence and should lead to better vaccines and diagnostics.

The study was co-funded by DAERA and DAFM



Left: Figure 1 –

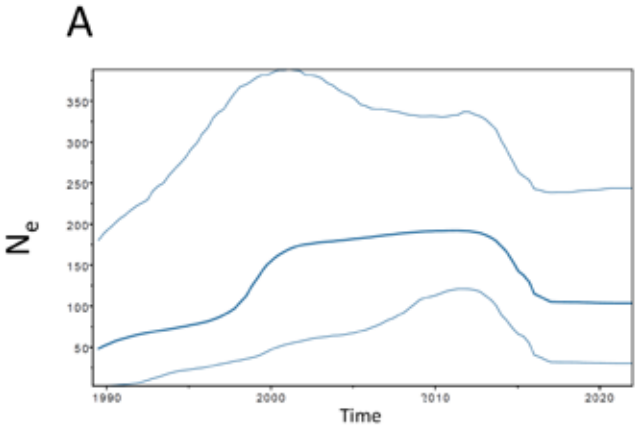
A – Phylogenetic tree of the common 1.140 M. bovis lineage colour coded into sub-branches of closely related bacteria.

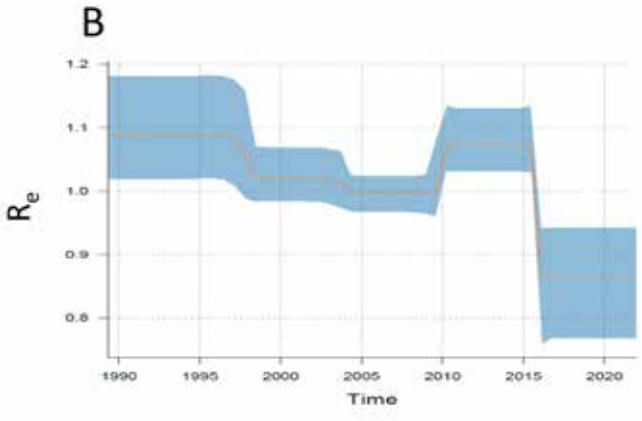
B to I – colour coded maps of where these specific sub-branches can be found in the Northern Ireland landscape.

Below; Figure 2 –

A – Skyline plot of fluctuations in effective population size (Ne) of the common M. bovis 1.140 lineage through time.

B – Birth Death Skyline plot of fluctuations in reproduction number (R_e) of the common M. bovis 1.140 lineage through time.





Supporting the risk assessment of emerging marine biotoxins in UK shellfish

Dermot Faulkner, Hugh McEneny

Summary

AFBI are the designated UK National Reference Laboratory (NRL) for marine biotoxins. AFBI scientists have developed methods to monitor for emerging marine biotoxins in shellfish. The work is supporting the UK competent authorities and official laboratory network through assessment of analytical methods and in gathering surveillance data on emerging biotoxins to inform risk management.

Background

Consumption of shellfish contaminated with biotoxins can lead to food poisoning and longer term health impacts. European Union (EU) regulations set maximum levels (MLs) for biotoxins in shellfish placed on the market and official methods for regulated biotoxins.

Pinnatoxins are an emerging toxin group of interest unregulated in the UK or EU. To date, no information has been reported linking these toxins to poisoning events in humans and there are no approved official methods. European Food Safety Association (EFSA) were unable to recommend MLs in a 2010 review, recommending further research.

The French health agency (ANSES) subsequently carried out a risk assessment in 2019, proposing a limit in shellfish of 23 µg/kg for Pinnatoxin-G (PnTX-G).

AFBI Science

PnTX-G is the predominant toxin analogue reported in shellfish and may be used to monitor for the presence or absence of related Pinnatoxins.

AFBI has developed an LC-MS/MS method for testing shellfish for both regulated lipophilic toxins and PnTX-G. Data has been collated in shellfish from 2018 as part of an NRL project approved by FSA. The work supports the development of analytical methods for the detection of this toxin class in the absence of approved methods and confirms, for the first time, the presence of low levels of PnTX-G in NI shellfish.

Impact of AFBI Science

AFBI scientists have demonstrated the potential for including an emerging biotoxin class within future UK monitoring programmes, which may become more prevalent due to climate change and rising sea temperatures around the UK.

The data generated to date and future horizon scanning efforts will help better inform UK risk assessment and policy development. FSA requested data from AFBI in 2023 that will be presented to the Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (COT), an independent scientific committee providing advice to the Food Standards Agency on matters concerning the toxicity of chemicals.

Further information: Risk of emerging marine biotoxins in British shellfish – Pinnatoxin | Committee on Toxicity (food.gov.uk)

The study was co-funded by Food standards agency (FSA)

Natural Antimicrobials Promote the Anti-Oxidative Inhibition of COX-2 Mediated Inflammatory Response in Primary Oral Cells Infected with *Staphylococcus aureus*, *Streptococcus pyogenes* and *Enterococcus faecalis*

Prof Nicolae Corcionivoschi

Summary

Staphylococcus aureus, Streptococcus pyogenes and *Enterococcus faecalis* can colonize the tooth root canals, adhere to dentin walls, and frequently cause periodontitis in dogs. Bacterial periodontal diseases are common in domesticated pets, causing severe oral cavity inflammation and a strong immune response. The results presented in this study describe the impact of a natural antimicrobials mixture (organic acids) on the oxidative control of a pro-inflammatory response in *S. aureus, S. pyogenes* and *E. faecalis* infected primary oral epithelial cells (D6234). As shown in Figure 1, the antimicrobial mixture has a triple effect during infection. First by attenuating some of the bacterial virulence factors (motility, EPS, biofilm) and weakening of bacterial membranes. Secondly, the antimicrobial mixture can reduce the pathogen ability to adhere to D6234 cells and increase epithelial tight junctions without any impact on cell viability. Thirdly, the antimicrobials were able to reduce the inflammatory effect and the oxidative stress in infected cells and inhibit the oxidative pathways involved in controlling a pro-inflammatory response. The antioxidative effect is achieved by inhibiting the externally regulated kinases (ERKs) which play an important role in cell survival during oxidative stress and are involved controlling the immune response through oxidative dephosphorylation. As future potential, we predict (as shown in Figure 1) that, *in vivo*, the antimicrobial will be able to reduce gum inflammation and oxidative stress caused by plaque resident bacterial pathogens such as *S. aureus, S. pyogenes* and *E. faecalis*, and significantly prevent plaque formation.

Background

In order to reduce the usage of antibiotics and to mitigate the risks of infections caused by *S. aureus, S. pyogenes* and *E. faecalis,* research should identify novel solutions, including new antimicrobial agents, develop alternative therapeutic strategies to antibiotics, promote effective oral hygiene practices and enhance our understanding of the complex interplay between the host and microbial factors.

AFBI Science

The aim of our study was to reveal further details of the biological mechanisms and establish the benchmark for their mode of action against pathogenic bacteria of plaque origin. In our *in vitro* studies, we use primary oral epithelial cells to establish their antagonistic effect against *S. aureus, S. pyogenes* and *E. faecalis*, pathogens frequently isolated from dental plaque. The approach taken, using antimicrobials in a mixture

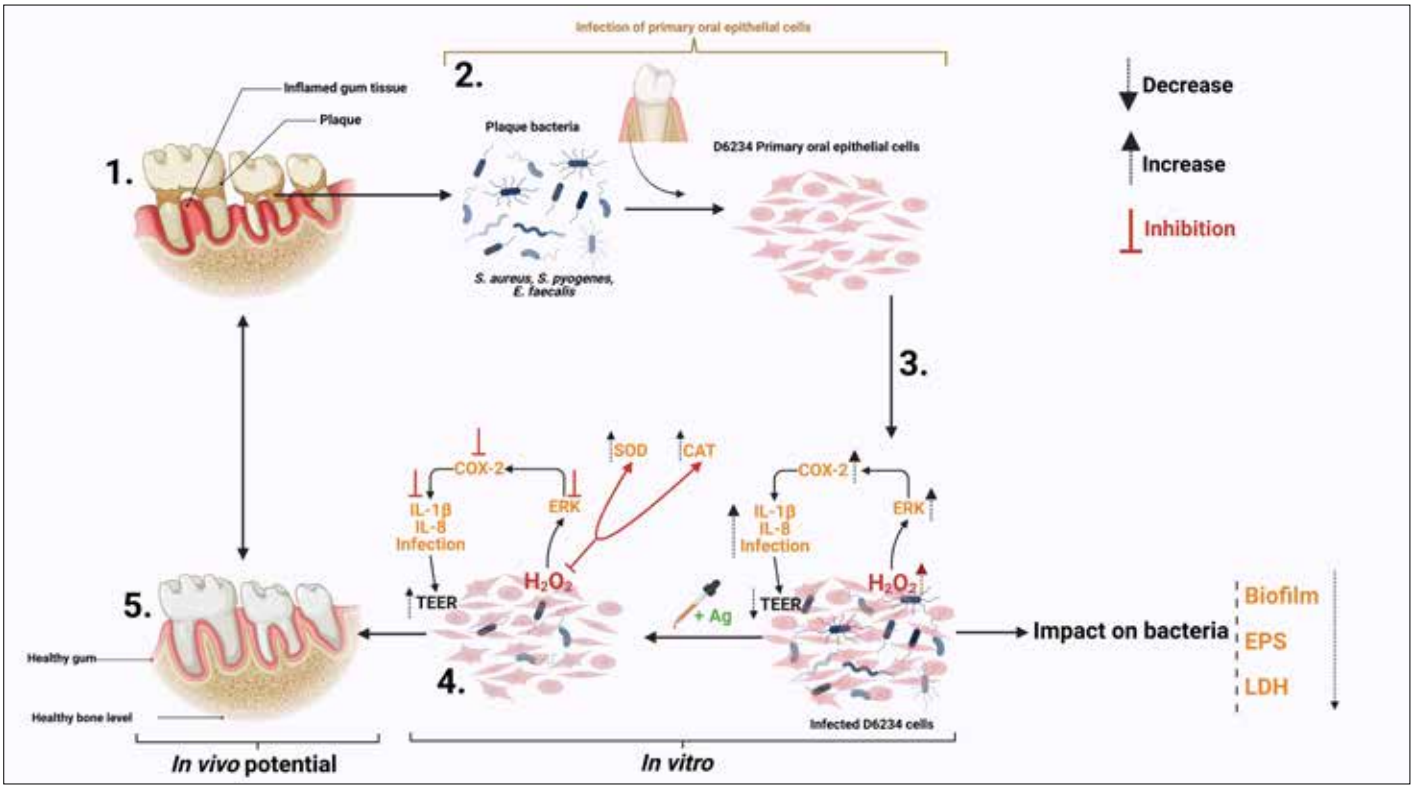


Figure 1. Summary of the impact Auraguard on S. aureus, S. pyogenes and E. faecalis in an in vitro oral primary epithelial cell infection model. 1). The appearance of dental plaque and inflamed gum tissue; 2). Isolated plaque bacteria (S. aureus, S. pyogenes and E. faecalis) and isolated D6234 primary oral epithelial cells from healthy gum tissue; 3). Infection of D6234 cells with S. aureus, S. pyogenes and E. faecalis in the presence of 0.125% Ag and the subsequent metabolic effects; 4). Lower infection rates following infection; 5). Expected in vivo intervention results.

(Auraguard), proved to be very efficient as they seem to have increased efficiency when used in combinations. This blended approach was proven to be efficient against bacteria, parasites and viruses both *in vitro* and *in vivo*, clearly showing their efficiency in improving gut health in a variety of hosts.

Impact of AFBI Science

Understanding the biological mechanism by which natural antimicrobials reduce bacterial infections and reduce epithelial inflammation is essential to establish best practices for end users and ensure that their specific anti-bacterial effect can be consistently utilized. Natural antimicrobial formulations enriched with organic acids and plant extracts are currently promising candidates for successful pathogen control at the farm level. They can be utilized as novel feed additives in the animal diet to fortify the animal immune system, can benefit intestinal health and/or promote weight gain. Commercially available natural antimicrobials were able to significantly reduce the virulence of pathogenic microorganisms in poultry, shrimp and in *in vitro* assays. The successful identification and progression of natural antimicrobials involves a plethora of interdisciplinary approaches, technological updates comprising innovative research trends, in order to promote natural antimicrobials in the future as an impactful novel level drug. Furthermore, the application of biotechnology, molecular biology, pharmacognosy, ethnopharmacology and genetics in a whole integrated ensemble may play a valuable role as a key-tool in novel natural antimicrobial and drug discovery.

The study was co-funded by Environtech Ireland

Protecting Fish and Shellfish health in Northern Ireland

Paul Savage, Prof Louise Cosby

Summary

Northern Ireland (NI) has a high fish health status due to natural factors such as its island location, temperate climate and low number of native species. NI also has a history of strict controls on imports and enforcement of fish health legislative controls designed to prevent the introduction and spread of disease. AFBI Fish Diseases Unit (FDU) support DAERA Fish Health Inspectorate (FHI) in relation to sampling and diagnostic testing of fish, shellfish, and crustaceans for listed and emerging diseases. AFBI FDU also provides scientific advice and support to DAERA's Aquaculture and Fish Health Policy Branch (AFHP) and the FHI in relation to contingency planning and representation on policy groups and attendance at meetings.

Background

In 2022, the aquaculture sector in Northern Ireland produced approximately 3,490 tonnes of shellfish valued around £6.8 million and over 1199 tonnes of finfish valued around £7.1 million. The main shellfish species cultivated are Mussels and Pacific Oysters and the main finfish species cultivated are Atlantic Salmon, Rainbow Trout and Brown Trout. At present there are 78 licensed fish farms. Forty-six of these, (covering 54 sites) are licensed for the cultivation of shellfish (45 marine and 1 land-based) and 32 for the cultivation of finfish (30 inland and 2 marine).

AFBI Science

The Fish Diseases Unit (FDU), based at Veterinary Sciences Division (VSD) at AFBI Stormont, carries out a comprehensive range of accredited tests to assist in the diagnosis and surveillance of fish, molluscan, and crustacean diseases and provides information on the health status of farmed and wild populations. Specialist advice on animal diseases is given to the aquaculture industry and veterinary profession. AFBI ensure that their services are conducted in compliance with relevant legislation and in accordance with appropriately recognised scientific

standards, including the Official Controls Regulation (OCR), the Animal Health Law (AHL), and associated tertiary legislation, in particular Commission Delegated Regulation (EU) 2020/689 regarding requirements for surveillance and diagnostic methods; and the valid and up-to-date World Organisation for Animal Health (WOAH) Manual of Diagnostic Tests for Aquatic Animals (Aquatic Manual). These tests include Virology/virus isolation, IFAT, Serology, Conventional and real time PCR, Phylogenetic analysis, Sequence and genome analysis, Bacteriology, Parasitology, Histopathology, Electron Microscopy, Haematology and clinical Biochemistry. A high throughput of diagnostic work from the UK and Ireland allows the FDU to conduct passive surveillance for outbreaks of notifiable, new or emerging diseases, changes in patterns of endemic diseases and conditions appropriate for further research. The laboratories are the sole provider of this service in Northern Ireland.

Last year AFBI tested 600 farmed finfish from 12 fish farms and 240 wild finfish from 8 rivers. No significant viral, bacterial or parasital pathogens were identified. In the past Salmonid alphavirus (SAV), the cause of salmon pancreas disease has been isolated, as well as Infectious pancreatic necrosis virus (IPNV). Both of these viruses are not notifiable pathogens and vaccines against both are commercially available.

Last year AFBI tested 120 Pacific oysters (Magallana gigas) from mortality events. In all cases the cause of the mortalities was attributed to the bacterium *Vibrio aestuarianus*. This was detected by real time PCR (qPCR) and Histopathology. There is evidence that *Vibrio aestuarianus* is increasingly becoming the main pathogen of concern for the Pacific oyster industry on the island of Ireland.

