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T Research

Research and innovation news at Teagasc

Plight of the bumblebee

Organic farming: unblocking the bottlenecks
Beefing up meat quality
Improving oestrus detection

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Changing face of postgraduate research training

From its establishment in 1988, Teagasc has attached high priority to training postgraduate students with a view to: providing research training opportunities for young scientists; facilitating liaison with third-level colleges; introducing new science into the organisation; and increasing the organisation's research capacity.

For many years, through its Walsh Fellowships Programme, Teagasc was the principal funder of postgraduate research trainers in Ireland.

In recent years, the Irish research environment has changed radically and more changes are afoot. A broad move to 'professionalise' graduate research training is underway, including the setting up of graduate schools in the universities, combined with a move to a four-year doctoral cycle involving a much stronger taught element in the PhD. Similarly, within Teagasc, new research structures will evolve as postdoctoral fellowships and principal investigators become more established. In addition, the nature of research across much of the agri-food/life sciences areas has also been changing. Traditional disciplines are melding together and new specialties are developing. In some areas, there has been a notable trend towards larger research teams, with implications for both postgraduate management and training.

Thus, the traditional image of a Walsh Fellow undertaking specialised research within a narrow technical topic is being challenged by a changing external environment in which there is far more competition for the best graduates and far greater attention to a broader training approach, and a changing internal Teagasc environment in which the role and organisation of the Fellow's research is also changing. In light of these changes, Teagasc recently commissioned a consultant to undertake an evaluation of the Walsh Fellowship Programme and to make recommendations for the future funding and management of postgraduate training in the organisation. The organisation will implement these recommendations with a view to ensuring the long-term development of the Programme and ensuring that it continues to operate as a premium postgraduate training programme.

Dr Lance O'Brien
Teagasc Head Office

T Economics

T Horticulture

T Credits

Teagasc — Agriculture and Food Development Authority

NDP — National Development Plan 2007 - 2013

AIB

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Post doctoral fellowship scheme

Teagasc has recently obtained sanction to implement a post doctoral fellowship scheme. The proposed scheme will offer individual funding over two years to researchers at an early stage of their career who plan to complete post doctoral level research in agriculture, food and related sciences. The Teagasc scheme aims to further develop and enhance the science and technology skills and knowledge of high quality scientists, and to strengthen the organisation's scientific base, thereby complementing government initiatives to build Irish research and technological development and innovation capacity and excellence, and develop a knowledge society and a knowledge-based economy. Teagasc proposes to fund the scheme from a mixture of external and internal funds, including funding a number of fellowships from the enhanced Dairy Levy Fund. Teagasc will also seek to use funding provided by national and international funding agencies, such as the Irish Research Council for Science, Engineering and Technology (IRCSET), the Environmental Protection Agency and the European Commission. Externally funded awards will be complemented with a small number of internally funded awards in areas of critical importance to the programme.

William C. Haines Dairy Science Award

Joseph O'Donnell, executive director of the CDRF (left), presents Professor Paul Ross with the William C. Haines Dairy Science Award.

The California Dairy Research Foundation (CDRF) has presented Professor Paul Ross, Head of the Biotechnology Department at Teagasc Moorepark Food Research Centre, with the William C. Haines Dairy Science Award in recognition of his contribution to the field of dairy science. Paul received his award at the 9th Cal Poly Dairy Ingredients Symposium in San Francisco recently, where he gave a presentation on mining biodiversity for fermented dairy products such as yoghurt and cheese.

Presenting the award, Joseph O'Donnell, executive director of the CDRF, said: "Professor Ross has played a leading role in creating a multinational focus on developing and delivering dairy products to a world in need of improved nutrition. His work in microbiology, especially in exploring lactic acid bacteria and probiotics and their antimicrobial peptides, will influence the future quality of dairy products."

The award, established in 2004, recognises individuals who, through their accomplishments in research and development in the field of chemistry, biochemistry, microbiology, technology, nutrition and/or engineering, have made a significant contribution to dairy science, the betterment of the dairy industry and consumers of dairy products.

Teagasc food industry training

A new food industry training and conference facility was recently opened at Ashtown Food Research Centre (AFRC). The Teagasc Food Training Programme operates from the AFRC in Dublin and provides specialist technical training for the food sector. Training is an integral part of Teagasc food industry development support towards achieving competitiveness, innovation, safety and quality in food. The training team consists of a core of 10 trainers and is supported by the expertise of a dynamic food research programme at Teagasc and also by external experts.

Teagasc is a national leader in the provision of specialist technical training and training development in this area. The training service is accredited to the international standard ISO 9000 and the centre is a registered FETAC Provider Training Centre under the National Qualifications Authority of Ireland. External accreditation helps to ensure that courses are designed to best standards and also that the training provides a transferable skill recognition for the participant. Training is aimed primarily at the food-processing sector and particular emphasis is given to food sector support programmes and regional food development programmes.

At the official opening of the new Teagasc Food Industry Training and Conference facility at AFRC were (from left): Tom Kirley, Acting Director, Teagasc; Declan Troy, Head of AFRC; Mary Coughlan, TD, Minister for Agriculture and Food; and Antonio di Giulio, Directorate General Research, EU Commission.

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Rural economy research centre opened

The new headquarters of the Rural Economy Research Centre (RERC) at Athenry were officially opened recently by Mary Coughlan TD, Minister for Agriculture and Food. The centre provides Teagasc with an important research resource, with 40 permanent staff, along with 20 PhD students under the Walsh Fellowship programme and 15 post-doctoral research posts.

Head of Teagasc RERC, Dr Cathal O'Donoghue, said: "RERC has developed a research capacity in policy modelling and analysis over the last 10 years that is internationally recognised. The National Farm Survey provides an unrivalled database for economic and rural development research and policy analysis. In addition, important research on rural viability is being undertaken".

Agricultural Research Forum 2007

Pictured at the annual Agricultural Research Forum in Tullamore were: Teagasc Moorepark Researcher Dr Mairead Bermingham with plenary speaker Dr John Sweeney, National University of Ireland, Maynooth. Dr Sweeney's plenary lecture was entitled 'Climate change: impact of agriculture in Ireland over the next 25-40 years.' Dr Bermingham presented a paper entitled 'Irish Holstein-Friesian cows are taller now than a decade ago', co-authored by Donagh Berry, Teagasc Moorepark and Andrew Cromie, Irish Cattle Breeding Federation. (Photo: Mark Moore.)

CAP health check

Teagasc recently hosted an international workshop on the impact of potential changes to the EU milk quota regime.

Later this year, the Common Agricultural Policy (CAP) will again find itself under scrutiny across EU Member States. In 2006, the EU Agriculture and Rural Development Commissioner, Mariann Fischer Boël, announced that there would be a 'health check' of the CAP in 2008. Consequently, the debate on the specifics of this health check is now starting to take shape. The European Commission has already strongly indicated that it does not envisage the continuation of milk quotas beyond 2015 and, therefore, the practicalities of a transition from a quota regime to a no quota system now need to be addressed.

To examine this issue, the Rural Economy Research Centre (RERC) is undertaking a study that will examine the impact of a transition to a no quota environment. As part of this study, farm and processing sector representatives participated in a Teagasc Dairy Stakeholder Workshop on milk quotas in November 2006 in order to ascertain their perspectives on the most relevant issues that need to be considered in this study.

The stakeholder consultation was followed by the above-mentioned international Dairy Quota Modelling Workshop, hosted by RERC, which took place in Dublin in February this year. Academics from around Europe and the US gathered to consider the complex economic issues involved in estimating how milk supply and demand around the EU would adjust as milk quotas are removed. "Since the EU has had milk quotas in place since 1984, this long period of supply management makes it more difficult to project how milk producers would react to the removal of the production constraint," explains Thia Hennessy, RERC.

The team of economists attached to the FAPRI-Ireland Unit at RERC, in conjunction with FAPRI (Food and Agricultural Policy Research Institute) at the University of Missouri, will examine the milk quota issue over the course of 2007. "A previous FAPRI-Ireland study looked at the milk quota issue back in 1998 but the circumstances facing the dairy sector today are somewhat different to those faced by the sector 10 years ago. In the time since the previous study was completed, two EU enlargements have taken place, significant growth in off-farm job opportunities has occurred and the sector now also faces the prospect of further changes in trade policy. Furthermore, the economic modelling capacity within Teagasc has developed substantially over the last decade. Hence, the 2007 study that is now underway is clearly warranted," Thia concluded.

GM seminar

Teagasc Rural Economy Research Centre, in association with the Agricultural Economics Society of Ireland and the Agricultural Science Association, recently hosted a seminar on issues associated with genetically modified crop technology in Irish agriculture.