Impact of AFBI Science

AFBI provides advice and a rapid diagnostic service for the diagnosis, surveillance and screening of fish, shellfish and crustacean diseases and pathogens, as well as emergency response capabilities for any mortality events or suspected disease outbreaks. By helping to maintain the high fish health status of the aquaculture industry in Northern Ireland, we improve the producer's ability to trade openly outside the UK, reduce their losses from disease and help protect this valuable natural resource.

The study was co-funded by DAERA, Marine and Fisheries Division

Enhancing the natural and marine environment

Lough Neagh 2023– Environmental Tipping Points.

Dr Yvonne McElarney, Dr Adam Mellor, Dr Kevin Gallagher, Adele Boyd, Dr Matt Service, Dr Harry Teagle, Dr Rachel Cassidy, Dr Russell Adams, Dr Ewan Hunter

Summary

Following weeks of warm, settled weather in the summer of 2023, dense buoyant mats of toxic cyanobacteria appeared across Lough Neagh. Driven by the wind, the mats drifted and collected in bays, marinas and on shorelines, in quantities causing concern for human and animal health, and which restricted economic and recreational activities. Further downstream towards the coast, businesses shut, bathing waters were closed, and coastal communities felt the impact of what was initially perceived as a freshwater problem. The Department of Agriculture, Environment and Rural Affairs (DAERA) and local councils issued warnings to protect the public from the potential risk of exposure to bloom generated toxins, whilst Northern Ireland Water (NIW) offered assurances about drinking water safety. Ecological concerns about both the cause and effect of the blooms were headline news, and complaints about the odour, skin irritation and other health related symptoms united public opinion in the need for action.

Background

With a surface area of over 383 km^2, Lough Neagh is the largest lake in the UK and Ireland, representing a massive natural resource.

The Lough has huge ecological significance with numerous conservation designations, and drains a large rural catchment dominated by agriculture. With a rich environmental and cultural heritage, Lough Neagh supports

significant commercial fisheries, has historically been an important location for overwintering wildfowl, and provides drinking water to over 40% of the Northern Irish population.

The effects of nutrient enrichment are not new to Lough Neagh, and a long history of scientific study is available to explain the Lough's current problems and identify potential solutions. Lough Neagh's waters and sediments contain highly elevated levels of phosphates and nitrates fed by rich nutrient inputs from the surrounding river catchments; including agriculturalland, industrial and to a lesser degree,from wastewater sources. The lake's shallow depth and predominantly windy conditions ensure that the water is well mixed and despite high organic inputs, low dissolved oxygen concentrations have historically been rare.

High nutrient levels in the Lough have nourished blooms of cyanobacteria, documented from the late 1960's onwards. The recently observed bloom was caused by a species called Microcystis aeruginosa, which was first recorded here in 1900, but has rarely been detected over the last 70 years. Concerns about water quality and Lough Neagh's ecology have been raised before the current media storm, but nutrient management measures in the Neagh-Bann catchment have not succeeded in reducing nutrient concentrations, and both AFBI and the Northern Ireland Environment Agency (NIEA) have identified recent increases of nutrients entering the Lough.

AFBI Science

AFBI research and monitoring activity in and around Lough Neagh forms part of the UK's Long Term Ecological Research network (LTER), and our scientists have also been studying the nutrient biogeochemistry, fisheries, lake ecology, and the land-use and catchment processes affecting Lough nutrients.

A number of pressures have been identified that will have contributed towards fuelling the recent algal blooms, and their influences on broader ecosystem health are a cause for genuine concern. Alongside the pervasive nutrient enrichment, AFBI have highlighted a dramatic rise in water temperatures since monitoring commenced over 50 years ago (Figure 1). This has been accompanied in recent years by increases in water clarity, a reduction in plankton, and the spread of the invasive zebra mussel across the Lough which may have played a role in triggering the *Microcystis* bloom in 2023.

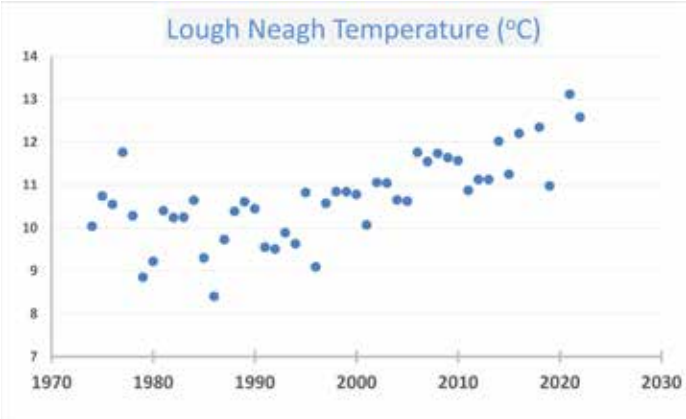


Figure 1. Lough Neagh annual mean temperatures (°C)

Figure 2. Cyanobacteria scum on Lough Neagh

Amongst the key ecosystem health and water quality pressures AFBI has identified are:

- Nutrient Concentrations.
- Invasive Species.
- Climate Change
- Fauna
- Flora (Phytoplankton)
- Fish Populations
- Contaminants

- **Nutrient Concentrations.**
  Agriculture, as the largest land use in the Neagh-Bann catchment, is currently estimated to contribute significantly towards the Lough's total nutrient loads, with the remainder coming mainly from the wastewater generated by a population of over 450,000 people and industrial activities in the catchment. Nutrient concentrations have increased in recent years, and phosphorus is currently present at over four times the ideal background level for the Lough. This is due to both the high concentrations in rivers feeding the Lough, and recycling from the phosphorus-enriched sediments.

- **Invasive Species.**
  The introduction of roach, and the more recent introduction and expansion of zebra mussel populations are changing the Lough's ecological balance. These relatively new inhabitants have the potential to dramatically affect both phytoplankton and zooplankton populations. Zebra mussels may be producing clearer water by filtering it, which could be helping the establishment of invasive aquatic plants including the pondweed *Elodea*. Also knocking on the doorstep of the catchment are further invasive species including the quagga mussel, the Asian clam and the bloody red shrimp.

Anodonta encrusted with invasive Zebra Mussel

- **Climate Change.**
  Water temperature is increasing by nearly 0.5 °C per decade. This rate has accelerated since the 1990s, and predicted future rises will increase thermal stresses experienced by lake creatures and create additional indirect pressures. For example, increased temperature speeds up phosphorus release from the nutrient enriched sediments of the Lough bed. Higher temperatures also reduce the amount of oxygen the water can hold, and the significant oxygen depletions seen in the summers of 2018 and 2021 could become more common as our climate changes.

- **Flora (Phytoplankton).**
  There was 78% less chlorophyll (a pigment used to monitor phytoplankton abundance) in 2022 than in 2019, and water clarity has simultaneously increased from 0.8m to 3m visibility. This change may be a consequence not only of the changing plankton community, but is also being linked to plankton consumption by the invasive zebra mussel. Recent changes in the plankton community represent a transition from species that favour murky water, to *Microcystis*, which thrives in clearer water.

- **Fauna**.
  Mysid shrimps, once a common component of the Lough's zooplankton, need cold water to survive. These creatures are now found only rarely in fish stomachs, and recent targeted surveys show these shrimps to have all but disappeared. Similarly, the Lough Neagh Fly and its larval stages are now largely absent; these chironomid species often indicate poor water quality but are a keystone ecological species and their demise brings uncertainty to how the Lough's food webs are changing.

- **Fish Populations.**
  AFBI surveys reveal a general reduction in fish stocks including brown trout, bream, perch and roach. Most worryingly, gaps in the endemic Pollan population are appearing. Whilst spawning is occurring, survival of juvenile Pollan (and some other fish) is below that required to maintain healthy populations, so further changes in the Lough's fish communities are anticipated. By contrast, the percentage contribution of perch (a visual predator) to the fish community, may be increasing. Concerns over the future of the local eel population are legitimate, however the drivers of population decline in migratory species such as eels include wider pressures outside the immediate freshwater habitat..

Mysid Shrimp

- **Contaminants.**
  Lough Neagh was highlighted in a recent edition of Nature as being amongst the most microplastic contaminated freshwater systems in the world. The ecological significance of this has yet to be fully understood, but the pressures from agro-chemicals and domestic contaminants are unlikely to diminish and are a focus of current research.

Impact of AFBI Science

The ecological pressures facing Lough Neagh are neither new, nor uncommon, with cyanobacterial lake blooms a growing international problem and a focus of considerable scientific and management activity. AFBI science has provided the environmental evidence-base for Lough Neagh, informing the DAERA response to this last year's blooms, and ongoing and future AFBI science will inform the options to commence restoration.

The cumulative impact of nutrients from multiple sources has been felt beyond the Lough as far away as the north coast. Understanding the Lough at a landscape and full catchment scale is therefore imperative, and the application of the catchment-to-coast approach applied by Fisheries and Aquatic Ecosystems Branch will be important.

Recent research from the Agri-Environment Branch further indicates that the supply of nutrients to the Lough is being underestimated, so enhancing observation programmes to understanding the timing and loads of nutrients to the Lough is essential. and iIntegrating the available data with catchment and ecosystem models will help to evaluate effective solutions.

The AFBI-led Northern Ireland wide Soil Nutrient Health Scheme (SNHS), which is currently in its second year,is quantifying the surplus nutrients in the soils field by field.By identifying where excess nutrients are entering the aquatic environment from agriculture, modelling can advise the design of mitigation and management strategies. AFBI have been leading the way on modelling nutrient dynamics at large catchment scales, using an aquatic ecosystem modelling framework that integrates both land-use and wastewater infrastructure. At smaller scales, process-based modelling is used to understand the pathways and conditions under which nutrients are lost to the aquatic system.

To identify nutrient sources, and to better understand how the ecosystem will respond, modelling of the Neagh-Bann catchment needs to predict the potential ecological outcomes of interventions. The predicted outcomes of potential mitigation actions that may be required from agriculture and wastewater will provide a degree of assurance, before measures are implemented.

Acknowledging the economic and welfare necessity for fixing this is essential, as other catchments are under similar pressures. Understanding and, communicating and the timeframe for recovery will be important.

The most recent research suggests that recovery will take between 20 and 40 years, even with significant reductions in nutrients entering the Lough. The practical solutions required to improve Lough Neagh and the health of its inflowing catchments exist, but the process will not be simple, easy or quick, as we balance economic and societal considerations.

The ecological recovery following nutrient mitigation will also take some time, and the Lough will have a new ecological baseline driven by the factors we cannot control locally, with invasive species and warming temperatures all having an influence.

Ultimately, the ambition and expectations around Lough Neagh's remediation require good science, with clear, sensitive and compelling communication. Societal commitment to an effective remediation programme requires transparent target setting and progress monitoring that can clearly demonstrate progress in the restoration of Lough Neagh to a clean, productive and biodiverse state.

The study was co-funded by DAERA

AFBI shine a light on eel migration

Dr Derek Evans


Figure 1


Figure 2a


Figure 2b

Summary

A chance discovery by AFBI scientists that juvenile European 'glass' eels fluoresce under Ultraviolet (UV) light illumination has important implications for surveying this critically endangered species. This work was based on an original idea developed by Andrew Moore.

Background

Glass eel surveys are a nocturnal activity, occurring in remote coastal/estuarine areas during spring tides, and associated with lunar darks. The current Europe-wide collapse in eel stock (of 94%), resulting in low levels of glass eels, has meant that surveys are often focused on simple presence/absence observations using strong beam torches to illuminate the occasional inward glass eel migration along the banks of estuaries and rivers. Observations are then confirmed and enumerated by AFBI staff using drag nets to capture the glass eel (Figure 1).

AFBI Science

To enhance glass eel detection, AFBI scientists have developed a variety of netting and illumination techniques, which have culminated in the potential use of UV light as an additional survey tool. Under UV illumination, glass eel fluoresced bright yellow, making them very obvious in surrounding waters and immediately identifiable as a live eel as opposed to torch illuminated debris in the surface waters (Figures 2a & 2b). In contrast, follow up experiments using the UV light source on preceding eel life stages such as pigmented glass eels (elvers), "bootlace eels" (juvenile yellow eels), older yellow eels and migrating silver eels found that the older eel stages had lost this capacity to fluoresce.

Impact of AFBI Science

This is the first time that UV fluorescence of European glass eels has been recorded. However, our literature review uncovered that their propensity to fluoresce, revealed through genome sequencing, has been known for some time. What started here as a curiosity-driven proof-of-concept study to demonstrate the capacity of glass eels for fluorescence under UV light has revealed the potential for a readily applicable field survey tool. Through their propensity to fluoresce, UV illumination offers of easier identification of wild glass eel in dark background water. This therefore offers many advantages for non-destructive survey. In follow-up fieldwork trials AFBI staff were able to identify the presence of glass eel in dark tunnels which would otherwise have gone unnoticed.

The study was co-funded by DAERA

Achieving net zero: exploring the contribution of new woodlands

Dr Diane Burgess, Dr Marios Zachariou

Summary

AFBI has developed a model to determine how land can be used to deliver the greatest benefits to society. This model was used to demonstrate how creating new woodlands can contribute to achieving net-zero by 2050.

Background

A current challenge facing policy makers is how to use our land to achieve net zero. Planting new woodland provides an opportunity to reduce greenhouse gases and sequester carbon. However, as this will reduce agricultural production, this must be balanced against the benefits to the economy and society.

AFBI Science

AFBI has developed a Land-Use Model for Northern Ireland (LUMNI) to identify the best use of land by comparing the benefits from alternative land-uses. The impact of different levels of woodland planting were explored.

The model included benefits from:

1. **Agriculture:** production of meat and milk and associated outputs of greenhouse gas (GHGs).
2. **Woodlands:** timber sales and carbon sequestered.