Presently, no GM crops are cultivated in Ireland. However, it is anticipated that the introduction of co-existence guidelines could encourage the uptake of certain GM varieties. Hence, this timely seminar focused on regulatory, management and economic issues that will become increasingly important in the debate on the implications of GM technology for Irish agriculture.

Regulatory issues in relation to GM crop technology and the coexistence of GM and non-GM crops in Irish agriculture were addressed by Gerry Lohan, Department of Agriculture and Food, and Dr Ewen Mullins of Teagasc, Oak Park, outlined findings from recent research on GM crop technology in Ireland.

Dr Fiona Thorne from Teagasc Rural Economy Research Centre presented research findings from an inter-disciplinary project that examined the potential economic implications for Ireland of a voluntary adoption of a GM-free island.

Biofuels conference

Pictured at the Agri-Vision for Bio-Energy National Bio-Energy Conference 2007, held by Teagasc and the Department of Agriculture and Food, were (from left): Sir Ben Gill, Chairman, UK Biomass Task Force; Raymond O'Malley, farmer and rape processor; J.J. Kavanagh, Chairman, IFA Biofuels Committee; and Tom Kirley, Acting Director, Teagasc.

Sir Ben Gill gave a rousing speech on 'Biofuels, biomass: when will tomorrow become today?' at the Agri-Vision for Bio-Energy National Bio-Energy Conference held in Dunboyne, Co. Meath and Clonmel, Co. Tipperary. He called on governments to lead the way to make the use of biofuels a reality.

"A clear direction on the use of renewable fuels needs to come from all our central governments with the setting of targets and obligations where appropriate. In the case of liquid biofuels, this clearly argues the need for oil companies to be required by law to include a fixed percentage of renewable fuels in their mix and to pay a penalty for failure to do so. This in itself will drive the economics of the process in a way that has until recently not been clearly demonstrated," said Sir Gill.

"And for heat and electricity … in the next decade many of our (UK) coal-fired power stations will have to be phased out under new EU emissions directives. Governments should direct that they should be replaced by a much bigger number of more local power stations, using local resources of biomass from virgin crops to waste, and at the same time distribute the heat into the local neighbourhood."

World *E. coli* congress at AFRC

Pictured at the Pathogenic E. coli *Network (PEN) International Congress at Teagasc Ashtown Food Research Centre (AFRC) recently were (from left): Professor Yngvild Wasteson, NVH, Norway; Dr John O'Sullivan, PEN Project Executive Manager, AFRC; Dr Rosangela Tozzoli, ISS, Italy; Dr Geraldine Duffy, AFRC; Dr Declan Bolton, PEN Project Co-ordinator, AFRC; Professor Sven Lofdahl, SMI, Sweden; and Dr Chris Baylis, CCFRA, UK.*

Ag-Biotech Conference 2008

The Agricultural Biotechnology International Conference will take place in Ireland for the first time in August 2008. The conference provides a forum for internationally renowned speakers to address the challenges facing the global biotechnology industry.

Chairman of the 2008 Ag-Biotech Conference and Head of Teagasc Crops Research Centre, Jimmy Burke, said: "This conference offers a great platform to showcase our growing life sciences industries. Various Technology Foresight reports for Ireland have identified biotechnology as one of the core technologies that our country and Irish industry must now embrace. These reports have also identified the agri-food sector as one that can benefit significantly from the tremendous potential offered by modern developments in biotechnology." The conference is the largest agricultural biotech conference in the world and provides a unique opportunity for Irish academia and business sectors to discuss the issues, options and challenges being met by the biotechnology industry.

Slurry event

A demonstration of traditional and novel low-emission slurry spreading equipment took place at Teagasc Oak Park recently, with a particular view to meeting the challenges of the Nitrates Directive. Attendees were given a talk on the spreading of pig slurry onto tillage land as a long-term sustainable outlet. The event coincided with the 2nd International Workshop on Slurry Efficiency at Teagasc Johnstown Castle. Overseas visitors included Ken Smith, ADAS, Jaap Schröder, Wageningen University and Research Centre, and Ruth Grant, National Environmental Research Institute, Denmark. (Photo: Mark Moore.)

Irish productivity

Perspectives on Irish Productivity is a book of short, accessible essays by some of the leading economic and management thinkers in Ireland and overseas on various aspects of Ireland's productivity challenge. The book contains 25 contributions, each focusing on a specific aspect of productivity. Fiona Thorne, based at the Teagasc Rural Economy Research Centre in Kinsealy, co-authors a chapter on 'Productivity in Irish Agriculture' with Alan Matthews and Carol Newman from Trinity College Dublin. The book is available for download at www.forfas.ie/publications.

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ASA 2007 research fund

Applications are now being accepted from members of the Agricultural Science Association for its 2007 International Research Fund. Sponsored by AIB, the fund of up to €6,000 covers the cost of an international study. The closing date for applications is May 18. For further information, see www.asaireland.ie.

Delivering arable biodiversity

At a recent Association of Applied Biologists conference in the UK, delegates heard that it is easier to increase numbers of species when they are already present, rather than trying to reintroduce an extinct species, and then trying to increase their numbers. This point is particularly relevant to Ireland, where a number of reintroduction programmes are now underway (golden eagle and white-tailed eagle). These high-profile schemes raise the question: 'Would the substantial amount of resources being invested in such schemes be more wisely used in protecting some of our 18 native red-list species, many of whom are doomed to extinction unless drastic actions are undertaken?'

"There are many potential measures that have been developed in the UK that could be implemented in Irish agri-environmental schemes," says Dr Daire O'hUallachain, Teagasc Johnstown Castle. "These measures include small skylark plots (two 4m x 4m undrilled patches for each hectare of tillage). Such measures do not significantly reduce the crop yield, but their influence on biodiversity is significant. Some of these measures could be considered for future REPS schemes."

Johnstown Castle, in conjunction with UCD and UCC, has commenced a large-scale, innovative research project on potential new REPS measures to further protect and enhance biodiversity in field margins and riparian zones in Ireland. This project is funded by the Department of Agriculture and Food, under the Research Stimulus Fund.

Advances in milking

Dr Eddie O'Callaghan, Teagasc, addresses delegates at the Teagasc/IDF International Symposium on Advances in Milking in the Dairymaster parlour in Teagasc Moorepark. (Photo: O'Gorman Photography.)

The greenhouse effect

TREVOR DONNELLAN and KEVIN HANRAHAN examine greenhouse gas emissions from Irish agriculture, and how agricultural policy changes will impact on our Kyoto Protocol commitments.

Since the industrial revolution, fossil fuels (oil, coal and natural gas) have provided power for industry and facilitated the way of life we enjoy today. Owing to the use of fossil fuels, levels of atmospheric carbon dioxide have increased, which may augment the greenhouse effect to the point where a change in climate occurs. Higher levels of other trace gases, such as nitrous oxide (N_2O), methane (CH_4) and chlorofluorocarbons (CFCs), may also contribute to a change in climatic conditions. Collectively, these gases are referred to as greenhouse gases (GHG). Among developed countries, Ireland is relatively unusual in that agricultural production contributes to over one-quarter of total Irish GHG emissions in the form of methane and nitrous oxide.

As concerns about the potential future impact of global warming increase, EU Member States agreed in March 2007 to new and more extensive reductions in GHG emissions. The new agreement commits the EU to reducing its GHG emissions to 20% below their 1990 level by 2020. However, as of yet, the precise details of the agreement, including Ireland's contribution to the overall EU reduction target, have yet to be agreed. Notwithstanding this new EU agreement, the Kyoto Protocol, which was signed back in 1997, had already seen targets put in place for reductions in

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GHG emissions. The Protocol set specific limitations for GHG emission levels to be achieved by the first commitment period (2008-2012) in countries that are signatories to the agreement. These targets were set with reference to GHG levels in 1990. Most developed countries must reduce their GHG emissions below the 1990 level to comply with the Protocol. Within the EU, Ireland received a concession that allows an increase in its GHG emissions by no more than 13% above the 1990 levels by the first commitment period. Crucially, Ireland's GHG emissions have risen considerably since the 1990 base period, and have already breached the 13% permitted increase. Consequently, it has become necessary to monitor how emissions are likely to develop into the future. Compliance with the Kyoto Protocol requires that Ireland report on its projected level of emissions every two years and Ireland stands to be fined if it is unable to meet its Kyoto target.

Impact of climate change

While some remain sceptical about the evidence of global warming, the body of scientific opinion contends that a significant alteration of our climate is probable within this century, and among other things, this could impact on sea levels, agricultural production and the prevalence of diseases.

GHG emissions from agriculture heavily depend on the level of agricultural activity in the economy. The Common Agricultural Policy (CAP), trade policies and international supply and demand conditions for agricultural commodities each impact on the level of agricultural activity in Ireland.