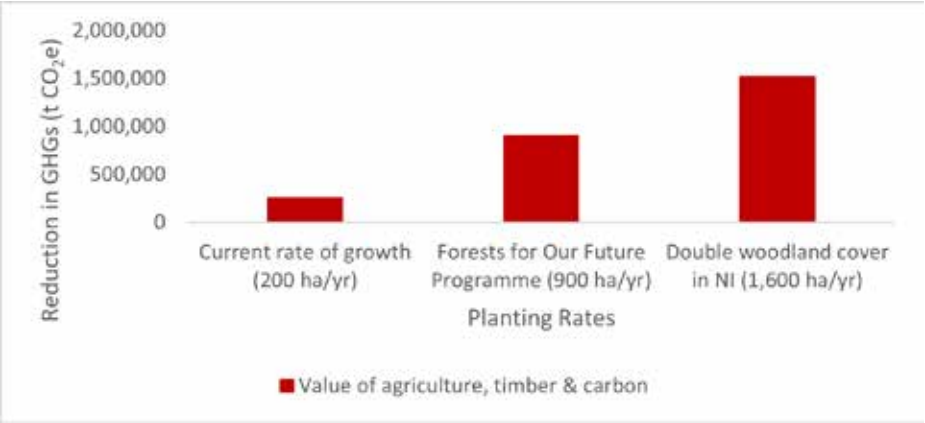


Figure 1. 2050: Avoided GHGs (t CO_2e)

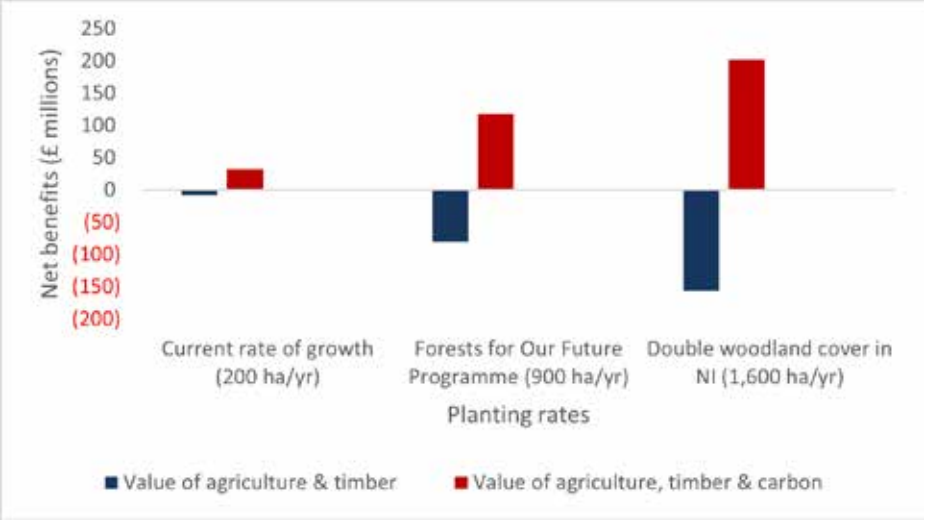


Figure 2. Net benefits from woodland planting

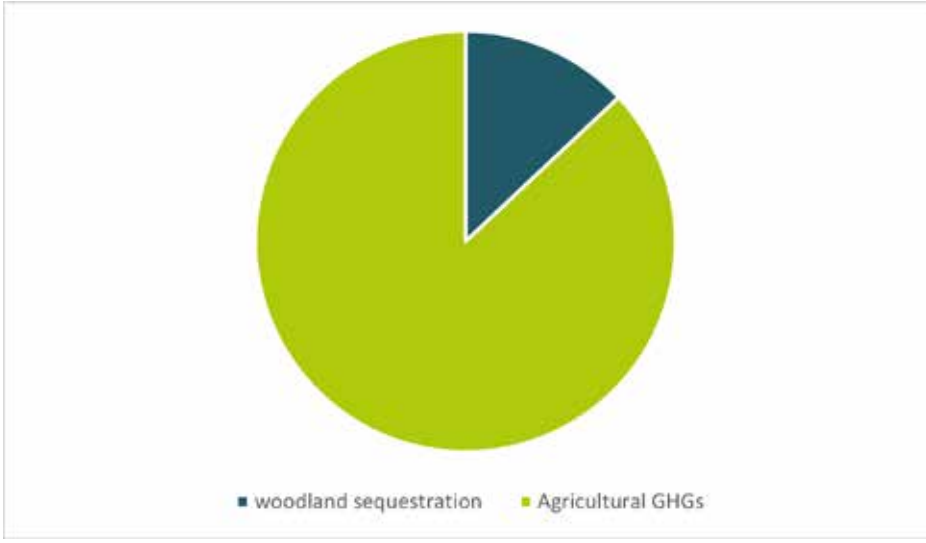


Figure 3. Sources of GHG reductions

Impact of AFBI Science

The model showed:

1) Current planting rates will reduce GHGs by 0.12 million tonnes of CO_2e in 2050. If 1,600 ha of woodlands are planted each year, GHGs will be reduced by 1.5 million tonnes, which represents 26% of agricultural sector emissions in 2019 (Figure 1).

2) The benefits from timber do not compensate for the losses from agricultural production (Figure 2). To enhance planting rates, landowners may also need to be rewarded for reducing GHGs.

3) Only 13-27% of the GHGs reduction results from carbon sequestration of the new woodlands (Figure 3). Therefore based on the values in this study, payments from agri-environment schemes and/or carbon trading based on carbon sequestration are unlikely to result in the enhanced planting rates that will reduce GHGs by 1.5 million tonnes of CO_2e.

The study was co-funded by DAERA

Reducing MCPA herbicide pollution at catchment scale using an agri-environmental scheme

Rachel Cassidy, Phil Jordan, Luke Farrow, Stewart Floyd, Colin McRoberts, Phoebe Morton, Donnacha Doody

Summary

Measures introduced through an agri-environmental scheme were successful in reducing MCPA herbicide concentrations in a drinking water source catchment.

Background

Almost all drinking water in Northern Ireland is abstracted from surface water sources and must be treated to meet the required standards for public supply. This is a complex and expensive process, and particularly so where pesticides are involved.

In recent years, the acid herbicide 2-methyl-4-chlorophenoxyacetic acid (MCPA) has caused significant problems for water treatment due to its prevalence in rivers and lakes across the island of Ireland. This is associated with its extensive use in treating grasslands for weeds and rushes, and with its mobility through soil and water following application.

AFBI Science

As part of the Source to Tap INTERREG project (www.sourcetotap.eu), an agri-environmental scheme (AES) was introduced in the Derg catchment (384 km^2) to potentially reduce the burden of pesticides in the water treatment process. The main measure offered was contractor application of glyphosate by weed wiping as a substitute for boom spraying of MCPA, supported by educational and advisory activities. The experimental design involved a full before-after-control-impact comparison over four peak MCPA application seasons (April to October 2018 to 2021) where a neighbouring catchment, well matched in terms of scale (386 km^2) and land use, did not have an AES. Change was assessed by a high-resolution water quality monitoring approach where river discharge and MCPA concentrations were measured synchronously in each catchment. During peak application periods, the sample resolution was every 7 hours, and daily during quiescent winter periods. This sampling approach enabled flow- and time-weighted concentrations to be determined, and export loads calculated.

Impact of AFBI Science

Annual loads from the catchments were up to 0.242 kg km^{-2} yr^{-1}, and over an order of magnitude higher than previously reported in the literature. Despite this, and accounting for inter-annual and seasonal variations in river discharges, the AES catchment indicated a reduction in both flow- and time-weighted MCPA concentration of up to 21% and 24%, respectively, compared to the control catchment. No pollution swapping with glyphosate was detected. However, the percentage of MCPA occurrences above the drinking water threshold of 0.1 µg/L did not decline and so the need for water treatment was not reduced. Through DAERA funding, monitoring has continued since the scheme ended and assessments are ongoing to determine if the impact of the AES has continued in the two years since activities and engagement stopped.

The study was co-funded by INTERREG VA and DAERA E&I

The Living With Water Programme

Dr Adam Mellor, Dr Matt Service, Dr Jay Calvert, Dr Rebecca Kyle

Belfast Harbour (reproduced with permission from NI Water)

Summary

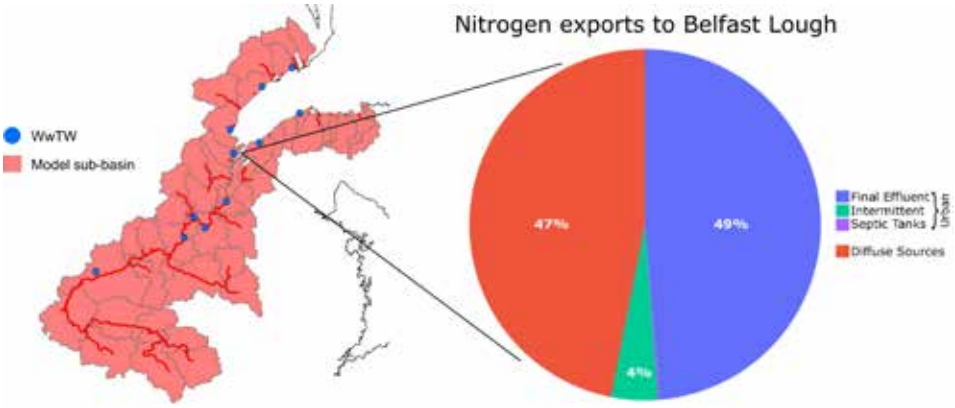
The Living With Water Programme (LWWP) is a multi-agency initiative headed by the Department of Infrastructure (DfI) to develop a Strategic Drainage Infrastructure Plan (SDIP) for Belfast to support economic growth, protect the environment and address flood risk. Northern Ireland Water (NIW) funded AFBI to develop the modelling to understand nutrient and bacterial behavior in the catchment using an innovative ecosystem modelling approach developed by AFBI.

Background

DAERA wanted to improve how wastewater consents were licensed to encourage better environmental outcomes. AFBI worked with NIW to incorporate wastewater inputs with land use and agricultural data to fully represent nutrient and bacteria loadings from both urban and rural sources in the River Lagan catchment.

AFBI Science

Following intensive water quality sampling, AFBI developed a suite of connected models using a framework called the System for Understanding Carrying Capacity, Ecological, and Social Sustainability (SUCCESS).



Living With Water Programme
Strategic Drainage Infrastructure Plan

The SUCCESS framework included:

1. A catchment model to replicate the transport and evolution of nutrients and bacteria.
2. A three-dimensional hydrodynamic model of Belfast Lough to capture physical processes.
3. An ecosystem model to integrate biogeochemical processes and ecosystem services provided by both aquaculture and wild species.

Impact of AFBI Science

Using AFBI's modelled outputs, NIW have secured DAERA approval for infrastructure investment plans worth over £400 million, provided demonstrable improvements to water quality in Belfast Lough, and saved over £100 million through optimizing investment strategies based on AFBI's modelling work.

The AFBI models were able to identify the key sources of nutrient and bacteria inputs from urban and diffuse sources. AFBI are now applying the models to investigate climate change impacts and shifts in land management practices, to understand how rainfall patterns and land-use affect water quality in Belfast and other catchments.

The study was co-funded by Northern Ireland Water

Managing ecological and genetic diversity in agroforestry systems across Europe.

Dr Rodrigo Olave, Mrs Emily Hall, Mr Greg Forbes, Mr John Kearns, Mr Salim Edris

Sheep grazing in genetically improved varieties of 14-year-old cherry (Prunus avium) trees, AFBI Loughgall

Summary

Increasingly in recent years, agroforestry as a multifunctional land use management system has gained attention as a regenerative farming practice that can potentially achieve a balance between the competing demands of food, fuel, fibre and timber production, whilst potentially increasing biodiversity, reducing agricultural pollution and improving carbon sequestration. However, it is uncertain how historical changes in land use and land management within these systems can affect wider ecological and genetic diversity, and therefore the potential impact on regulating processes such as soil nutrient cycling, carbon sequestration and ultimately ecosystem sustainability and resilience.

Background

AFBI has been investigating the potential of integrating agriculture and forestry on the same land base, using agroforestry systems since 1989. To date, there have been very few studies which have addressed the microbial community functions in different land use systems, especially comparing silvicultural systems with other land use types.

The AFBI site is part of two agroforestry network experiments across Europe

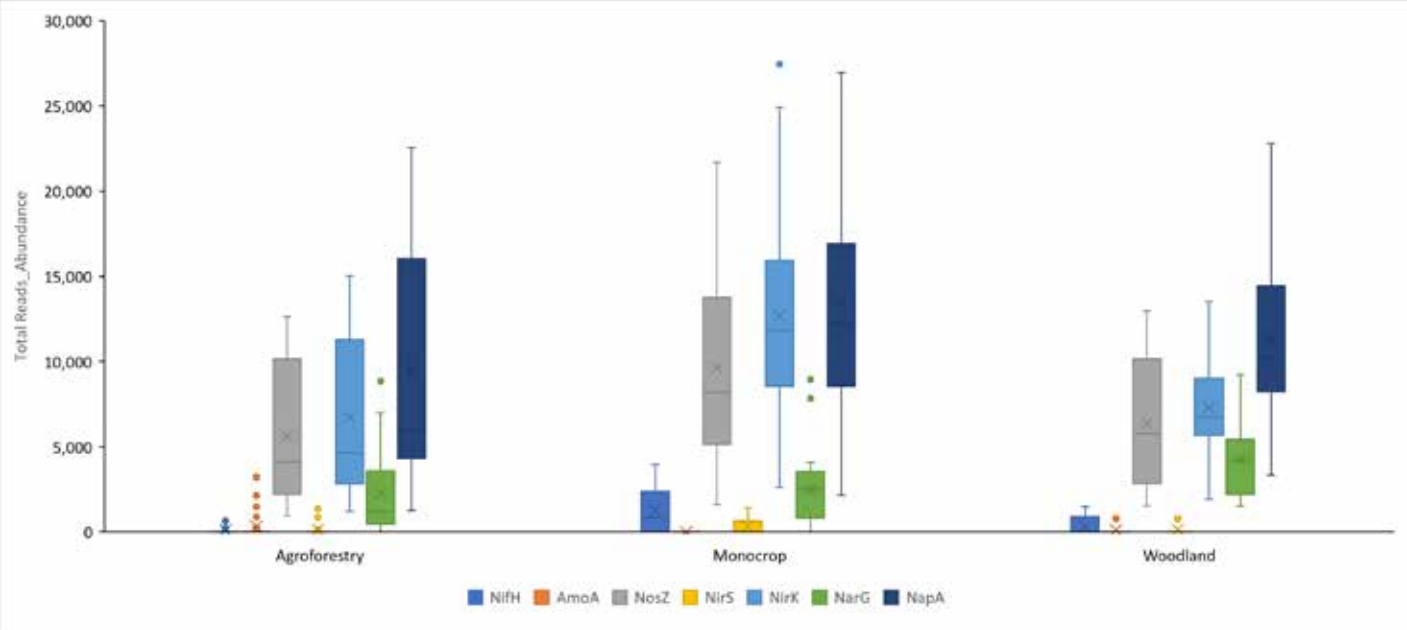


Figure 1. Enzyme functions associated with the nitrogen cycle in agroforestry, grassland and woodland

(AGROMIX and UNDERTREES) and is regularly visited by scientists, practitioners and policy makers from the UK, Ireland and further afield and is used by students from several Universities across the world. The Agroforestry research platform at AFBI also has genetic field experiments as a strategy resource to focus on the conservation and selection of broadleaved tree species for the UK and Ireland.

AFBI Science

AFBI are using genomic tools to characterize soils from long-term agroforestry sites that have experienced different management over time, and compare these systems to adjacent permanent grassland, cropland, or forested control sites to assess both variation in microbial taxa and potential functionality of microorganisms. The taxonomic and functional profiling as well as the composition and relative abundance in each site are quantified at the phylum level. To date, over 100 samples have been processed and 5500 unique species detected: 160 Archaea, 5259 Bacteria, 75 Eukaryota and 8 viruses. Of these, 3967 have a mean relative abundance of less than 1%. Proteobacteria and Actinobacteria can be considered dominant species with further relative abundance and functional grouping analysis ongoing for two other agroforestry sites in the UK.

Initial results show clear differences between the abundance of enzyme functions associated with the macronutrient cycle in agroforestry relative to grassland and forest plots (Figures 1 and 2).

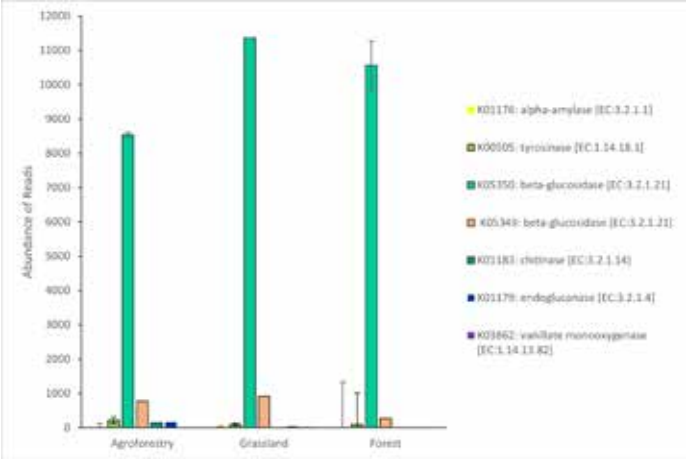


Figure 2. Enzyme functions associated with the carbon cycle in agroforestry, grassland and woodland

AFBI research highlights the ecological distinctness of each habitat, as some enzymes are found only in agroforestry and others only either in grassland or forest systems.

An environmental agroforestry experiment between outdoor pig production and 22-year-old oak (Quercus robur) trees grown by different nursery production methods, AFBI Loughgall

Ireland forests. All aspects of outputs from the system are monitored to also quantify GHG emissions to explore the effects of land use intensity on soil cycling, GHG emissions and carbon intensity and will feed directly in the UK GHG Inventory to refine our understanding of emissions from these systems and how they are affected by land use.

Impact of AFBI Science

The Agroforestry Research Platform at AFBI Loughgall contains some of the UK's oldest long-term agroforestry and tree improvement research trials and have been studied extensively to show that favourable returns from intensive integrated land-use systems are possible, whilst potentially increasing biodiversity, reducing agricultural pollution and increasing carbon sequestration.