The Rural Economy Research Centre (RERC), Teagasc, has developed a range of economic computer models at the FAPRI (Food and Agricultural Policy Research Institute)-Ireland Unit, which allow the projection of future levels of agricultural activity and GHG emissions under different scenarios. The methodology developed in Teagasc is at the forefront of international capacity in this area, and has been demonstrated at the Secretariat of the United Nations Framework Convention on Climate Change (UNFCCC) in Bonn.

Ireland's GHG emissions have risen considerably since the 1990 base period, and have already breached the 13% permitted increase.

Implications of agricultural policy for greenhouse gas emissions

The primary purpose of the FAPRI-Ireland modelling tools is to allow the economists at RERC to analyse the effect of policy changes on economic indicators such as the supply and use of agricultural products, agricultural input expenditure and sector income. In so doing, these models allow us to produce future projections of animal numbers and to input usage volumes (e.g., fertiliser, feed, fuel, energy) and other indicators. These data can be incorporated into related environmental models to enable the provision of base (inventory) data and future projections relating to GHG emissions from agriculture. The same approach can be used to produce ammonia emissions projections.

Earlier work by the authors in 2003 showed how the move to decoupled CAP payments would provide a significant side benefit for the Irish economy in terms of contributing to Ireland's Kyoto commitments. It was found that by the end of the commitment period, reduced overall agricultural activity would lead to a decrease in total GHG emissions from the agricultural sector of 15% relative to the 1990 level.

The most recent RERC agricultural GHG study in 2006 looked at how GHG emissions might be affected by a possible World Trade Organisation (WTO) agreement that would remove export subsidies and reduce import tariffs for agricultural products. Interestingly, this work, which has just been published by the Centre for European Policy Studies (CEPS), showed that in contrast to the policy changes introduced under the decoupling of production, the potential WTO reform examined in the study would not change to any great extent the future level of GHG emissions projected in the earlier 2003 study. Nevertheless, the evidence from this work is that changes in agricultural policy can help to contribute to the reduction in GHG emissions from agriculture. Policy makers now recognise that, in tandem with the development of new GHG abatement technologies and advances in farm management practices, agricultural policies may present a means of reducing GHG emissions from the sector.

Policy makers now recognise that, in tandem with the development of new GHG abatement technologies and advances in farm management practices, agricultural policies may present a means of reducing GHG emissions from the agricultural sector.

The work in this area represents another important arm in RERC's applied research output, which is targeted at national objectives. Studies of this kind facilitate the needs of the Department of Agriculture and Food, the Department of the Environment and the Environmental Protection Agency (EPA) in understanding and reporting on our Kyoto Protocol commitments. In the next stage of this work, RERC will collaborate with the Economic and Social Research Institute to produce a GHG emissions modelling tool for the whole economy in a project funded by the EPA. Work on this project should begin later in 2007.

For the authors' 2003 report see:
http://www.enarpri.org/Publications/WPNo16.pdf

To obtain a copy of the CEPS publication see:
http://shop.ceps.eu.

Trevor Donnellan and **Kevin Hanrahan** are Senior Research Officers in the FAPRI-Ireland Unit at the Rural Economy Research Centre, Teagasc, Athenry.


Oestrus detection: a modern take on an age-old problem

Work on oestrus detection currently being carried out in Moorepark could have long-term benefits for the Irish dairy industry. STEPHEN BUTLER explains.

The widespread use of artificial insemination (AI) at farm level, in conjunction with intensive genetic selection programmes to identify elite sires, has resulted in a truly remarkable improvement in the milk production potential of the dairy cow over the last half-century. The use of AI in Ireland is now at historically low levels, and is considerably lower than our international competitors, which in the long term will undermine the competitiveness of the Irish dairy industry. A Teagasc survey carried out in 2006 indicated that less than one-third of replacement heifers coming into the national dairy herd are from AI sires, the remainder being the progeny of a stock bull. This compares unfavourably with other countries; for example, >90% of replacement heifers come from AI sires in The Netherlands and New Zealand. The average Economic Breeding Index (EBI) of a stock bull is €8, compared to an average EBI of €78 for AI sires on the active bull list. A long-term strategy of using stock bulls instead of AI to generate replacements will reduce the rate of genetic progress, leading to a herd with a lower genetic potential and, ultimately, lower profitability. Importantly, the Teagasc survey highlighted inconvenience of heat detection and labour availability as the principal barriers to increased AI usage.

Oestrus expression

Successful use of AI requires the ability to accurately identify the precise time during a 21-day oestrus cycle when a cow is 'in oestrus', also commonly referred to as being 'in heat'. The duration of oestrus is about six to 10 hours, and during this time a number of behavioural and physiological changes occur that are telltale signs that a cow is in heat. The primary behavioural trait of oestrus is standing to be mounted by a herdmate or a bull. Cows will stand to be mounted approximately one or two times per hour during oestrus; the incidence is higher with a greater number of sexually active females in the group, and when the underfoot surface conditions are soft rather than hard (e.g., pasture vs. concrete).

A second trait associated with oestrus is increased physical activity; when housed, cows in oestrus have a roughly two- to four-fold increase in walking time compared to cows not in oestrus. The increased activity replaces time usually spent eating and, as a result, there is also a characteristic drop in milk yield around the time of oestrus **(Figure 1)**. There are numerous other changes associated with oestrus, including discharge of clear mucus, increased bellowing, swelling of the vulva, an increase in body temperature ('in heat') and release of attractant oestrus pheromones. These changes, however, are variable from cow to cow, and cannot be used on their own as reliable indicators of oestrus.

Heat detection aids

So how can the behavioural and physiological changes that occur during oestrus be used to reliably identify cows in heat and signal the correct time for insemination? Standing to be mounted by other cows is the definitive indication that a cow is in heat, but the total duration that a cow is receptive to being mounted could be as low as 30 seconds or less during a 21-day oestrus cycle. In the 1980s, tail painting – application of a narrow strip of paint along the tail head – was suggested as a heat detection aid; if the strip of paint remains intact, the cow has not been mounted, but if the paint is partially or completely removed, the cow has been mounted. Research from Moorepark has shown that the use of tail paint and visual observation three times per day can achieve a heat detection rate of 90%. This simple, practical technique remains the most widely used heat detection aid today.

A drawback of tail paint use is the need to reapply the paint two to three times per week (depending on weather conditions) during the breeding season. This is becoming a problem on dairy farms, as herd sizes expand in the face of ever-scarcer labour resources. The Kamar® device was developed in the 1960s in the USA. This detector is a pressure sensitive device with a

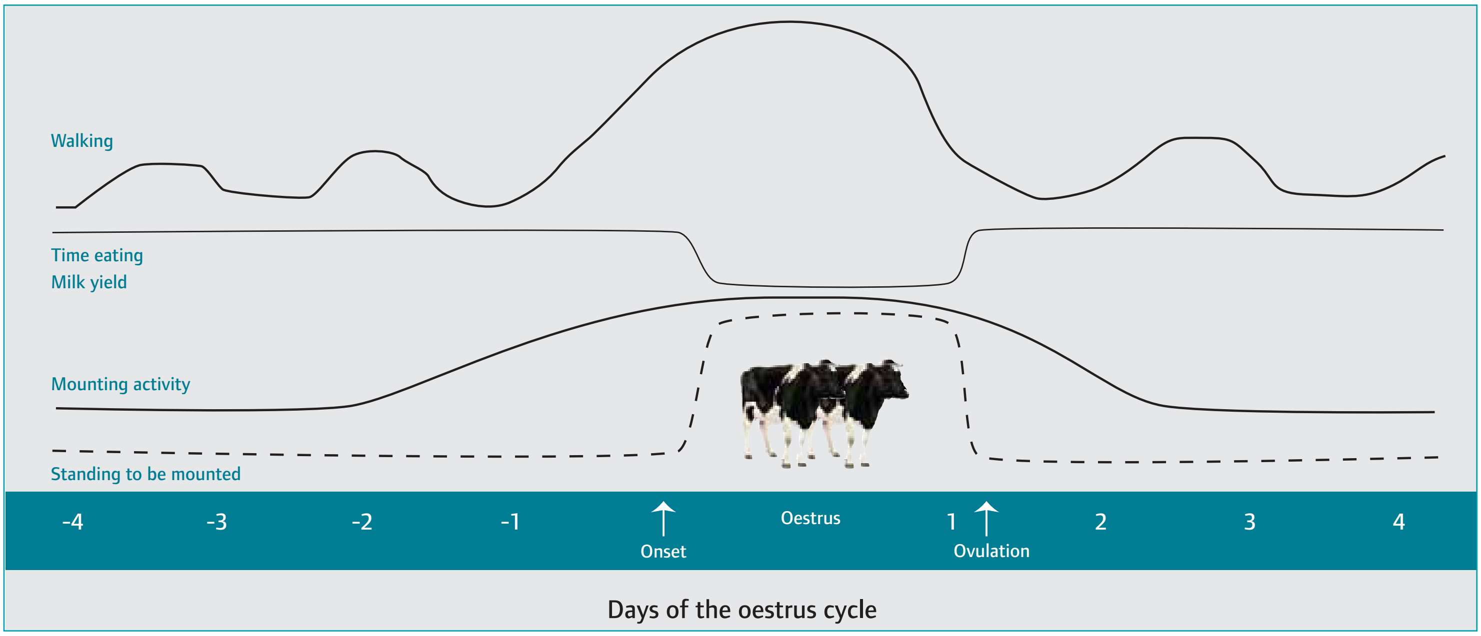

FIGURE 1: Schematic diagram illustrating the principal changes associated with oestrus in cattle.

built-in timing mechanism designed to be activated by standing heat behaviour. When glued onto the tail head, pressure from the brisket of a mounting animal requires approximately three seconds to turn the detector from white to red. This timing mechanism helps to distinguish between true standing heats and false mounting activity.