Latest AFBI research is ongoing, using ecological and genetic tools to better manage diversity in agroforestry systems. This research is in the context of wider soil nutrient cycling (including nitrogen and carbon), and how this may be correlated with land management and future climate change, and also in safeguarding native and non-native tree species against future climate change by selecting material that is most adaptive and resilient.

The study was co-funded by EU, DAERA & DAFM

AGROMIX

THIS PROJECT HAS RECEIVED FUNDING FROM THE EUROPEAN UNON'S HORIZON 2020 RESEARCH AND INNOVATION PROGRAMME UNDER GRANT AGREEMENT No: 862993

UNDERTREES

THIS PROJECT HAS RECEIVED FUNDING FROM THE EUROPEAN UNON'S HORIZON 2020 RESEARCH AND INNOVATION PROGRAMME UNDER GRANT AGREEMENT No: 872384

FitForest (19/R/511)

Response of tree species to climate change

AdaptFores (21 R 302 (49720))

Adaptation, mitigation and protection strategies to increase resilience of Irish forests to address the impacts of climate change

AshForFuture (23 RP 1030 (72963))

Breeding *Fraxinus excelsior* (Common or European ash) for dieback disease tolerance to conserve and re-establish ash on the island of Ireland

Quantifying ammonia emissions from pig production

Dr Elizabeth Ball and Dr Christina Mulvenna

Summary

AFBI research has established an up-dated ammonia emission factor which will provide an accurate baseline from which to assess the effectiveness of ammonia mitigation strategies in finishing pigs. The ammonia emission value of 1.55kg/pig place/year and 16.9% TAN (total ammonia nitrogen) is over 40% lower than the current standard figures and reflects the lower dietary crude protein in modern finishing pig diets and the improved efficiency of production.

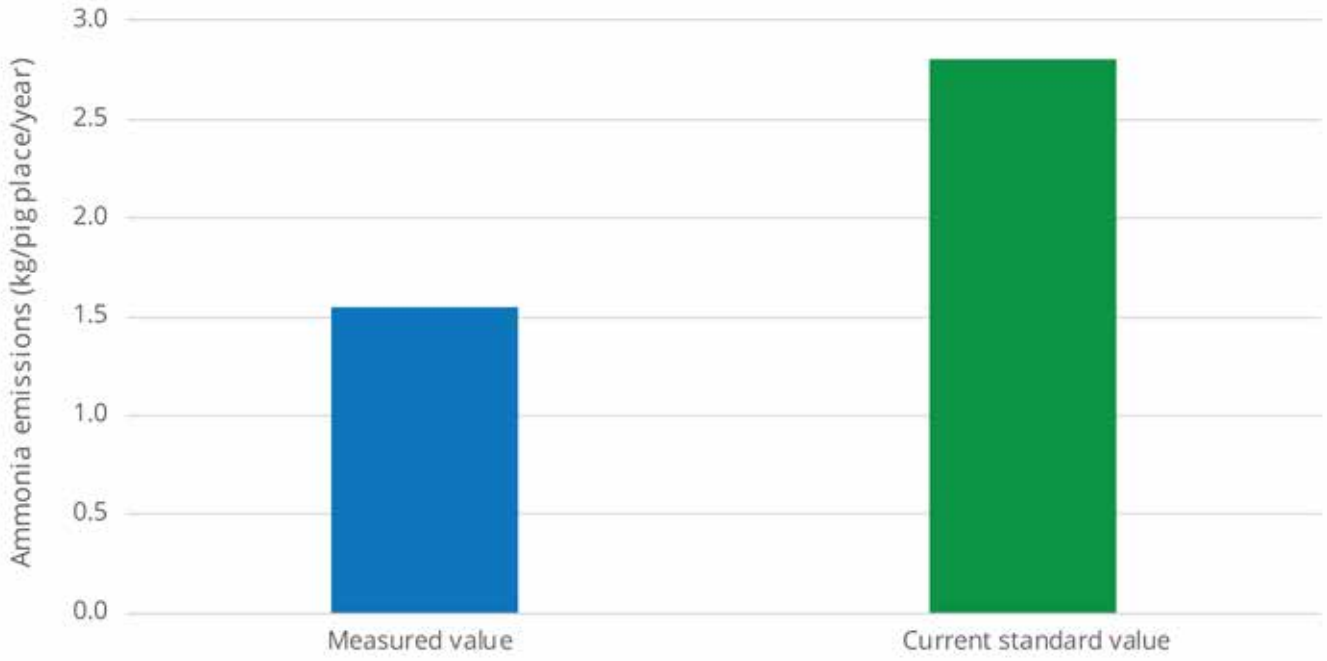
Background

Ammonia emissions from pig production in the UK is relatively small and the industry has been proactive in reducing emissions. To do this even more effectively, it is important to have an accurate understanding of ammonia emissions from pigs in modern systems. The current emission factor in the UK Inventory (2021) is mainly based on historic data conducted several years ago. Since that time, dietary crude protein (CP) has been reduced and production efficiency has increased resulting in lower nitrogen (N) excretion. However, the standard value for ammonia emission has not been updated and therefore the baseline value for ammonia emission is unknown, making it difficult to understand the effect of ammonia mitigation strategies or to make informed decisions on business expansion close to ammonia sensitive sites.

AFBI Science

Ammonia emissions were measured from two pig units in Northern Ireland representative of indoor finishing pig units. The study followed the principles of the Verification of Environmental Technologies for Agricultural Production (VERA) Test Protocol for Livestock Housing and Management 2.0 and ammonia emissions was assessed over three years and measurements were conducted over five different time points and over a range of pig weights (41-121kg). The mean ammonia emission across the sites was 1.55kg/pig place/year and the mean %TAN was 16.9%. These are over 40% lower than the current standard figures in the UK Inventory (2021) and this substantial reduction can be seen in Figure 1 (over page).

Figure 1. Comparison of measured ammonia emissions with the current standard value (kg/pig place/year)



Impact of AFBI Science

Over the years, AFBI has worked closely with industry (John Thompson & Sons Ltd and Devenish Nutrition) to reduce the level of CP in pig diets. The reductions in ammonia emissions are a reflection of the lower dietary CP now being offered to finishing pigs in Northern Ireland on the back of this research carried out by ABFI and our industry partners, as well as the increased efficiency of modern genetics. Having an accurate quantification of ammonia emissions from finishing pigs on slatted systems will enable more effective implementation of mitigation strategies. The updated emission factor will be presented to the UK Ammonia Inventory with a view to updating the standard value for finishing pigs in Northern Ireland.

The study was co-funded by DAERA

Soil Health in Northern Ireland

Dr Lisa Black, Dr Paul Cottney, Dr Archie Murchie and Dr Suzanne Higgins

Summary

Soil health is an emerging, complex, and extensive discipline covering aspects of soil chemistry, physics, and biology. AFBI research has focussed on evaluating soil biological traits for their potential to indicate soil health. Results to date suggest that quantifying soil enzymes and soil respiration can indicate change in soil carbon (C), with potential to act as proxy for monitoring soil health and the impact of land-use.

Background

To function sustainably, soils need to be in good chemical, biological and physical condition. Soil biological parameters are underrepresented in international evaluation of soil health and this is highlighted by the new EC Soil Health Law which demonstrates the importance of identifying ways to monitor soil health, including biological parameters, and to harmonise methodology.

AFBI Science

Recent work at AFBI has focused on identifying the value of soil biological traits in understanding the impacts of land-use on soil health. A healthy soil, in an intensively used agricultural system such as Northern Ireland, is one that accumulates, or at least maintains, organic C. If organic C in a range of soils can be linked to specific chemical, physical and/or biological traits, then this could

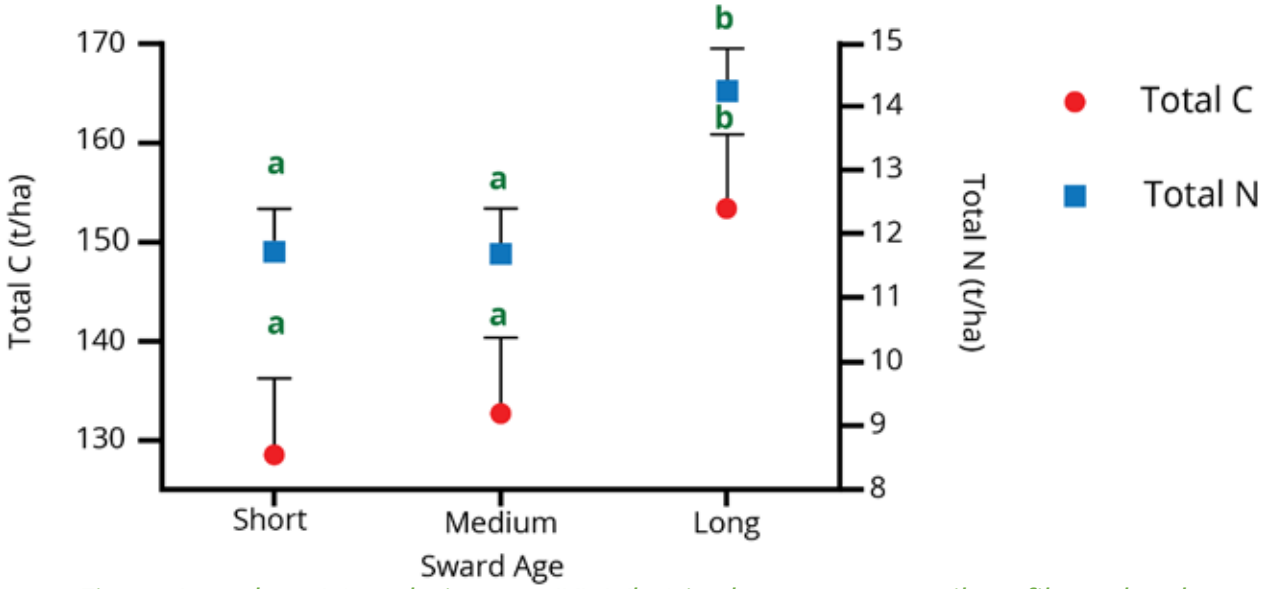


Figure 1. Carbon (C) and nitrogen (N) (t/ha) in the top 30 cm soil profile under short, medium, and long-term grassland swards. Error bars represent SED. Means with differing letters are significantly (p<0.05) different to each other.

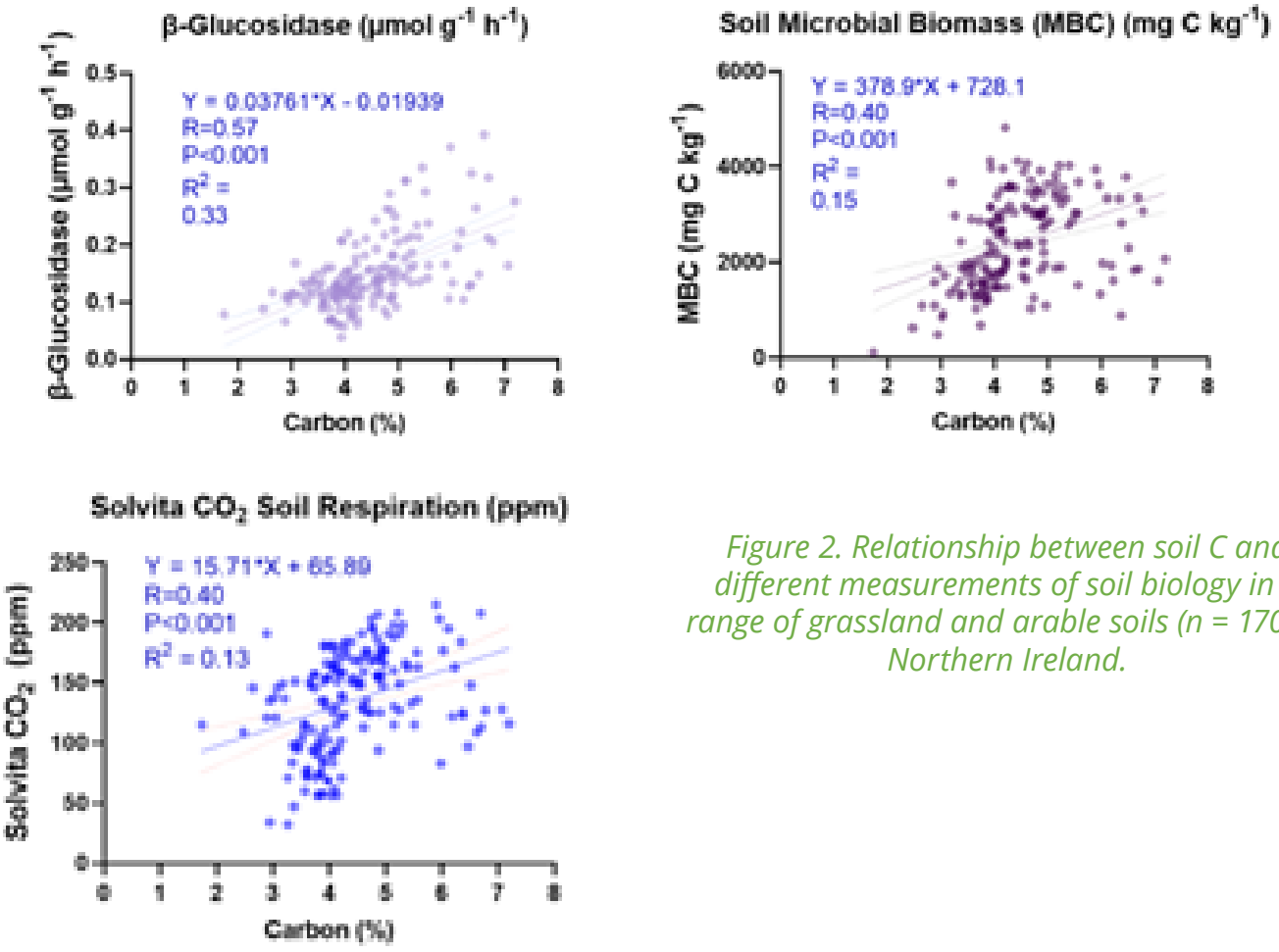


Figure 2. Relationship between soil C and different measurements of soil biology in a range of grassland and arable soils (n = 170) in Northern Ireland.

give insight into organic C changes in soils without the need for historical data through measurement of associated properties.

A range of soil parameters have been measured as potential indicators for soil health in grassland and arable fields across Northern Ireland and in AFBI long-term experimental trials.

The relationships between soil organic C and microbial traits, using data from a range of soils and land use types (Figure 2), suggests that soil biological traits have potential as indicators of soil health. All three traits, β-glucosidase, soil microbial biomass and Solvita soil CO2 respiration, showed highly significant correlations with soil % C.

Impact of AFBI Science

Work carried out by AFBI, and collaborators, has shown the importance and potential for soil biological characteristics to be indicators for soil health.

Land-use, including cultivation, organic manure inputs, agrochemical use, plant species grown, and varieties selected all have a role to play in maintaining or improving the health of our soils. These results will help establish proxies to establish real time results and an understanding of soil health which farmers can use to base decisions on.

The study was co-funded by DAERA Evidence and Innovation

Ongoing AFBI Science making an impact

Mitigation of enteric methane emissions from cattle and sheep

Dr Omar Cristobal Carballo, Dr Xianjiang Chen and Prof Tianhai Yan

Summary

The aim of the Ruminant Nutrition Unit is to test and develop feeding strategies and additives (novel farm-ready technologies) to reduce methane emissions from enteric fermentation in ruminants.

Background

Livestock production represents the largest agricultural activity, as well as the largest environmental challenge in Northern Ireland (NI) agri-food sector. The UK has committed to reduce greenhouse gas (GHG) emissions by 78% by 2035 compared to 1990 levels, and net zero by 2050. Therefore, it is necessary to develop novel farm-ready technologies to reduce methane emissions from enteric fermentation in sheep and cattle production systems. At AFBI, several promising feed additives have been tested for their capacity to mitigate methane emissions from sheep and cattle production systems, while simultaneously monitoring their effects on animals' health and productivity.