The use of AI in Ireland is now at historically low levels, and is considerably lower than our international competitors, which in the long term will undermine the competitiveness of the Irish dairy industry.

Application of the original Kamar® was a tedious process, as it required the addition of a liquid glue. A number of companies now produce alternative heat detection aids. Check Mate® is a device similar to the Kamar®, but it has a greater surface area for adhesion to the cow, and is manufactured with the glue already applied – simply peel off the back and stick the device on a clean, dry tail head **(Figure 2)**. Similarly, the Estrotect™ Heat Detector is a peel-and-stick-on device, but works on a different principle. This device uses simple 'scratch-off' technology, and works in much the same way as a lottery scratch card. Mounting by other cows scratches off the grey surface layer, revealing a bright fluorescent colour beneath. Multiple mounts are required to completely remove the grey surface, again minimising the likelihood of incorrectly identifying a cow in heat **(Figure 2)**.
The Check Mate® and Estrotect™ heat detectors will, according to the manufacturers, remain on the tail head for up to six weeks or more, representing a considerable advantage over tail paint where labour resources are scarce. A number of these new heat detection aids will be evaluated on commercial dairy farms during the 2007 breeding season in a new study set up at Moorepark, and results will be reported in a future issue of *TResearch*.

Automation of heat detection

As farm sizes expand, automation is replacing human labour for many of the daily routine tasks. Automatic cow identification, daily milk yield recording, concentrate feeding and cow drafting facilities are becoming common on dairy farms, and robotic milking suitable for pasture-based systems is on the horizon. The ultimate goal is to eventually incorporate automation of heat detection into this process; ideally, cows in heat would be automatically drafted for insemination at the end of the milking process. But what aspect of oestrus expression lends itself to automation of heat detection? Research to date has focused on the two primary signals of oestrus expression – standing to be mounted and increased activity.

Automated mount detectors

A number of devices work exclusively by recording the number of standing mounts and some also record the duration of each mount (e.g., HeatWatch®, MountCount®). These systems are based on a radiotelemetric device consisting of a radiowave transmitter linked to a pressure sensor that is secured to the tail head region using glue. Mounting by a herdmate for a minimum of two seconds results in activation of the pressure sensor, and produces a radiowave transmission. The transmitted signals are sent to a PC via a fixed radio antenna. While this device has provided a lot of information on the intensity and temporal variation in oestrus expression, its use at farm level has been limited due to cost and difficulty keeping the patches attached, and hence it is primarily used as a research tool.

A cow in oestrus standing to be mounted by a herdmate.

FIGURE 2: Top: inactivated (left) and activated (right) Check Mate® devices. Bottom: inactivated (left), partially activated (middle) and completely activated (right) Estrotect™ heat detectors.

A low cost approach to automated heat detection being developed at Moorepark involves taking a digital photograph of a heat detection aid (e.g., Check Mate® or Estrotect™) on the tail head region of each cow at each milking. As the colour changes that occur with these aids following activation are readily apparent, image analysis software could be calibrated to automatically determine when cows have been mounted. Eventually, it is envisaged that this process would facilitate automatic drafting of cows for insemination following identification of an activated heat detection aid.

Automated activity detectors

Pedometers are instruments for recording the number of steps taken over a period of time, and hence the approximate distance covered. A number of companies manufacture pedometer devices to allow daily measurements of the distance covered by dairy cattle, with the information being automatically retrieved by an interrogation device at each milking. The activity data for each cow is then compared against her activity over the preceding number of days, and cows with an abrupt rise in activity are flagged for examination. Additionally, some pedometry systems can be integrated into the milking process and deviations in milk yield (a reduction is expected on the day of oestrus) are incorporated into an algorithm to improve the likelihood of successfully identifying cows in heat. Further improvements in the accuracy of the system are possible by incorporating other in-line automatic measurements such as the temperature and electrical conductivity of the milk (an increase in both is expected at oestrus relative to the days prior to oestrus). Finally, because all these data are being collected automatically, and because the typical oestrus cycle is 21 days, the system can be programmed to know when a cow is expected to be in oestrus. To date, pedometry systems have not been extensively used in pasture-based systems of production. This is because cows travel variable distances each day to get to the grazing area; today the cows may be in a pasture close to the milking facility, tomorrow they may be at the furthest possible distance away. When this occurs, pedometer measurements are of little use. However, it should now be possible to correct for distances covered by the herd to get to the grazing area using computer software with appropriate algorithms. In the future, global positioning system (GPS) devices or accelerometers could further improve on the data captured by pedometers, as these will also be capable of differentiating the type of activity that the cows engage in, not just the amount of activity.

Unobserved oestrus is a major reason for poor reproductive performance, economic loss and frustration on dairy farms.

Conclusion

Heat detection is generally regarded as one of the most tedious and challenging tasks required for successful dairy farming. Unobserved oestrus has been reported to contribute twice as many days open as infertility, and hence is a major reason for poor reproductive performance, economic loss and frustration on dairy farms. A variety of heat detection aids now exist that, when used correctly, will improve heat detection efficiency. As herd sizes expand, automation of heat detection and drafting for AI will become an integral part of the milking process.

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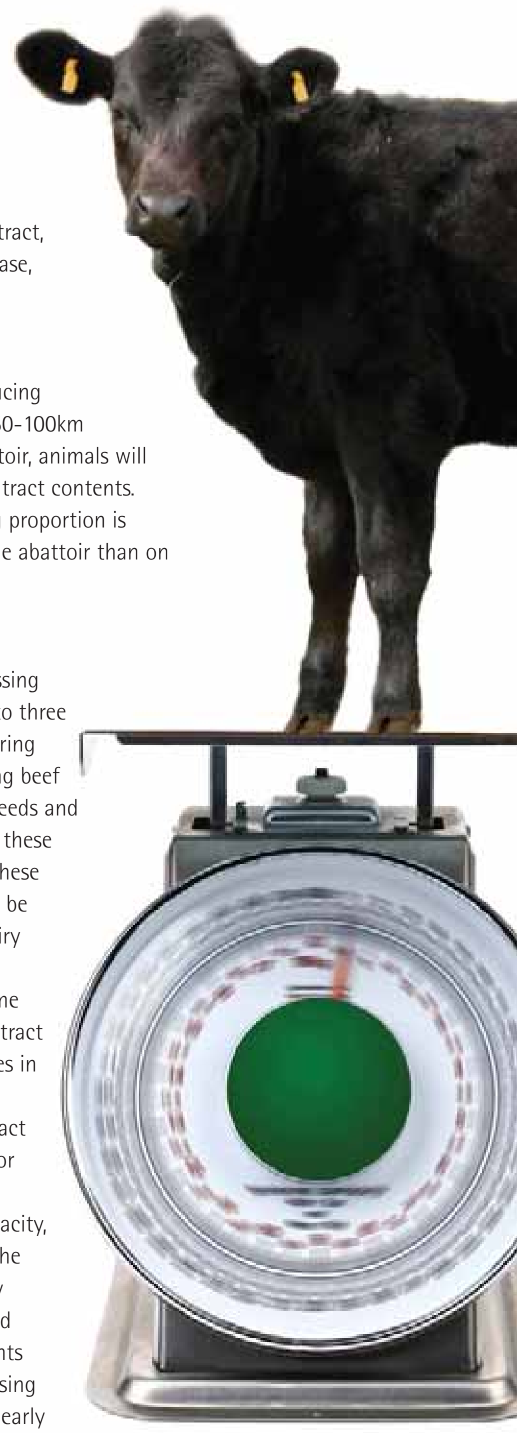
Dressing proportion variation in beef cattle

GERRY KEANE explains what causes differences in dressing proportion between animals at slaughter.