AFBI Science

Microalgae – sheep study

Microalgae (*Schizochytrium* sp.) are microorganisms rich in docosahexaenoic acid (DHA). Two studies were conducted to assess the effect of supplementing microalgae in a total mixed ration (TMR) diet with 50:50 grass silage and concentrate (dry matter (DM) basis) on methane emissions and performance of finishing lambs. In study 1, dehydrated microalgae cells were supplemented at three different levels. Lambs consuming high levels of microalgae reduced feed intake, whilst growth and methane emissions did not differ, indicating feeding microalgae has potential to reduce methane emissions per kg live weight gain.

Based on these results, a second study was conducted using the microalgae oil to replace soyabean oil in a design similar to that in the first study. The result found that replacing soyabean oil with microalgae oil could reduce enteric methane emissions per kilo of DMI from lambs by up to 20%.

Calcium peroxide – sheep study

Methane inhibitor supplementation approaches have been proposed to reduce enteric methane emissions in ruminants. However, if feed additives are to become part of a successful abatement strategy for the NI national agricultural systems, it is essential that they are shown to reduce methane emissions without decreasing animal's productivity. Calcium peroxide, a novel rumen methane inhibitor, acts affecting the hydrogen available in the rumen used by methanogens to produce methane. This inhibitor was evaluated in a dry ewe study for its effect on methane emissions and animal performance. Feeding calcium peroxide had no effect on feed intake, but increased daily gain by up to 19%, and reduced daily methane emissions (g/d) and as a proportion of live weight gain (g/kg) by 11% and 28%, respectively.

Seaweeds – dairy cow study

The *in vitro* screening trials showed that seaweeds had potential to manipulate rumen microbial activities for lower methane emissions. A dairy study was conducted to evaluate the effects of feeding 4% (DM basis) of seaweeds (*Himanthalia Elongata*) powder or extract.

The results indicated that dietary inclusion of seaweeds power or extract had no significant effects on dry matter intake, milk yield or milk composition or methane emissions. However, feeding seaweeds powder shifted nitrogen excretion with less urine nitrogen output, implicating less nitrous oxide and ammonia emissions from slurry.

Impact of AFBI Science

A significant programme of work is underway, mainly in collaboration with Queen's University Belfast to develop strategies to mitigate enteric methane emissions from sheep and cattle production. This work will create a scientific framework for targeting GHG emissions through dietary supplementation. These mitigation options could be implemented on-farm in an environmentally sustainable (following life cycle analysis) and cost-efficient manner. Additionally, the screening of strategies to mitigate enteric methane improves national GHG inventories by providing emissions data from multiple animal trials in different animals, carried out using best practice. This will be a critical strategy in the toolbox to reduce carbon footprint of cattle and sheep production in NI.

The study was co-funded by thefollowing projects:

HORIZON 2020 project: *MASTER*

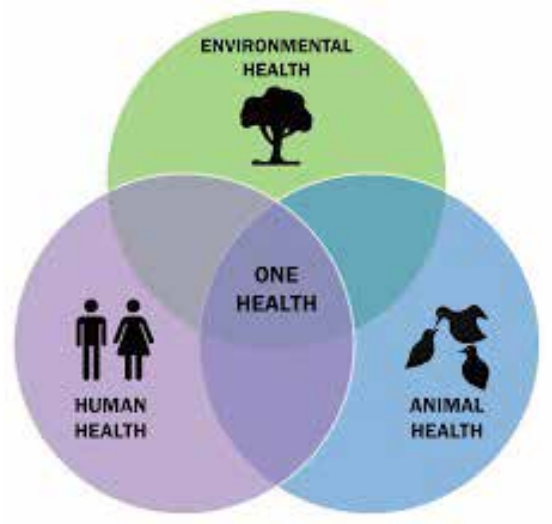
THIS PROJECT HAS RECEIVED FUNDING FROM THE EUROPEAN UNON'S HORIZON 2020 RESEARCH AND INNOVATION PROGRAMME UNDER GRANT AGREEMENT No: 818368

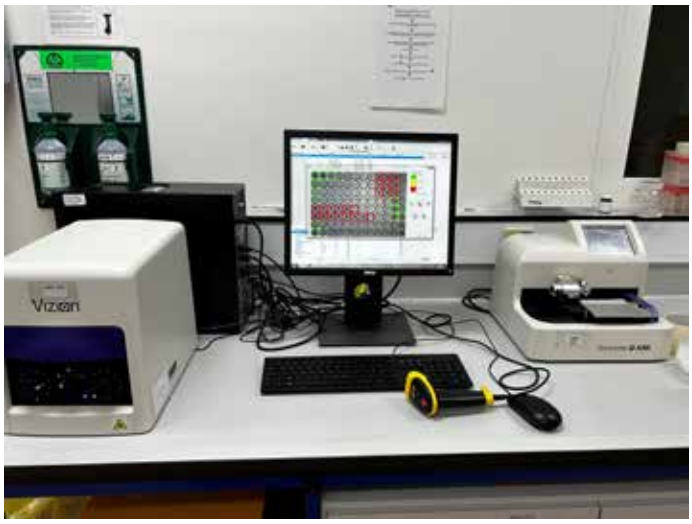
METHABATE project funded by DAFM / DAERA Ref. 19/R/479

SEASOLUTIONS funded by DEFRA under ERA-NET contract no. SCF02017

Antimicrobial testing post-Brexit

Catherine Couzens





Summary

The Antimicrobial Resistance (AMR) lab in the Bacteriology branch in Veterinary Science Division (VSD) is a brand new, independent lab. The main purpose of the lab is to provide AMR tests for the European Union (EU) harmonising survey. This survey was initially carried out within the *Salmonella* lab. However, as BREXIT occurred, Northern Ireland was asked to stand as a unique special non-member state in regards the realm of AMR. This resulted in new and increased sample numbers for the AMR lab. We had to develop processes and practical applications to scale up testing. We had to work independently from the Animal and Plant Health Agency (APHA) in the UK. We carried out all aspects of the isolation and identification process in the EU commission decision on the monitoring and reporting of antimicrobial resistance in zoonotic and commensal bacteria 2013/652/EU (2014-2020) and decision 2020/1729/EU (2021-2027).

While the use of antimicrobials in farmed animals has decreased over the past few years in Europe, the on-going presence of antimicrobials still causes an issue on the farm and in the environment. Many antimicrobials are only partially taken up by livestock and the residues of the antimicrobial are excreted into the environment, including as part of manure and slurry that is spread on farmland as fertiliser.

As we can monitor the trends of the AMR pathogens and identify the hotspots then we can work together to reduce the use and manage the risks of the AMR pathogens.

Background

What is AMR?

Antimicrobial resistance (AMR) is the ability of microorganisms to resist antimicrobial treatments. Antibiotics develop an inability or reduced ability to inhibit the growth of a bacterium. Bacteria are becoming more resistant to antibiotics which is compromising effective treatment of infectious diseases in both animal and humans.

AFBI Science

The AMR lab has the knowledge and skills to isolate and characterise the pathogen infecting the livestock and environment while defining the resistance that has occurred. We use pre-enrichment and various selective media to encourage growth and have developed a PCR to identify the *campylobacter* strains and used various biochemical tests to identify *E.coli, Staphylococcus* and *Enterococcus*. Once we isolate a suspect *Salmonella*, we use our extensive knowledge and accredited protocols to identify the species of *Salmonella*.

We are the only veterinary lab in Northern Ireland to offer Minimal Inhibitory Concentration (MIC) testing. We test the sensitivity of a pathogen against a particular antibiotic, to see the lowest concentration of the said antibiotic at which the pathogen no longer grows. The European Committee on Antimicrobial Susceptibility Testing (EUCAST) set the break points/ cut offs that determines the susceptibility or resistance of the pathogen. If the MIC is higher than the breakpoint, then it is resistant. We report as a non-member state to the EU abattoir survey, Border Control Posts survey and Retail Meat survey under Commission Implementing Decision (EU) 2020/1729 – the monitoring and reporting of antimicrobial resistance in zoonotic and commensal bacteria.

Our work encompasses many pathogenic bacterial species including: *E. coli, Salmonella*, *Campylobacter*, ESBL./AmpC *E.coli, Enterococci*, MRSA, *Listeria*; with expanding capability. We isolate and characterize the pathogens through selective media, biochemical test, serology and PCR. We are working closely with colleagues in whole genome sequencing (WGS) to offer a more comprehensive form of genetic testing.

We also support our AFBI colleagues by taking a closer look at their pathogens and identifying and characterising antimicrobial resistance, as well as contributing to the raw pet food survey and assisting colleagues in research projects such as The Lough Neagh investigation.

Impact of AFBI Science

The AMR lab in AFBI at VSD is an evolving and growing laboratory both in highly skilled scientific staff and new projects and harmonized surveys. The ISO 17025 accreditation we have gained has given us the confidence to reach out and promote the work we do.

As one of the leading Agri-science institutes in the UK, AFBI can showcase the multidisciplinary work we do and how we can collaborate with other branches in the fight against AMR. The AMR lab is able to analyse any isolates of concern and collate the data for trend analysis. We work closely with our epidemiologist in our branch and analyse samples from soil and crop surveys or pathogens isolated from bathing or drinking waters. The AMR lab's knowledge and contribution/membership to governmental committees will mean we can represent all of the agriculture in Northern Ireland on a larger scale, ensuring our farming industry is at the forefront of the AMR fight.

As a member of DEFRA Antimicrobial Resistance Co-ordination group (DARC) we are able to discuss emerging resistances and respond quickly. We work with veterinary and public health professionals, policymakers and academics sharing the emerging resistance, tracking changes and investigating where the initial resistance came from through the different surveillance programmes. The work we do in veterinary research also positively contributes to research in human health and the environment.

Together we can combat the global threat that is antimicrobial resistance.

AFBI's agronomy projects focused on sward resilience

David Patterson

Summary

AFBI has initiated a suite of grassland research projects focused on understanding how enhanced sward diversity, along with other associated benefits, can impact the sustainability of grass-based livestock farming environments. These projects have lifespans ranging from 2 to over 20 years and some are currently coming to an end - this article provides a brief summary of the findings.

Evaluation of novel sward species

Sward resilience can be enhanced with inclusion of novel species from more than one functional group (grasses, legumes, herbs) to cope better with weather, economic and environmental shocks. Multi-species swards (MSS) can produce similar yields to grass swards receiving 45% less fertiliser nitrogen (N). They are characterised by deep rooting systems which confer greater drought and water-logging tolerance and nutrient uptake. The *Ecosward* project identified knowledge gaps in MSS management and established the way forward for subsequent studies.

The *SUPER-G* project supported plot-based studies which found that 'over-yielding' occurred where the herbage yield of mixtures was higher than expected from the respective monocultures. A follow-on grazing study found that autumn-born Holstein steers rotationally grazed on MSS enhanced animal performance compared with grass/clover swards along with reduced intestinal worm burden, however bloat issues arose on high clover content swards. A fourth study investigated the incorporation of MSS in ruminant grazing systems on seven commercial farms across NI. Collectively these projects have shown positive impact of MSS for animal production efficiency and have identified further challenges particularly around grazing management, bloat and herb persistency.

AFBI are investigating the

- (i) suitability of plantain-grass swards for paddock grazing with dairy cows
- (ii) animal performance
- (iii) environmental impact (GHG emissions and N use efficiency).

Preliminary findings show no negative impact of plantain inclusion on milk yield and composition; however, the plantain-grass swards grew over 1tDM/ha more than grass-only swards along with a higher utilisation. Indoor feeding trials using zero-grazed swards will provide vital data on N use efficiency and Methane (CH_4) and Nitrous oxide (N_2O) emissions.

Deeper rooting characteristic of herb species such as Plantain and Chicory

Indoor controlled feeding study to assess dairy cow emissions and N use efficiency.

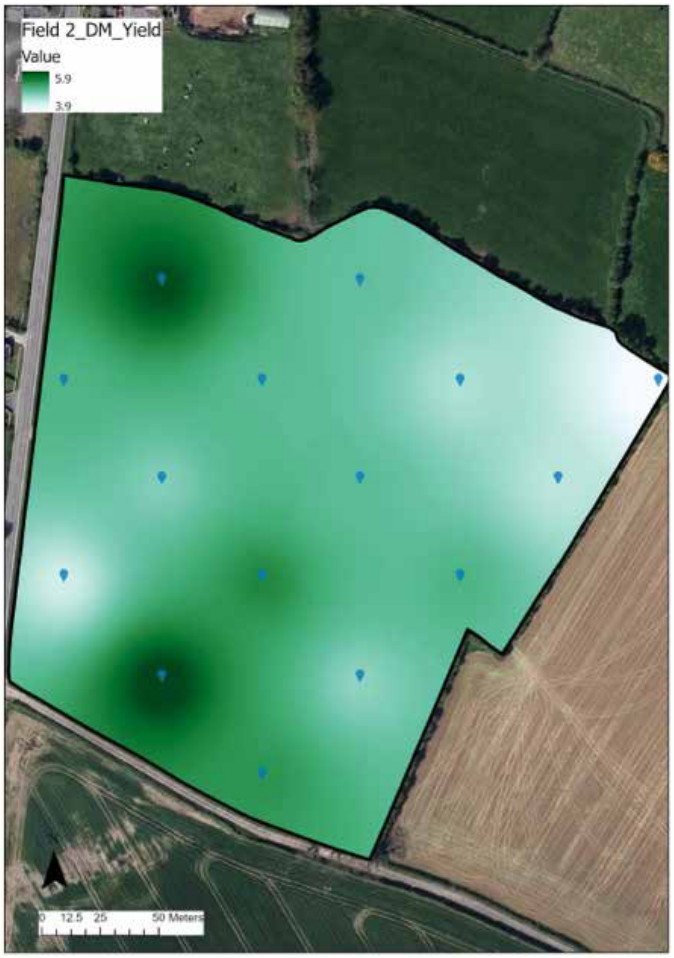
Plantain for dairy cow grazing

Plantain (*Plantago lanceolata*) is a leafy herb with a fibrous root system that is highly palatable to grazing ruminants, with its high mineral content and health-boosting chemical compounds.

Investigating sward variability

The *SilageCheck* project is investigating field and sub-field variation in grass silage yields and quality on NI dairy farms, to identify and interpret the drivers behind areas of poor performance.

Results show major yield variation within and between fields on the same farm and between farms. Yield variation per field was at least 1 t DM/ha and up to 5 t DM/ha in one case. Soil pH, P and K indices all displayed considerable variability at the sub-field scale. *SilageCheck* will combine spatial yield variability from five commercial dairy farms and relate this to detailed soil, botanical and nutrient composition data – this will impact on future grassland management practices to improve yield continuity and quality of grass silage production in NI.



Use of yield and nutrient mapping to improve precision of silage field operations

Monitoring and modelling sward productivity

GrassCheck records baseline herbage growth and quality data, generates short-term grass growth predictions for farm management decisions and builds core data to inform wider policy decisions for NI. *GrassCheck* was used historically during the fodder crisis to inform timely policy interventions and will be vital for modelling the impact of longer-term climate change on farming systems. The data collected and used by the *GrassCheck* farmer network (over 35 sites) has consistently shown that annual grass production, utilisation and grass quality can exceed industry benchmarks - this will also have a positive impact on the carbon footprint of local farming systems. To address the reduced use of fertiliser N, a new grass/white clover (*CloverCheck*) plot series will substantiate the benefits and importance of utilising biological N from legumes, in response to both global energy price fluctuations and climate change mitigation.

Yield and herbage quality sampling on GrassCheck and new CloverCheck trials

Overall

Ultimately it is essential that we assemble and amalgamate the findings from these individual studies into holistic grass-based farming systems. They must then be modelled and ground-truthed, in order to evaluate the collective impact on net zero targets alongside benefits for biodiversity, water quality and soil health.