Dressing proportion, or kill-out as it is colloquially known, is an important trait in beef production that can vary greatly from one animal to another. It is defined as the proportion of cold carcass in the unfasted live weight, and is expressed as a percentage or as g/kg. As slaughter animals are paid for based on carcass weight, dressing proportion is of great interest to producers because it is the factor that converts live weight (which can be measured on the farm) to carcass weight (on which payment is based). Standard dressing procedures are agreed between representatives of producers and the export beef plants so there should be no differences between individual plants in dressing proportion for similar cattle. There may, however, be differences between export plants and domestic abattoirs because of differences in dressing practices. Their suppliers understand this.

The two main reasons why animals differ in dressing proportion are differences in digestive tract contents and differences in the proportions of the various offal components.

Digestive contents

Digestive contents can range from less than 120g/kg to in excess of 200g/kg live weight. It is a function of the digestibility and degradability of the diet, and of the weight and maturity of the animal. As digestibility of the diet increases, the indigestible fraction decreases, resulting in less indigestible feed residue in the digestive tract at slaughter. Conversely, as diet digestibility decreases, the quantity of feed residue in the digestive tract increases, resulting in greater tract contents at slaughter.

The relationship between feed digestibility and digestive tract contents is influenced by feed degradability. At the same digestibility, feeds can differ in degradability and, consequently, in residency time in the digestive tract. An example is the difference between grass and clover. At the same digestibility, clover has higher degradability and so moves faster through the digestive tract. When intake is constant, animals on higher degradability feeds (e.g., clover) have lower digestive tract contents, resulting in a higher dressing proportion. However, where feed is available *ad libitum*, intake may increase with increasing degradability. Depending on the balance between the intake increase and the decreased residency time in the digestive tract, total tract contents may increase or decrease, with consequential effects for dressing proportion.

When animals are disturbed, handled and transported they defecate more, thus reducing digestive tract contents. On a journey of 50-100km over two to three hours to a mart or abattoir, animals will typically lose 30-40kg of mainly digestive tract contents. Carcass weight is not affected, so dressing proportion is higher when based on arrival weight at the abattoir than on farm weight.

General breed effects

Breed type is a major factor affecting dressing proportion. Cattle breeds in Ireland fall into three broad biological types, namely, early maturing beef breeds and their crosses, late maturing beef breeds and their crosses and pure dairy breeds and their crosses. Not all breeds fit neatly into these categories, e.g., dual purpose breeds, but these often have beef and dairy strains that can be categorised with the relevant beef and dairy biological types.

Breeds differ in dressing proportion to some extent because of differences in digestive tract contents, but mainly because of differences in the proportions of offal components.

Differences between breeds in digestive tract contents arise because genetic selection for milk production in dairy breeds was accompanied by an increase in rumen capacity, permitting higher forage intake. Thus, at the same live weight, dairy breeds, particularly Holstein/Friesians, have a higher intake and consequently higher digestive tract contents than beef breeds, resulting in a lower dressing proportion. Differences in intake between early and late maturing biological types are not as clear cut, but some late maturing breeds, such as the Belgian Blue and Limousin have lower intakes and, consequently, lower digestive tract contents, than early maturing breeds such as the Aberdeen Angus and Hereford. This contributes to their superior dressing proportion.

Organ and tissue growth patterns

The main reason for differences between biological types in dressing proportion is differences in the proportions of offal or non-carcass parts. These differences arise because of differences in the relative growth patterns for the different organs, parts and tissues throughout life; (to eliminate the confounding effects of differences in digestive tract contents, growth and proportions of body parts and organs are expressed relative to empty body weight). In all species, growth is an allometric rather than an isometric process. This means that some parts, organs or tissues grow relatively more slowly or rapidly than others and so become, respectively, decreasing or increasing proportions over time. Many different methods and equations are used to describe allometric growth but the simplest and most widely used equation is:

$$y = ax^b,$$

Where y is the part, organ or tissue, and x is the whole unit of which y is part.

Thus y could be the head or hide weight and x the empty body weight. The equation describes how the weight (and consequently the proportion) of the head or hide changes as empty body weight changes.

Growth coefficients for various non-carcass parts relative to empty body weight are shown in **Table 1**. There are very big differences between offal components in their relative growth rates. With the exception of the offal fats, all offal components have growth coefficients <1.0, indicating that they grow more slowly and thus become a decreasing proportion of empty body weight over time. This is evident from the changes in proportions of these organs and parts as empty body weight increases from 500-600kg. In contrast, the offal fats grow more rapidly than empty body weight and so become an increasing proportion as empty body weight increases. However, the increasing proportion of fats does not completely offset the decreasing proportion of the other offal components, and as a result, the carcass has a higher relative growth rate than the empty body weight. Thus, it increases as a proportion of the empty body weight (i.e., dressing proportion increases with increasing slaughter weight).

TABLE 1: Allometric growth coefficients for offal components and carcass, and proportions (g/kg) of offal components and carcass at 500 and 600kg empty body weights.

	Growth coefficient (b)	Empty bodyweight (g/kg)[1] at 500kg	600kg
Hide	0.64	79	68
Head	0.64	37	32
Feet	0.55	24	20
Internal organs	0.61	39	33
Internal fats	2.15	22	35
Ruminal fat	2.76	14	30
Rumen complex[2]	0.53	41	34
Intestines	0.84	80	75
Carcass	1.04	600	611

[1]Offal components plus carcass do not sum to 1,000g/kg because some offal (e.g., blood and trim) and chill weight loss are not included.
[2]Includes reticulum, omasum and abomasum.

Offal components and carcass proportions by breed type

Friesians (FR), Hereford x Friesians (HF) and Charolais x Friesians (CH) are taken as representatives of dairy, early maturing and late maturing biological types, respectively. Empty body weights, together with the proportions of offal components for these three breed types, taken from a study at Grange, are shown in **Table 2**. FR had significantly higher proportions of internal organs, offal fats and gastrointestinal tract, and a significantly lower proportion of hide, than the two beef crosses. They also had a significantly higher proportion of head/feet/tail than HF but not CH. HF had significantly higher proportions of hide and offal fats than CH. Arising from these differences, FR had a higher proportion of total offal components and a lower proportion of carcass (i.e., a lower dressing proportion) than both HF and CH. Similarly, HF had a higher proportion of total offal components and a lower proportion of carcass (i.e., lower dressing proportion) than CH. The cold carcass proportions were 13g/kg and 24g/kg higher for HF and CH, respectively, than for FR. These correspond closely to the differences in dressing proportion observed in practice between these breed types and indicate that at the same slaughter weight (e.g., 630kg) HF and CH would have about 8kg and 15kg, respectively, more carcass than FR.

The differences in offal components and carcass proportions shown in **Table 2** do not represent the full range found in commercial practice. This is because the animals were all steers out of Holstein-Friesian cows. In practice, dressing proportion can vary from <500g/kg for poorly finished Holstein steers to >600g/kg for continental type young bulls. Double muscled young bulls have an even higher dressing proportion. At the same slaughter weight, bulls have at least a 15g/kg higher dressing proportion than steers, all else being equal. This is due to their lower digestive tract and contents proportion (younger, with less developed digestive tract and lower intake) and lower internal fats. Likewise, heifers have a 10-15g/kg lower dressing proportion than steers, partly because they are lighter (it has been shown earlier that dressing proportion increases with increasing weight), partly because the reproductive tract is extra offal and partly because of higher internal fats.

Dressing proportion by biological type and fat class

As shown already, dressing proportion varies with biological type and slaughter weight. Within biological type, weight and fat class are closely related, and fat class is more often the slaughter criterion than weight. The relationships between biological type, fat class, slaughter weight and dressing proportion are shown in **Table 3**. Here, for better definition, the late maturing biological type is split into progeny from late maturing sire breeds

TABLE 2: Offal components and carcass as proportions (g/kg empty body weight) for FR, HF and CH steers representing dairy, early maturing and late maturing biological types, respectively.

Breed type	FR	HF	CH
Empty bodyweight (kg)	516[a]	505[a]	532[b]
Hide	67[a]	79[c]	72[b]
Head/feet/tail	59[a]	57[b]	58[ab]
Internal organs	36[a]	34[b]	33[b]
Offal fats	67[a]	60[b]	52[c]
Gastrointestinal tract	110[a]	102[b]	100[b]
Blood and trim[1]	79	73	79
Total offal components	418[a]	405[b]	394[c]
Cold carcass	582[a]	595[b]	606[c]

[1]Not measured, estimated by difference, includes chill loss.
FR = Friesian, HF = Hereford x Friesian, CH = Charolais x Friesian.
Values within a row with common superscripts do not differ significantly.