Choices for NI Agri-food Sectors to Achieve Its Net Zero Carbon Objective

Dr Ziping Wu

Summary

Through horizon scanning for the key categories of greenhouse gas (GHG) emissions and approaches in GHG mitigation, this study uses AFBI Systems Models including Input-output Tables (IOT), Computable General equilibrium (CGE) models and GHG accounts to analyse the interactions between economy and GHG emissions / removals. The study informs Agri-Food Climate Change Policy and agriculture's contribution to achieving UK net zero greenhouse gas emissions, including defining targets, measuring progress, and understanding trade-offs.

Background

The Climate Change Act (NI, 2022) sets a target of at least 100% reduction in net zero GHG emissions by 2050 (i.e., net zero emissions by 2050) for Northern Ireland compared to its 1990 baseline, along with interim reduction targets in 2030 and 2040. As more than 75% of land is used by the agricultural sector, agricultural production sectors including forestry and fishery has contributed for approximately 36% of GHG emissions in NI in 2016. The agricultural sector is also a potential key area for carbon neutralisation and green growth in NI.

AFBI Science

In this project, AFBI economists have worked on following specific topics.

1. Based on NI IPCC emission figures, we have carried out horizon scanning for the key categories of GHG emissions / removals in NI agriculture and potential corresponding technical, economic and regulatory remedies in GHG mitigation. NI emissions/ removals from two IPCC sectors (Agriculture and Land Use, Land Use Change and Forestry) are benchmarked with other UK countries / regions. Links between economic and GHG impacts for different technical measures of GHG mitigation are established.
2. We have developed GHG accounts for 82 economic sectors and household consumption in NI, including 12 agriculture, forest and fishery subsectors and 10 food processing and feed subsectors. By combining IOT and GHG accounts, the key sources of emissions for each economic sector from uses of energy, animals, fertiliser and land are identified and quantified, and emission intensities for each economic sector calculated.
3. We have also developed a single region CGE model to examine different economic and GHG mitigation impacts of economic measures (consumption tax and production tax) in NI.

The main strengths of the system models are in its full coverage in economy and in capturing structural changes in economy associated with technical and economic shocks.

In the next stage in this project, the database and tools developed will also be used in investigating the economic and GHG impacts of different technical measures identified for overall economy and individual sectors.

Impact of AFBI Science

The GHG mitigation and climate adaptation actions are likely to significantly alter the production structure and supply chains in the local agri-food sector and the economy and further influence the natural environment and ecosystem services. Research results from the project has been disseminated to different stakeholders including policy makers and academic audience.

We have directly involved in discussions in developing NI GHG mitigation Action Plan. Results from topic area 1 above have provided a basis for mitigation policy selection (Figure 1). Those from topic area 2 presented a proximate way for the trade-off between economy and GHG emissions, and those of topic area 3 may provide some insights for NI in using an economic approach in mitigating GHG emissions.

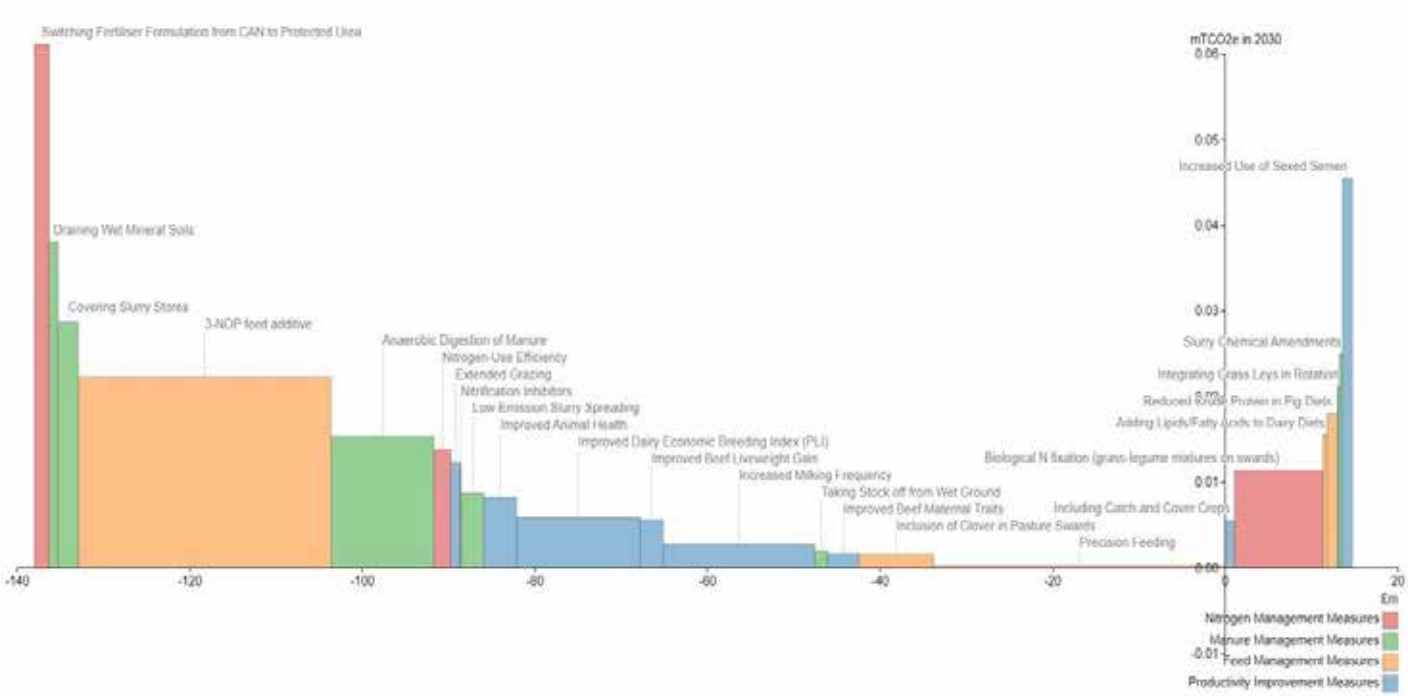


Figure 1. A visual representation of the technical measures reviewed in the development of the Potential Agriculture GHG Mitigation Strategy in Northern Ireland (2020-2030).

Source: Author's Calculations based on Eory et al (2021), Lanigan, et al (2019), Morrison, et al (2022) and other literature.

Note: The height of each bar represents the mitigation potential for each measure, while the breadth represents the economic costs per tonne of annualised CO_2 equivalent associated with implementing such a measure. Measures with narrow and high columns would be considered better than broader and shorter bars.

The study was co-funded by the DAERA E&I Programme

Biomass Connect: A UK wide Biomass Innovation, Demonstration and Information Platform

Chris Johnston / Callum Williams

Summary

Biomass Connect is a UK Innovation and Information Platform established at Hillsborough, and seven other sites in Great Britain, during the spring/summer of 2023 and continuing until 2025. The project is a demonstration and knowledge sharing initiative to showcase best practice and innovations in land-based biomass feedstock production.

Biomass crops are non-food plants cultivated for a number of purposes including for commercial power, heat & power, domestic fuels, domestic heat, anaerobic digestion, pulp, animal bedding, compost, mulch, construction materials, phytoremediation, cosmetics, skincare and food supplements. The project compares how well different crops and varieties grow in regions across the UK and demonstrates innovations which have the potential to maximise their economic and environmental benefits. At AFBI we are demonstrating a wide range of tree varieties, energy grasses and other crops. These include varieties of willow, alder, black locust, eucalyptus and poplar, as well as a number of energy grasses and other crops such as miscanthus, reed canary grass, switch grass, sida, silphium and hemp.

Background

The UK government recently published the Biomass Strategy which set out the important role biomass can play in reaching the Net zero targets. Although recognising that biomass is currently both imported and produced domestically, it identifies the need to ensure that future upscaling must comply with strict sustainability criteria ensuring genuine emissions savings.

To achieve this, it needs to be massively upscaled if our reliance on fossil fuel imports is to be drastically reduced, as required for the climate action agenda.

As recently as March 2023, The UK Climate Change Committee's advice to Northern Ireland on "The Path to Net Zero" has included engineered carbon capture and storage from both solid biomass grown in Northern Ireland and anaerobic digestion

to produce biomethane, especially for the hard to decarbonise sectors (heat, transport, industry). In fact, the committee specified that using biomass grown in NI, together with associated Carbon Capture & Storage (CCS), could sequester over 1 million tonnes of CO_2 equivalent annually by 2050. In the UK, this would require a significant upscaling of the industry[1] to enable a projected 700,000 ha planted by 2050[2], or indeed anywhere near that starting from a current estimated UK total of about 12,000 ha (predominantly miscanthus and willow).

AFBI Science

The primary aims of the platform are to provide independent information including any variations in the different crops across the regions of the UK. The current project will run for 3 years until 2025 where data on establishment, agronomy, yields, disease, environment and management will all be collected, centralised and interpreted.

As well as being a project partner in the Biomass Connect Hub platform, AFBI also leads one of the innovation projects developing a Biomass Crops information and "pocket consultant" called Envirocrops. AFBI is also a project partner in the Rothamsted Research (Willow Trials) and Aberystwyth University (Miscanthus Trials).

Impact of AFBI Science.

The Biomass Connect platform has established a fully connected and regionally-based community who are contributing to the development, establishment and operation of the platform. Building this focal point for the industry will support the ambitious scaling up of planting capability.

AFBI monitors and manages this platform under strict protocols, in order to provide robust, independent information on biomass feedstock implementation, management, performance, agronomy, weed control, yields and environmental benefits. In doing this AFBI is de-risking new crop adoption by ensuring that geographic variations in the efficacy of biomass feedstocks and relevant innovations are fully evaluated and demonstrated to a broad range of stakeholders across the UK. AFBI continues to contribute to an increasing number of technical articles, Fact sheets and Best practice Guidelines.

AFBI staff regularly provide presentations, seminars and webinars on the opportunities for biomass crops, specifically on their role in waste management and environmental protection of the aquatic environment. The Low Carbon Agricultural Show February 2023 and Biomass-Connect Webinar Series November 2023 are examples. There is evidence of clear impact of these dissemination events by the follow on interest from industry and government in GB, largely promoted by the new Nutrient Neutrality laws.

AFBI also held the first Demo event on the 28th September and will repeat this in 2024.

The study was fully funded by the UK Department of Energy Security and Net Zero (DESNZ) – Biomass Feedstock Innovation Programme

[1] https://www.theccc.org.uk/publication/advice-report-the-path-to-a-net-zero-northern-ireland/
[2] https://www.theccc.org.uk/wp-content/uploads/2020/12/The-Sixth-Carbon-Budget-The-UKs-path-to-Net-Zero.pdf

Figure 1a. AFBI Hillsborough Biomass Connect Demonstration Platform of 11 different potential biomass cops.

Figure 1b. Hemp varieties (L) Willow biofiltration & water quality protection (R)

Organisation	Site name
Rothamsted research	North Wyke*
Agri-Food and Biosciences Institute	Hillsborough*
NIAB	Headley Hall*
Newcastle University	Cockle Park Farm
IBERS, Aberystwyth	Trawsgoed*
Scotland's Rural College (SRUC)	Auchincruive*
Scotland's Rural College (SRUC)	Penicuik
Bio Global Industries	Buckinghamshire

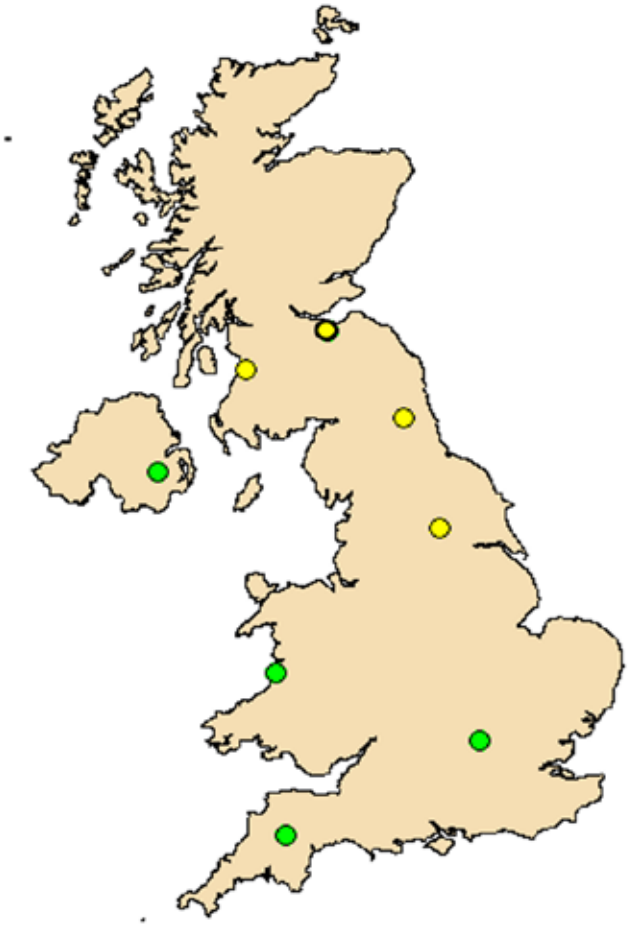
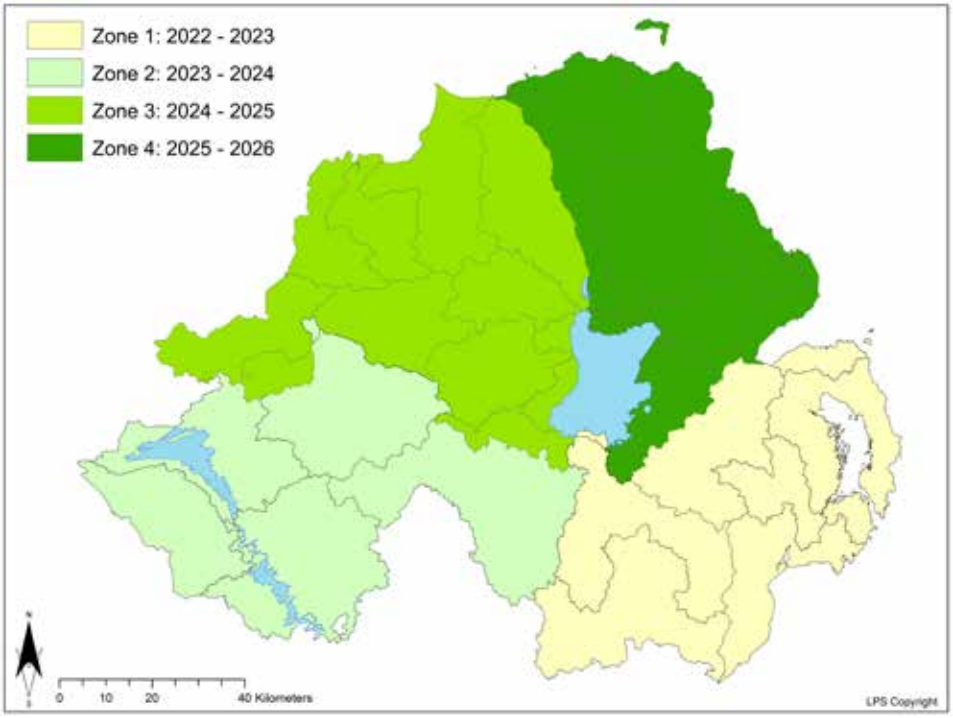


Figure 2. Project Partners and Demo site locations.

Breaking new ground – the Soil Nutrient Health Scheme

Alex Higgins, Colleen Ward, Suzanne Higgins, JR Rao, Rachel Cassidy



Summary

The Soil Nutrient Health Scheme (SNHS) is the most comprehensive soil sampling and analysis programme ever undertaken.

Background

The Scheme, which is funded by DAERA, is being rolled out across Northern Ireland in four geographic zones over the period 2022-2026 and is open to all category 1 farmers.

Those participating in the scheme will receive:

1. Detailed information on the nutrient and pH status for each field, and crop-specific recommendations for the year of application
2. LiDAR-derived runoff risk maps highlighting sub-field scale hot-spots with potential for nutrient loss to waterbodies
3. Estimates of C stored in soils and as above ground biomass on each farm
4. Training on the interpretation of soil nutrient reports and generation of farm nutrient plans (provided by CAFRE).