TABLE 3: Slaughter weights and dressing proportions at fat classes 3, 4 and 5 of steers of four biological types.

Fat class		Biological type			
		Early	Dairy	Late (D)[1]	Late (C)[2]
3	Slaughter wt. (kg)	530	570	590	600
	Dressing (g/kg)	515	505	525	540
4	Slaughter wt. (kg)	590	640	680	700
	Dressing (g/kg)	530	520	545	560
5	Slaughter wt. (kg)	650	700	750	790
	Dressing (g/kg)	540	530	565	580

[1]Late maturing out of dairy cows.
[2]Late maturing out of continental cows.

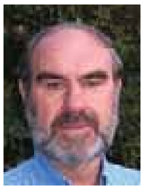
and dairy cows (late D), and progeny from late maturing sire and cow breeds (late C). At any fat class, slaughter weight is in the order: early < dairy < late (D) < late (C), with the difference between biological types holding reasonably constant across fat classes. Dressing proportion ranges from 515g/kg for the early type slaughtered at fat class 3 to 580g/kg for the late (C) type slaughtered at fat class 5. These are mean values and the values for individual animals within a class can vary greatly depending on breed type, slaughter weight and diet. Also, these values are for steers. At the same fat class, bulls would be considerably heavier with a higher dressing proportion, while heifers would be considerably lighter with a lower dressing proportion.

Maturity and fatness

As some offal components are early maturing (e.g., feet, hide and metabolic organs) and some are late maturing (e.g., internal fats), changes in dressing proportion with increasing weight depend on the balance between the early and late maturing components. In nearly all situations, the increase in the late maturing category is less than the decrease in the early maturing category, and so dressing proportion increases with increasing slaughter weight. The extent to which this happens, however, depends on the balance between the increasing and decreasing offal components. Breed types that have a high relative growth rate of internal fats (e.g., early maturing and dairy breeds) have a lower increase in dressing proportion with increasing slaughter weight than breeds with a lower relative growth rate of internal fats. If animals are retained to a stage of advanced fatness where growth of the early maturing offal components has almost ceased, then further increases in slaughter weight can be accompanied by a decrease in dressing proportion because the increase in the internal fats is greater than the decrease in the early maturing components.

Conclusions

Variations in digestive tract contents, and in organ and tissue growth patterns, are the main reasons for differences between animals in dressing proportion. As the quality and passage rate of feed increase, there is less indigestible residue retained in the digestive tract, resulting in a higher dressing proportion. Breeds and crosses can be grouped into biological types that differ in the growth patterns of the various offal components and the carcass. Dairy breeds have larger metabolic organs, a larger gastrointestinal tract and more internal fats than beef breeds, leading to a lower dressing proportion. Early maturing beef breeds have heavier hides and more internal fats than late maturing beef breeds, also leading to a lower dressing proportion. The heavier the animal, the greater the differences due to different organ and carcass growth patterns, so differences in dressing proportion increase with increasing slaughter weight. Dressing proportion generally increases with increasing weight and fatness because the differences in the early maturing offal components (e.g., structural and metabolic organs) more than offset the increases in the late maturing offal components (e.g., internal fat).



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Beefing up meat quality

RUTH HAMILL, DEIRDRE CORCORAN and ANNE MARIA MULLEN delve into how the tools of genomics can help improve meat quality.

Ireland has a good reputation internationally for producing high quality beef. However, quite often the quality of the meat that reaches the consumer's plate is variable in terms of some or all of the attributes that constitute quality. Technologies such as microarrays, real time PCR and the tools of proteomics are allowing researchers in the Ashtown Food Research Centre (AFRC) to delve deeper into the molecular and biological processes underpinning meat quality. Identification of the molecular signatures associated with meat quality and understanding how they respond to external stimuli (pre and post slaughter) will aid in the delivery of consistent quality meat, which attains market specifications.

Market research in some of Ireland's key export markets has given clear signals that beef consumers rate flavour, tenderness and juiciness as being really important in their 'eating experience', with tenderness being foremost in determining satisfaction. However, these can be disappointingly variable from one meal to the next. It is impossible to predict how tender and flavoursome a steak or chop will be just by its appearance in a retail pack. Therefore, providing consistently tender beef should be a key priority for the beef industry. While there have been many successful efforts at improving the tenderness of beef, an unacceptable level of variability still remains.

Post-mortem treatment

While many factors contribute to the variability in meat quality, from feeding through to animal management, when referring to eating quality (palatability) the most critical factors are those that occur post mortem. In particular, the early post-mortem handling of carcasses is paramount, with the chilling regime, method of hanging, boning and length of post-mortem ageing exerting an impact. Research has enhanced our understanding and optimisation of management systems for meat quality. However, even when all processing variables have been optimised, individual variation from animal to animal in meat quality remains evident. To date, it has been quite difficult to factor in this biological component of meat quality. It is perhaps not surprising that a significant proportion of the variability in these key components of palatability is dictated by the fundamental heritable material, the genes. Some of this variability is due to differences among individuals in DNA sequence in key genes; some is caused by variation in expression level or interactions between genes; and a further subset may be attributed to differences in protein complement and activity. The manner in which these interact with environmental factors (pre and post slaughter) influences the ultimate product quality. Increasing our understanding of the molecular basis of quality is driving current meat research across the globe, with the ultimate goal of improving these traits by employing a more informed animal selection process and through optimisation of management systems for quality.

Providing consistently tender beef should be a key priority for the beef industry.

Traditional selection

Part of the reason for this residual variability is because it is not as straightforward to improve meat quality traits by traditional selection when compared with improvements that were made in traits such as growth rates or milk yield in dairy cows – traits that can be measured easily or early in life. As eating quality can only be reliably measured post mortem, animals cannot be easily incorporated in traditional selection programmes. It could even be argued that a decline in eating quality has accompanied powerful, but unbalanced, selection strategies for other traits.

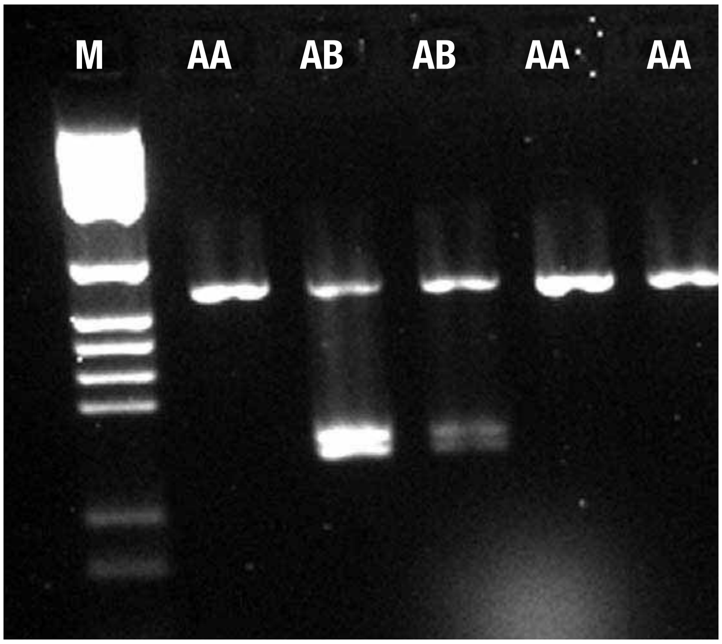

FIGURE 1(a).

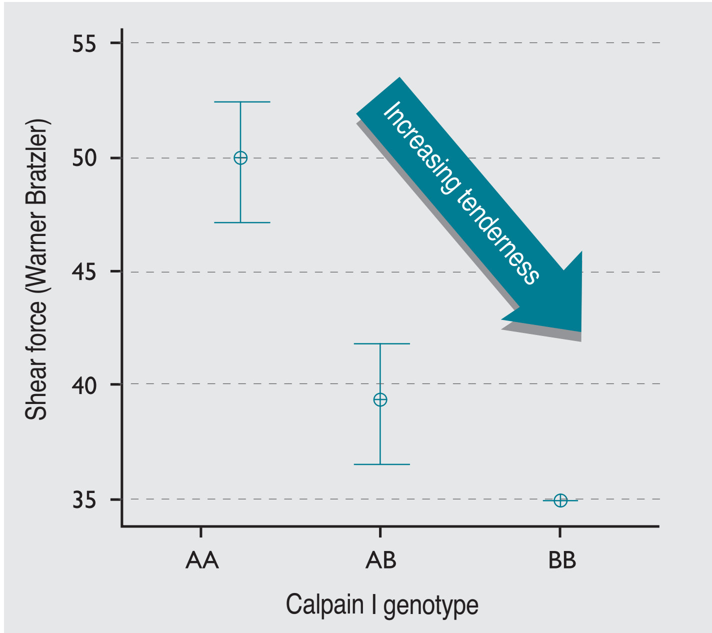

FIGURE 1(b).

FIGURE 1: Individuals are genotyped for a marker in the calpain I gene by the PCR-RFLP method (1a). M is marker ladder. Genotypes are tested for association with meat quality phenotypes, such as tenderness. The degree of tenderness in Irish beef (measured as Warner Bratzler shear force on beef aged for 14 days, 95% confidence intervals shown) is partly dependent on genotype at this calpain I marker (1b). Animals with the AB genotype produce more tender beef on average, as indicated by reduced shear force, compared with those of the AA genotype (only one individual had the BB genotype).

Fortunately, we are now entering an exciting period where a new generation of genomic technologies is now becoming accessible to researchers in the agri-food sector and, in particular, to researchers at AFRC. These have fundamentally changed our ability to study the molecular basis of cells and tissues, giving a more in-depth insight. In the past, research advancements in understanding the genomic aspects of biological traits that are of economic importance were restricted due to a lack of knowledge of the genome of domestic animals. With the publication of the bovine genome sequence, the scope for discovery and further elucidation of the genes involved in determining beef quality has never been wider. Both the human and bovine genome projects have helped to elucidate the function of large portions of the genome, and the pig genome project is also well underway. Following on from the first bovine genome sequenced (that of a Hereford heifer, by the name of L1 Dominette), representatives from a number of other breeds are also being sequenced, which will give us key insights into variability, both across the genome and in important genes among different breeds, and is giving us the opportunity to test natural variants in DNA sequence that are being identified for association with meat quality.

DNA polymorphisms and meat quality

In a competitive commercial environment, the benefits to be gained from selection for slight improvements in production and/or more consistent quality within the population are significant. If desirable DNA variants can be identified that have significant physiological associations with meat quality, these may be combined with estimated breeding values (EBVs) and incorporated into best linear unbiased prediction (BLUP) models in a process known as marker-assisted selection (MAS). During the past few decades, advances in molecular genetics have led to the identification of multiple genes, or genetic markers associated with genes, that affect traits of interest in livestock. These markers are known as single nucleotide polymorphisms (SNPs) as they result from a single base change, which may, however, be of critical functional importance. Depending on the location of the SNP in the gene, resulting effects include changing the nature of the coded protein, modulating levels of protein production or inactivating a gene.

Increasing our understanding of the molecular basis of quality is driving current meat research across the globe.

Several markers for tenderness in beef have been identified from the calpain I gene, a proteolytic enzyme that breaks down muscle myofibrils, and its inhibitor, calpastatin. Significant associations between these markers and tenderness in Irish beef have been detected at the AFRC, indicating the potential for genetic improvement in this trait **(Figure 1)**. Candidate genes for beef marbling include the leptin gene, the thyroglobulin gene, the DGAT (diacylglycerol acyltransferase) gene, which is also involved in the regulation of milk fat level and the fatty acid binding protein family, although research at the AFRC suggests that these SNPs may not be as influential on intramuscular fat content in Irish beef.

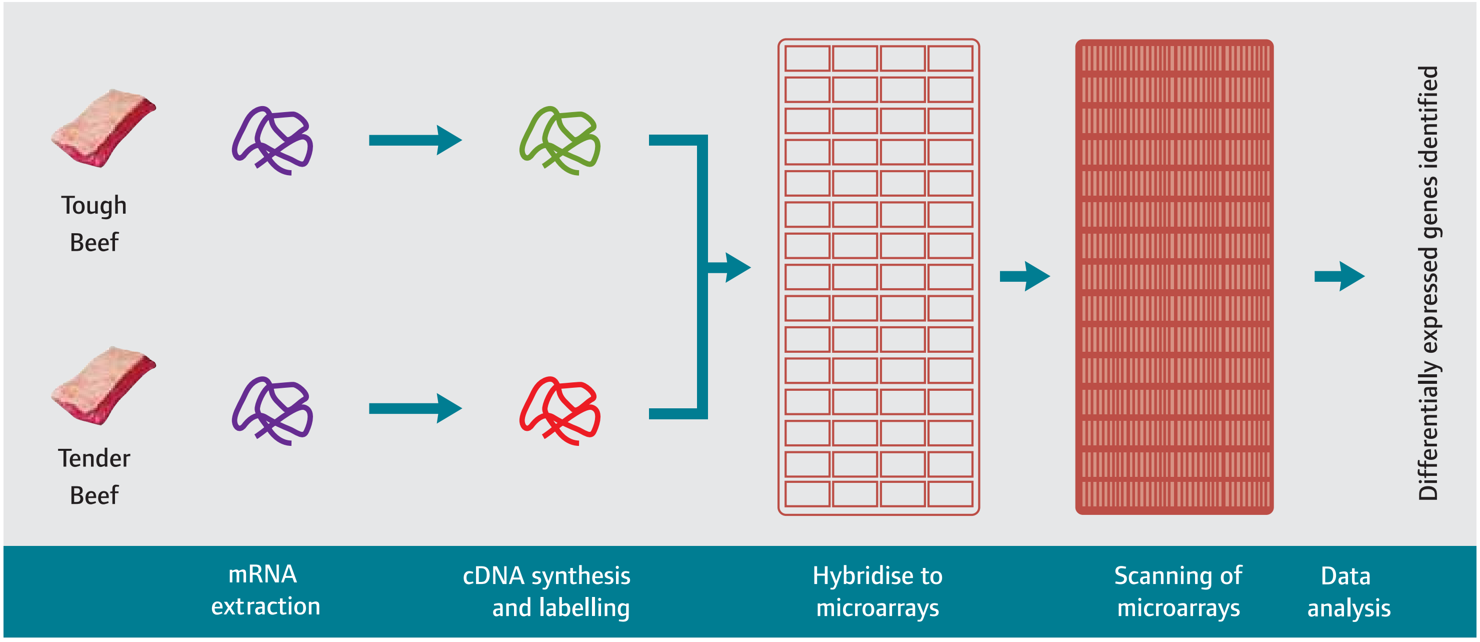

FIGURE 2: Simplified diagram of a microarray experiment. RNA is extracted from tough and tender beef, converted to cDNA and labelled with fluorescent dye, then cDNA is competitively hybridised to complementary probes on the array surface and differentially expressed genes are subsequently identified.

With pork, MAS has been most successful in the elimination of undesirable traits, ensuring more consistent meat quality from the population. However, resource populations of inter-breed crosses with divergent traits have been used to identify candidate genes for intramuscular fat in pigs. Traditionally in Europe, there has been strong selection for lean growth, whereas in China pork meat with a high fat content has been selected. Mapping inter-breed crosses of Chinese and European pigs resulted in the identification of IGF-2 (insulin-like growth factor-2) as a likely candidate gene.

At present, the increased profit due to the incorporation of molecular markers in selection programmes is derived mainly from sires with favourable allelic combinations achieving increased market share of breeding stock. A number of companies are currently marketing commercial tests for polymorphisms in genes that are related to particular meat quality phenotypes in beef production. These genotyping companies recommend that breeders select sires with high average scores across markers (i.e., high proportion of desirable variants), and avoid breeding from low scoring sires. However, it is also becoming possible for producers to subgroup animals according to genotype at multiple markers and manage animals for different goals. While the importance of genetic markers in animal selection is likely to grow in the coming years, a balanced approach must be taken to ensure that they enhance, but not supplant, traditional selection methods.

Advanced techniques

In the AFRC, gene expression analyses are carried out in parallel with genotyping studies. The reason for examining gene expression is to garner a clearer understanding of the production of proteins and the role each gene has in governing the phenotype of the trait of interest. In meat, as in any other mammalian tissue, thousands of genes are expressed at any given time. The goal is to identify and obtain a better understanding of the genes regulating muscle composition and their activities at key time points, such as those regulating muscle degradation in the immediate post-mortem period, which is an important period for meat tenderisation, as well as those genes that control the phenotypic traits used to describe meat quality (e.g., driploss, intramuscular fat, tenderness).

Techniques for evaluating gene expression have progressed from methods developed for the analysis of single specific genes (northern blotting, slot and dot blotting, semi-quantitative polymerase chain reaction [PCR]) to those focused on identifying a range of genes simultaneously that differ in expression between meat samples of differing quality (microarrays). Although microarrays are a relatively simple technology, they are revolutionising genomic research and the medical sciences. A microarray is a small glass slide that is coated with segments from thousands of genes. In the latest arrays, up to 200,000 gene segments may be represented on a single slide, giving the largest ever coverage of the genome.