Since starting in 2022 over 140,000 fields in Zone 1 (out of 150,000) have been sampled and reports issued; 190,000 fields are scheduled to be sampled in Zone 2 during 2023/24.

All work on the scheme is supported by a comprehensive programme of research in soils, water, carbon and behavioural change led by AFBI and with partners at both Ulster and Leeds Universities.

AFBI Science

Soils Research - Basaltic soils cover nearly a third of the landscape of NI and are characterised by high levels of minerals, including iron and aluminium. Research indicates that the Olsen Phosphorus (P) soil test, when applied to these soils, may be underestimating plant-available P. As a result, SNHS research will assess nutrient interactions and grass nutrient uptake specific and uniquely to these basalt soils through plot experiments on farms across the northeast. The soil test from this work will be used to provide accurate P recommendations to farmers in Zone 4 of the Scheme.

Water Quality and Catchment Research - Nutrient enrichment of freshwaters by P is a primary cause of water quality impairment in NI, with agriculture a key source.

In catchments with high rainfall, impermeable soils and steep slopes overland flow, or runoff, is the primary pathway by which nutrients and sediment are transferred to surface waters. High-resolution LiDAR digital elevation data provides the basis for modelling hydrological connectivity in the landscape, and identifying, in conjunction with soil permeability, those areas most prone to runoff and erosion. A programme of water quality monitoring in agricultural sub-catchments across each Zone will be used to develop and relate soil nutrient status and runoff risk potential to water quality.

Carbon Research - A high-resolution LiDAR scan of NI will provide the basis of modelling activities to estimate above ground biomass held in trees, woodlands and the 120,000 km

of hedgerows in the region. SNHS is also gathering information on rates of soil C sequestration in grassland fields on selected commercial farms and along undisturbed field boundaries on different soil types in NI (involving radio-carbon dating and soil microbiological assessments). Ongoing research will investigate how fungal and bacterial communities are affected by management and elucidate mechanisms and processes governing changes in soil C storage in grassland and hedgerow soils. The research will also focus on soil microbiology in terms of microbial activity and composition. This will help to understand how C cycling and storage is affected by soil microbes, which have evolved or adapted to different management practices in our soils.

Behavioural Research - An assessment of the extent to which participation in the various components of the SNHS scheme has influenced farmer awareness, attitudes and behaviour is an important component in monitoring and evaluation of overall impact. Research will apply a mixed-method approach using a questionnaire-based survey and qualitative semi-structured, in-depth interviews to explore farmers' awareness of the link between soil testing, improved productivity and water quality.

Impact of AFBI Science

The Soil Nutrient Health Scheme will enable Northern Ireland's farmers to optimise crop nutrient applications, assess on-farm carbon stocks and build resilience while providing a basis for strategies to improve the sustainability of the region-wide soil resource, agriculture, and the environment.

Key impacts:

- Initial results from Zone 1 have already highlighted issues with nutrient management on farms, with 57% of fields receiving a lime recommendation and 45% of fields having a surplus of P (Olsen P Index 3 and above). Low soil pH impedes nutrient uptake by the plant, and thus yields, even where nutrient levels are sufficient. Soil P excess is prone to loss to water and a major contributory factor to less than good ecological status across NI lakes and rivers. Improved farm nutrient management through SNHS soil sampling and training is key to improving nutrient use efficiency, minimising chemical fertiliser and concentrate feed imports and reducing the surpluses available for loss to the environment.
- The soil test for basaltic soils will have an important role through providing farmers in those areas with corrected P recommendations for grassland fields. The research on establishing a more accurate P test is underway with sampling on basalt farms in year 1-3. In Year 4 of the project farmers will receive a revised, more accurate P recommendation.
- Water quality programmes developed through SNHS will contribute to the development of strategies for achieving water quality improvements across catchments and provide a focus for mitigation through the runoff risk maps. Farmers in Zone 1 of the project have received their maps which are being made accessible through the government gateway portal.
- Information arising from carbon research will be used to update the UK soil C inventory, and to identify management strategies which enhance C capture by soil and above ground biomass.
- The Scheme will deliver an important baseline data on understanding farmer awareness, attitudes, and behaviour around nutrient management. The behavioural study research is already identifying patterns and changes required to make improvements to best management practice on farms.

The study was co-funded by DAERA

Research Highlights

Research Highlights 2024

Dr Simone Angioloni

Angioloni, S., Jack, C.G. (2022). Farm Fatalities in Northern Ireland Agriculture: What Fifty Years of Data Tell Us. Economics & Human Biology, 46(3):1-32.

Agriculture is one of the most hazardous sectors, in terms of fatal and non-fatal incidents. We analysed an administrative dataset of farm fatalities in Northern Ireland over a 50-year timeframe (1968–2017) to undertake an age-period analysis of incident-related mortality rates by sex, cause of death, season, and day of the week. Results indicated that fatalities due to animals have increased, while the incidence of deaths due to vehicles and equipment has substantially decreased over the years although it is still the primary cause of death. The elderly who are still actively involved in farming and children, in the spring and at weekends, are most exposed to the risk of a fatal incident. The incidence of on-farm deaths is five times higher in men than women.

Dr Elizabeth Ball

Ball, M.E.E., Smyth, S., Beattie, V.E., McCracken, K.J., McCormack, U., Muns, R., Gordon, F.J., Bradford, R., Reid, L.A. and Magowan, E. (2022). The Environmental Impact of Lowering Dietary Crude Protein in Finishing Pig Diets—The Effect on Ammonia, Odour and Slurry Production. Sustainability, 14: 12016. https://doi.org/10.3390/su14191201

Excess nitrogen excretion, ammonia and odour are environmental pollutants associated with pig production but reducing dietary crude protein (CP) could reduce these pollutants if diets are adequately formulated to maintain production performance.

However, the quantitative effect of lowering dietary CP on ammonia and odour emissions and slurry output has not been well-established and the objective of this study was to quantify the relationship between dietary CP and ammonia and odour emissions.

Thirty entire boar pigs (~75kg) were individually housed in calorimetry chambers to measure ammonia and odour emissions, feed intake and slurry output. Pigs were assigned to one of three treatment diets; (1) 180 g/kg CP, (high CP), (2) 150 g/kg CP, (medium CP), and (3) 130 g/kg CP, (low CP). The reduction in CP in the diet from high to medium CP resulted in a 22% reduction in ammonia emissions, and from the high to low CP resulted in a 47% reduction ($p < 0.001$). Slurry output from pigs offered the low CP diet was reduced by 39% ($p < 0.001$) and dry matter increased by 35% compared to slurry from pigs offered the high CP diet ($p < 0.05$).

There was no significant effect of reducing CP on performance or odour emission but hydrogen sulphide emissions decreased linearly ($p < 0.010$) with decreasing dietary CP, indicating a relationship between dietary CP and odour.

The results of this research have quantified the relationship between dietary CP and ammonia emissions; for every 1% reduction in dietary CP, ammonia emissions are reduced by 10% from finishing pigs.

Dr Khagendra Raj Baral

Baral, K., McIlroy, J., Lyons, G.A., Johnston, C. (2023). The effect of biochar and acid activated biochar on ammonia emissions during manure storage. Environmental Pollution, 317, Article No.120815

Reduction of ammonia (NH_3) is important to achieve Northern Ireland's NH_3 emissions reduction target of 30% by 2030. Manure management is the major source of NH_3 emissions in Northern Ireland. As an initiative, we evaluated the emission mitigation potential of biochars and acid-activated biochars originated from miscanthus or solid fraction of anaerobic digestate using as a floating cover during outdoor storage of cattle slurry. Light-expanded clay aggregate (LECA) was also evaluated.

It was concluded from this four month experiment that acid-activated biochar can effectively reduce NH_3 emissions by up to 28%, due to changes in physicochemical properties. LECA can also be an effective floating cover. However, biochar without activation may not be a good option if applied in a small quantity (7 mm thickness).

Dr Conrad Ferris

Barley, J., Ferris, C., Watson, S., Gordon, A. (2022). Physical and economic performance of dairy cows managed within contrasting grassland-based milk production systems over 3 successive lactations. Journal of Dairy Science, 105(4):3153-3175.

Four diverse grassland-based milk production systems were examined over three successive lactations. Systems examined involved a total confinement system, a conventional winter-calving system and two lower input spring calving systems; one involving Holstein cows and the other Jersey crossbred cows. Total milk output per cow largely reflected differences in concentrate inputs. Jersey crossbred cows produced a similar yield of milk solids as heavier Holstein cows. Even at relatively similar stocking rates (cows/hectare), diverse grassland-based milk production systems were associated with very different levels of performance on a per cow and per hectare basis. However, differences between systems in gross margin per cow/year were relatively modest. The results demonstrated that diverse grassland-based systems can be adopted in Northern Ireland, and provided these are managed efficiently, similar levels of economic performance can be achieved.

Dr Aaron Brown

Brown, A., Scoley, G., O'Connell, N., Gordon, A.W., Lawther, K., Huws, S., Morrison, S.J. (2023). Pre-Weaned Calf Rearing on Northern Irish Dairy Farms: Part 2. The impact of hygiene practice on bacterial levels in dairy calf rearing environments. Animals: 13: 1109

Pre-weaned dairy calves are very susceptible to disease in the first months of life and hygiene management plays a key role in reducing their exposure to pathogens. However, despite its importance, little research has previously evaluated the effectiveness of various hygiene protocols for calf housing and feeding equipment. In order to address this, a survey of pre-weaned calf housing and management was undertaken on dairy farms in Northern Ireland.

The objectives of the study were to highlight the key hygiene practices being undertaken for pre-weaned calves on these dairy farms and assess the impact of these practices on the level of bacteria within calf pens, feedstuffs and feeding equipment. Samples of milk, concentrate feed and drinking water alongside swabs of feed equipment and bedding were collected and cultured to determine total viable counts (TVC), total coliforms (TCC) and *Escherichia coli* (*E. coli*) as indicators of hygiene.

Within the farms in this study, much variation was observed in the practices for cleaning milk feeding equipment and pens which can lead to a greater risk of bacterial exposure for calves. The high levels of contamination found in the drinking water that was available to calves was of particular concern across all farms, with around 90% of samples taken above target hygiene levels for coliforms and *E. coli* which may indicate a common vector in the faecal–oral transmission of calf enteric pathogens.

The results from this study demonstrated that there are numerous sources of pathogenic exposure to young calves and that many of these sources could be mitigated through use of standardized protocols leading to improved performance and health.

Dr Ramon Muns Vila

Buckova, K., Muns Vila, R., Cerón, J., Kyriazakis, I. (2022). Consequences of timing of organic enrichment provision on pig performance, health and stress resilience after weaning and regrouping. Animal, 16(10):100637

Legislation dictates that farmed pigs must have permanent access to enrichment material (i.e., edible, chewable, manipulable) to enable proper manipulation and investigation. However, there is a need to find efficient and suitable enrichment for pigs in slatted systems. We aimed to explore the effects of a novel enrichment treatment consisting of fodder beet and jute bags provided daily for pigs, and investigated at which stage of growth additional enrichment provision was more important. We found that novel enrichment during the weaner stage reduced the amount of ear lesions observed in pigs and improved performance, during both weaner and finisher stages. Additional enrichment added during the finisher stage alone was associated with less positive effects, but its provision throughout reduced the number of body lesions observed.

Dr Ramon Muns Vila

Camp Montoro, J., Solà-Oriol, D., Muns Vila, R., Gasa, J., Llanes, N., Manzanilla, E. (2022). Blood and faecal biomarkers to assess dietary energy, protein and amino acid efficiency of utilization by growing and finishing pigs. Porcine Health Management, 8(1): 32

Feed offered to pigs is formulated to optimise their growth, health, and welfare. However, there are several factors that might affect the actual nutritional value of a diet (i.e., quality of ingredients, feed form, delivery method, farm management, etc.).

As such, suboptimal diets are not rare and can result in potential health and welfare problems for the pigs, and environmental contamination.

In a recent study, we studied blood serum metabolites as potential biomarkers to identify changes in protein, amino acid and energy dietary content in growing and finishing pig diets. Among the range of different blood metabolites we explored, 'urea nitrogen' levels showed high accuracy to detect excess of crude protein offered in growing and finishing diets. Levels of 'branched-chain fatty acids' showed promising results and merit further study.

Prof. Nicolae Corcionivoschi

Chfiriuc, C., Filip, R., Constantin, M., Gradisteanu, G., Bleotu, C., Burlibasa, L., Ionica, E., Corcionivoschi, N., Grigore, M. (2022). Common themes in antimicrobial and anticancer drug resistance. Frontiers in Microbiology: 13: 960693

Antimicrobial and anticancer drug resistance represent two of the main global challenges for the public health, requiring immediate practical solutions. In line with this, we need a better understanding of the origins of drug resistance in prokaryotic and eukaryotic cells and the evolutionary processes leading to the occurrence of adaptive phenotypes in response to the selective pressure of therapeutic agents.

The purpose of this paper was to present some of the analogies between the antimicrobial and anticancer drug resistance. Antimicrobial and anticancer drugs share common targets and mechanisms of action as well as similar mechanisms of resistance (e.g., increased drug efflux, drug inactivation, target alteration, persister cells' selection, protection of bacterial communities/ malignant tissue by an extracellular matrix, etc.). Both individual and collective stress responses triggered by the chemotherapeutic agent involving complex intercellular communication processes, as well as with the surrounding microenvironment, were considered. The common themes in antimicrobial and anticancer drug resistance recommend the utility of bacterial experimental models for unraveling the mechanisms that facilitate the evolution and adaptation of malignant cells to antineoplastic drugs.

Dr Ken Lemon

Esnault, G., Earley, B., Cormican, P., Waters, S.M., Lemon, K., Cosby, S.L., Lagan-Tregaskis, P.L., Barry, T., Reddington, K., McCabe, M.S. (2022). Assessment of Rapid MinION Nanopore DNA Virus Meta-Genomics Using Calves Experimentally Infected with Bovine Herpes Virus-1. Viruses, 14(9)

Bovine respiratory disease (BRD) is the leading cause of morbidity and mortality in cattle. Numerous viruses, both known and unknown, are thought to initiate BRD. Viral metagenomics sequencing on the portable, inexpensive Oxford Nanopore Technologies MinION sequencer has the potential for point-of-care/same-day metagenomic sequence diagnostics of known and unknown BRD pathogens to inform a rapid response and vaccine design. We assessed this potential using nasal swabs taken from calves that were experimentally challenged with a single known BRD-associated DNA virus, namely, bovine herpes virus 1 (BoHV-1). Extensive optimisation of the standard Oxford Nanopore library preparation protocols was performed, allowing BoHV-1 to be identified in the samples within approximately 7 hours from sample to result.

Dr Derek Evans

Evans, D.W. (2022). 20 Years of AFBI eel research on Lough Neagh. In: Lough Neagh - history, community and science, (Eds. Burke, William), Academic Press, London, U. K. pp:27-36.

For fisheries scientists curious about the lives of eels, Lough Neagh offers the opportunity to work with a unique fishing Co-operative, backed by a community and fishing fleet open to scientific research. AFBI eel scientists are unique within Europe in that unlike many of our European collaborators, Lough Neagh provides AFBI with access to live eels spanning their life cycle, from tiny juveniles to seaward migrating silver eels. Lough Neagh Fishermen's Cooperative Society has further provided access to a 108-year continuous harvest dataset. This exclusive situation has enabled AFBI scientists to turn fishing folklore into applied fisheries data, helping to sustain Europe's largest wild eel fishery in the face of declining international stocks.

Dr Ruth Kelly

Kelly, R., Montgomery, W., Reid, N. (2023). Initial ecological change in plant and arthropod community composition after wildfires in designated areas of upland peatlands. Ecology and Evolution, 13(2):9771

Wildfires in temperate upland areas are an increasing concern due to rising temperatures and increased droughts associated with changing climate, poor land management, and direct human interference. This study focuses on the impact of uncontrolled wildfires on heathland and bog sites of conservation importance. This study expands our understanding of potential impacts by including less well studied taxa, including mosses, liverworts, ground beetles and spiders, in addition to higher plants. Whilst broad vegetation classes showed initial recovery characterized by increasing cover of shrub and grasses. Wildfire sites were also associated with a loss of plant indicator species associated with blanket bog and heath. Furthermore, sphagnum moss communities which are central to peatland ecosystem functioning, showed no sign of recovery over the 3.5yr course of the study. Similarly, composition of ground beetles and spider communities differed between burnt and unburnt areas. We suggest a precautionary approach to management of upland vegetation, including education and vigilance, as uncontrolled wildfires may have complex lasting impacts on biodiversity and ecosystem functioning.

This study was conducted in collaboration with Dr Neil Reid and Dr Ian Montgomery at Queen's University Belfast, with partners at the National Museum of Northern Ireland. It was funded by the Northern Ireland Environment Agency (NIEA).

Dr Anna Lavery

Lavery, A., Craig, A.L., Gordon, A.W., Ferris, C.P. (2022). The impact of adopting non-antibiotic dry-cow therapy on cow performance and udder health. Veterinary Record: 190 (12), 1731.

While the prophylactic use of antibiotics at drying-off is commonplace, there is pressure to limit antibiotic treatment at the time of drying-off to individual cows either with, or at risk of, a subclinical intra-mammary

infection (selective dry cow therapy: SDCT). In the current study, cows with a history of low somatic cell count (SCC) and no clinical mastitis were randomly assigned to either an antibiotic or non-antibiotic dry-off treatment and cow performance post-calving and udder health examined.

During the first 150 days of the following lactation, daily milk yield and incidence of clinical mastitis were recorded, and monthly milk samples analysed for fat, protein and lactose content, and SCC. Performance measures did not differ between treatments. Cows dried off with non-antibiotic dry-off treatment had a lower mean milk SCC and less cases of mastitis in the subsequent lactation.

The results indicate that SDCT can be adopted with cows deemed low risk for intra-mammary infections, with no negative implications for performance or udder health.

Chris Johnston

Livingstone, D., Smyth, B., Sherry, E., Murray, S., Foley, A., Lyons, G.A., Johnston, C. (2023). Production pathways for profitability and valuing ecosystem services for willow coppice in intensive agricultural applications. Sustainable Production and Consumption, 36:281-291.

With the recent focus on water quality decline where diffuse agricultural pollution must shoulder some of the blame, the opportunity for water quality protection using fast growing woody tree species such as SRC willow is emerging as a viable part-solution.

Agricultural production systems must no longer focus solely on production efficiency but embrace and adopt increasing measures of sustainability with respect to water, air and soil quality. This study set out to investigate the economic and environmental return of diversifying into SRC willow, utilising the buffered sub-catchment at AFBI Hillsborough, along with real world data to develop a Lifecycle Assessment overview of costs.

Although this diversification option may be profitable on its own, dependent on the availability of certain markets, supply chains and harvesting strategies, it generally represents a loss when integrated into a typical dairy farm. However, when a monetised value of certain ecosystem services (nutrient removal) is incorporated, there was minimal impact on the economic return on the dairy land.

Dr Archie K. Murchie

Luke SH, … Murchie AK,…, Rosell S, and Dicks LV + 50 other authors (2023). Grand challenges in entomology: Priorities for action in the coming decades. Insect Conservation and Diversity 16: 173-189. doi 10.1111/icad.12637.

There are increasing concerns that insect populations are threatened at a global scale – so called 'insectageddon'. Insects are the most abundant and biodiverse terrestrial animals and their decline poses serious problems for the functioning of our ecosystems and serves as an early warning for degradation of the environment. In response to the many challenges facing insect populations and those who study them, the Fellows and members of the Royal Entomological Society came together to identify the 'Grand Challenges' in insect science, and to develop a list of research priorities. This was achieved by a stepwise process consisting first of an online survey and then through dedicated workshops.

The key priorities include the following:

- the requirement for more taxonomic expertise,
- understanding ecological networks and functions,
- the requirement for long-term and coordinated monitoring of insect populations,
- identifying drivers for changes in insect populations (including climate change),
- management of agricultural landscapes to reverse declines in biodiversity,
- the role of biodiversity in soil health/ quality,
- the development of methods to control crop pests without harming non-target insect species,
- improving the management of non-native and invasive species and their associated diseases.

Dr Yvonne McElarney

Nava, V., Chandra, S., Aherne, J., … McElarney Y., et al. Plastic debris in lakes and reservoirs. Nature 619, 317–322 (2023). https://doi.org/10.1038/s41586-023-06168-4

A global survey of 38 lakes located in 23 different countries, found that plastic fragments, fibres from clothes and packaging residues have seriously contaminated lakes including the largest freshwater lake in Britain and Ireland, Lough Neagh. As well as highlighting the global scale of plastic pollution, the work demonstrated that no lake, not even those furthest from human activity, can be considered truly pristine. Because lakes often contain high concentrations of microplastics, they can be considered 'pollution sentinels', as they collect and combine different sources of plastics from the wider catchment and the atmosphere. Lakes can retain, modify, and transport plastic debris across catchments to our seas and oceans. It was noted in this study that the plastics found in Lough Neagh were mostly fragments with some fibres and were made of polyethylene and polypropylene, which have harmful effects on aquatic life and the functioning of ecosystems. Results of this work should prompt countries across the globe to review pollution reduction strategies and waste management processes. The ecological impacts of climate change on Lough Neagh cannot easily be reversed, but with around half a million people living in the Lough Neagh catchment, we can be mindful of how fertilisers, wastewater and plastics can get into the environment. Making changes such as using less fertiliser, plastic packaging and synthetic fabrics could all help make a difference to improving water quality.

Dr Adrian Allen

Perets, V., Allen, A., Crispell, J., Cassidy, S., O'Connor, A., Farrell, D., Browne, J., O'Mahony, J., Skuce, R.A., Kenny, K., Gordon, S. (2022). Evidence for local and international spread of Mycobacterium avium subspecies paratuberculosis through whole genome sequencing of isolates from the island of Ireland. Veterinary Microbiology, Volume 268: 109416, Doi /10.1016/j.vetmic.2022.109416

Johne's disease caused by the bacterium *Mycobacterium avium paratuberculosis* (MAP) causes diarrhoea, wasting and reduced milk production in cattle. Historically, the

bacterium is tested with molecular tools to produce genetic fingerprints that are used for tracing sources of infection. We applied whole genome sequencing to an Ireland wide set of MAP samples, finding it provided superior resolution for epidemiological tracing. Comparison to archived wider European data also permitted production of time stamped family trees of the bacterium, which showed Irish samples shared an ancestor within the past ~50 years with samples from continental Europe. This was suggestive that MAP was brought to Ireland in already infected cattle, possibly via European trade networks related to formation of the EU and Single Market.

Frances Titterington

Titterington, F.M., Knox, R., Morrison, S.J., Shirali, M. (2022). Behavioural Traits in Bos taurus Cattle, Their Heritability, Potential Genetic Markers, and Associations with Production Traits. Animals, 12(19):2602

Cattle have the potential to seriously injure humans and cause damage to property. The risk of cattle reacting in a dangerous manner can be reduced through genetic selection for cattle which have a better temperament.

A literature search was undertaken which returned papers which met the criteria of "Bovine", "Genetics" and "Behaviour" or terms therein. Behavioural traits were grouped and their heritability, genomic associations and correlations with production traits examined. It was found that heritability estimates were more accurate in studies with large populations (n > 1000).

Gene associations with behavioural traits were found on all chromosomes except for chromosome 13, with associated SNPs reported on all chromosomes except 5, 13, 17, 18 and 23. Generally, it was found that correlations between behaviour and production traits were low or negligible, suggesting that genetic improvement can be undertaken without negatively affecting production. There was variation between the results of the studies examined, and this underlines that any genetic study is population specific. Thus, to assess the heritability, genetic associations with production and genomic areas of interest for behavioural traits, a large-scale study of the population of interest would be required.

Staff Highlights

Staff highlights

Dr Paul Caskie

AFBI economist, Dr Paul Caskie, has been appointed to the College of Experts for Office of Environmental Protection (OEP).

The OEP's role is to protect and improve the environment in England and Northern Ireland by holding government and other public authorities to account. It also has responsibility for reserved matters across the UK. The College was created in 2023 and has 54 members with backgrounds in environmental law or the natural or social sciences.

Members are drawn from academic and practitioner expert communities, to bring specialist knowledge of areas relevant to the OEP's remit, inform the organisation's strategy, and to provide focused expert input to detailed challenges facing OEP teams.

As a member of the College, there are valuable opportunities for Paul to network with leading researchers and practitioners from a wide variety of disciplines, which will be useful when AFBI economists are pursuing new research applications. Insights gained on OEP priorities will also inform the strategic direction of economic research in AFBI.

Prof Nicolae Corcionivoschi

In May 2023, Prof Nicolae Corcionivoschi became an Honorary Member of the Academy of Romanian Scientists (AOSR) at their General Assembly meeting.

The Academy of Romanian Scientists is a national forum of scientific consecration, which brings together leading representatives of science. The main goals of AOSR are to promote, develop, support, and protect science in all its forms, through actions and methods, be they direct, indirect or adjacent.

The main objectives of AOSR are to promote at national level interdisciplinary research, including agricultural microbiological research.

The impact for AFBI is significant as it helps Prof Corcionivoschi to establish links with academic bodies, research, and higher education institutions from abroad, and with scientists from abroad and foreign scholars. Moreover, it will help to promote young scientists by having access to scientific events and scholarships. This membership recognizes the high quality and the impact of AFBI of science in industry and academia.

Dr Derek Evans

In 2023, AFBI Freshwater Fisheries expert Dr Derek Evans (FAEB, EMSD) was appointed Director & Co-ordinator of the "Fish stocking guidelines" project by the European Inland Fisheries & Aquaculture Advisory Commission (EIFAAC).

EIFAAC are a regional body of the United Nations Food & Agriculture Organisation (FAO) based in Rome, whose Fishing Technology and Operations Team (NFIFO) promotes environmentally responsible, and economically efficient fishing operations through their regional bodies. EIFAAC's mission is to promote the long-term sustainable development, and responsible management of European inland fisheries and aquaculture. Delivery of these goals is through the provision of advice, & scientific information combined with encouraging stakeholder participation, communication and effective research. At the International level EIFAAC aligns its expertise with that of the International Council of the Seas (ICES) in the Annual stock assessment for European eel and it is through this dual connection that

Derek draws on his "fish stocking" expertise as the former Chair of the ICES Eel Stocking Review in 2016. The EIFAAC project consists of 32 scientists from across Europe with specific expertise in the best practice guidelines of the stocking protocols developed for a variety of freshwater fish species. The EIFAAC guidelines will be distributed beyond Europe, with a particular focus to Asian and developing nations to assist with their national stocking actions in the production of local food or habitat restoration projects.

Derek's appointment underlines AFBI's leadership in freshwater fisheries management not only in Northern Ireland, but with a wider influence internationally.

Prof Elizabeth Magowan

The British Society of Animal Science (BSAS) has a membership of almost 600 from across the UK, Ireland and beyond.

As the name suggests its key focus is on animal science and its dissemination. BSAS, together with France's National Research Institute for Agriculture, Food and Environment (INRAE) and European Federation for Animal Science (EAAP) deliver the journal 'animal' and its other main activities represent delivery of an annual conference; bespoke events on hot topics, such as the recent 'methane conference' and accreditation mainly for industry members.

At its core BSAS provides a strong supportive network for animal scientists to develop their career, build consortiums and connections and support each other.

Prof Elizabeth Magowan is the current president of BSAS. Elizabeth was voted into this position by the membership. As BSAS president and being supported by the wider presidential team of Helen Warren, Kim Matthews and David Kenny, BSAS trustees and CEO, Elizabeth has played a key role in setting the strategic direction of BSAS over the next 5 years and is actively delivering events to support the wider membership base.

The impact for AFBI is significant as membership of BSAS and this role enhances AFBI's position as a leader in animal sciences within the UK. This in turn enables AFBI to build and lead strong consortia and advance science and research to meet the needs of industry and policy makers.

Prof Steven Morrison

AFBI's Head of Livestock Production Sciences, Prof Steven Morrison was appointed as a Trustee of the British Society of Animal Science (BSAS) in June 2023.

In addition, he is Chair of its Awards and Sponsorship Committee and is also a member of the Finance, Income Generation and Governance Committee.

Steven's role is to establish and develop this key committee to develop a sustainable strategy that delivers events and services highly valued by BSAS individual members and corporate supporters. The committee will also set and secure awards to recognise excellence in all aspects of animal science from fundamental discovery to industry impact. Steven was also appointed to the BSAS Annual Conference organising committee for Belfast 2024.

(For further information on BSAS, please see the section for Professor Elizabeth Magowan).

Dr Pia Schuchert

AFBI Marine Fisheries expert Dr Pia Schuchert (FAEB, EMSD) was recently elected chair of the Ecosystem and Observations Steering Group (EOSG) at the International Council of the Seas (ICES) for the period 2024-2027.

ICES is an intergovernmental marine science organization, meeting societal needs for impartial evidence on the state and sustainable use of our seas and oceans.

ICES goal is to advance and share scientific understanding of marine ecosystems and the services they provide and to use this knowledge to generate state-of-the-art advice for meeting conservation, management, and sustainability goals.

The network consists of about 6000 scientists from over 700 marine institutes and from 20 member countries and beyond, including several members of the AFBI Marine Fisheries team. Pia will be chairing EOSG which is responsible for guiding and supporting the scientific work of expert groups gathering marine environmental data and ensuring that the data are effectively coordinated, integrated and quality assured. The EOSG plays a central role in taking marine survey and observation work into the future by developing monitoring to meet emerging data, science and advisory needs, so Pia will be playing a vital role by helping maintain a focus on integrated ecosystem assessment and ecosystem-based management.

Dr Erin Sherry

AFBI's Dr Erin Sherry has been elected as the incoming President of the Agricultural Economics Society of Ireland (AESI) from June 2024.

The AESI promotes knowledge in relation to agriculture, food, natural resources, bioeconomy and rural development, as well as fostering dialogue amongst academics, professionals, policymakers and industry representatives on emerging challenges and opportunities.

In addition to the general Annual Meeting, the society supports economists at an early stage of their career by holding a dedicated conference showcasing PhD and postdoctoral researchers, including a prize competition in honour of the society's first President Bob O'Connor.

Leadership in the society provides opportunities to forge collaborative relationships with policymakers and researchers, and position AFBI research at the core of international deliberations on vital and complex economic issues facing the sector.

Dr Masoud Shirali

AFBI Animal Geneticist, Dr Masoud Shirali, has been appointed to represent the United Kingdom on the management committee of the "EU COST ACTION: European Network on Livestock Phenomics."

This role is instrumental in developing new proposals within the EU and ensuring effective coordination and collaboration, spanning from September 2023 -2027.

Dr Shirali's involvement aims to address the knowledge gap in phenomics, fostering scientific collaboration, and advancing livestock phenomics concepts and applications to enhance the European livestock production sector's sustainability and competitiveness.

With approximately 187 lead scientists from over 36 member countries, his representation underscores his pivotal role in shaping future genome-to-phenome research in EU livestock production.

The "EU COST ACTION: European Network on Livestock Phenomics" serves as a platform for multidisciplinary collaboration, focusing on the systematic description of livestock traits and advancing phenotyping technologies, genome-to-phenome integration, computational resources, and regulatory frameworks.

Dr Shirali's participation in this network contributes to enhancing scientific collaboration, catalyzing developments, and ensuring the sustainable growth of the research landscape in the EU. His involvement underscores his instrumental role in influencing the direction of future research and contributing to the sustainability and growth of the research unit at AFBI.

Journal Articles 2022-2023

Journal Articles

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