Microarrays are now an invaluable exploratory tool to provide information on differentially expressed genes and enhance our understanding of the biological pathways that underlie the delivery of consistently high quality meat.

An ongoing collaborative project between the AFRC, University College Dublin and the National Diagnostics Centre has applied the suppressive

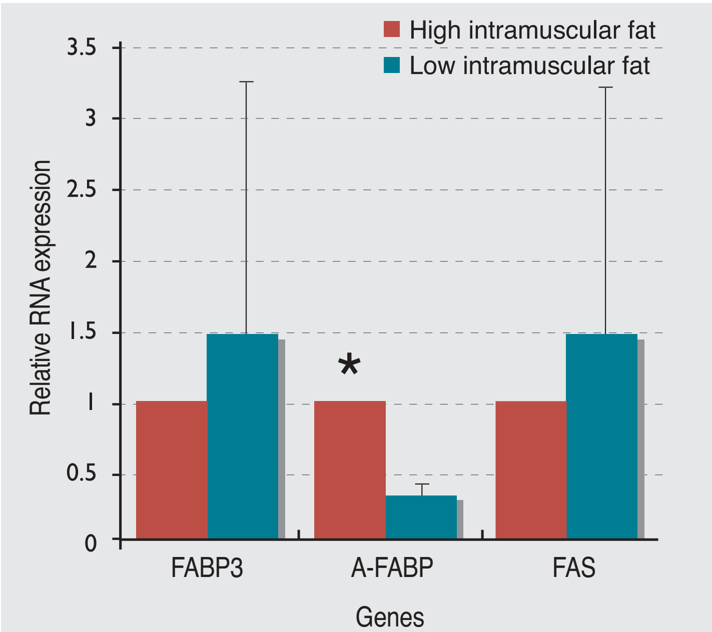

FIGURE 3: Abundance of gene transcripts can be measured using real time PCR. A real time PCR experiment carried out in the AFRC shown here indicated that the gene adipocyte-fatty acid binding protein (A-FABP), important in fatty acid deposition pathways, was significantly more highly expressed in tissue with a higher intramuscular fat level (indicated by asterisk). Other genes (FABP3 and FAS) were not found to be differentially expressed.

Post-mortem handling of carcasses is paramount in determining palatability.

subtractive hybridisation (SSH) technique to beef samples showing extremes of quality to create a muscle-specific cDNA library and, subsequently, a microarray. This microarray is being utilised to identify differentially expressed genes in meat samples that display extremes of phenotypes for intramuscular fat, driploss and toughness/tenderness. This greatly facilitates assessment of the molecular and biological processes underpinning meat quality. Across the scientific community, microarrays are providing ever-increasing insights into muscle biology **(Figure 2)**. Global gene expression profiles have been compared between white and mixed red fibre types, between muscles in steers fed varying quality diets and between two breeds of cattle with different meat quality merits (high versus low intramuscular fat).

From a mechanistic point of view, gene expression pathways were studied in fibroblast cells to elucidate the adipogenesis (fat deposition) process. In the AFRC, researchers are carrying out gene expression studies with the specific goal of understanding the molecular processes determining meat quality, namely through the identification of genes that play a role in determining driploss, intramuscular fat **(Figure 3)** and tenderness of meat. This focused approach to understanding the fundamentals of meat quality will become the building blocks to ultimately identify the key to consistently high quality meat.

Influential genes

Advances in beef genomics will have two major outcomes. The first will be the identification of genes that have different levels of expression depending on the phenotypes (meat samples) compared. Secondly, these highlighted genes may be of importance in critical biological functions relevant to meat quality and may ultimately form the basis for identification of a signature profile of quality meat. Gene expression levels may differ depending on genetic (e.g., breed) or environmental factors (diet, stress level) and the quest is to identify the most influential genes and the optimal production/processing environment from 'farm-to-fork', culminating in the delivery of consistently high quality beef. The full value and applications of the species genome projects will be realised only when the actual genes and gene products (proteins) that co-ordinate and regulate important animal and product quality traits are known and understood. An ideal application of this research would include incorporation of the outputs into management systems for quality. This is being tested at AFRC, where a holistic and multi-faceted model, originating in Australia (Meat Standards Australia), is being assessed for application in the Irish beef sector.

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Cheese: unravelling flavour and aroma

KIERAN KILCAWLEY describes the important compounds and mechanisms involved in developing cheese flavours and the facilities at Moorepark that are being used to monitor them.

The economic value of cheese in Ireland today is approximately €220 million and the volume of cheese produced is estimated to be 130,000 tonnes per annum, most of which is exported. Cheddar cheese is by far the largest volume cheese produced at about 80%. The remaining 20% of cheese produced is comprised primarily of Mozzarella, Emmenthal, Gouda, Swiss and Italian-type hard and semi-hard cheeses. These non-Cheddar varieties have seen growth in recent years as market demand exceeds supply, particularly in parts of Southern Europe. If these trends continue, it is likely to result in a greater volume and diversity of cheese production in Ireland. It has been predicted that cheese production in Ireland could grow to approximately 176,000 tonnes by 2015. In addition to large scale manufacture, Ireland has a burgeoning farmhouse cheese sector consisting of more than 60 companies that produce about 1,000 tonnes per annum. The scale of operation and variety of cheese produced varies markedly, with a considerable volume being exported.

Cheese research

In order to facilitate growth within these different cheese sectors, and to expand and develop new markets, Irish producers need to understand all aspects that impact on cheese production. Moorepark Food Research Centre (MFRC) has a long established history of cheese research, particularly in collaboration with University College Cork and, more recently, the University of Limerick and University College Dublin. Understanding the mechanisms that influence cheese flavour and aroma are critical facets of this research.

Understanding cheese flavour

To elucidate the flavour profile of any cheese is particularly difficult due to the presence of many flavour- and odour-active compounds, and because of the dynamic nature of the product, where compounds are continually being created and degraded. Cheese flavour has been investigated by many international groups over a number of decades, and for most varieties the definitive properties remain elusive. The compounds that influence cheese flavour/aroma are derived from the degradation of proteins (proteolysis), carbohydrates (glycolysis) and lipids (lipolysis) during production and ripening, the extent of which is usually characteristic of that variety. The primary agents influencing cheese flavour are: milk type and quality; indigenous milk enzymes; starter lactic acid bacteria; the coagulant (chymosin); growth of adventitious non-starter lactic acid bacteria (NSLAB) during production and ripening; and addition of moulds, yeasts or smear bacteria depending upon the cheese type. All of these biological and enzymatic agents are then subsequently influenced by make procedures and ripening regimes.

Complexity of Cheddar cheese

Cheddar cheese is a very good example of the complexity of cheese flavour. It is the most studied of all cheeses, primarily due to its popularity in the US, Great Britain, Canada, New Zealand, Australia and Ireland. However, the flavour profile of Cheddar remains elusive and is best described by the 'component balance theory', which states that cheese flavour is probably due to the correct balance and concentration of a wide variety of volatile sapid flavour compounds rather than any particular component. Even though we do not have a definitive answer, we do understand most of what occurs during production and ripening to influence Cheddar flavour. Cheddar is possibly one of the most difficult cheeses to study for a variety of reasons: an exact standard protocol of production does not exist; it is marketed as a mild, medium, mature or vintage cheese; and often has different characteristic sensory attributes.

Cheese is worth about €220 million to the Irish economy, with the volume of cheese produced being about 130,000 tonnes per annum, most of which is exported.

Flavour generation pathways of Cheddar cheese

Proteolysis

Most of the flavour components of Cheddar cheese are derived from protein degradation. Protein degradation is generally recognised as occurring in three separate phases:

- primary proteolysis, where large proteins, such as α-caseins and ß-casein, are hydrolysed to intermediate size peptides by chymosin and indigenous milk proteinases;
- secondary proteolysis, where further degradation of these intermediate proteins to small peptides and free amino acids occurs due to the action of proteinases and peptidases from starter lactic acid bacteria and the growth of NSLAB; and
- tertiary proteolysis, which is the catabolic degradation of free amino acids, and is the result of enzymatic, metabolic or spontaneous processes arising from live, dying or dead lactic acid bacteria and/or NSLAB during ripening.

The large peptides or intermediate peptides do not contribute to flavour directly; however, some intermediate and small peptides are responsible for bitterness. The aromatic, branched-chain and sulphur-containing amino acids directly contribute to cheese flavour; however, it is the catabolic products of free amino acids that appear to have the greatest impact. Many of these compounds are flavour and aroma active, such as aldehydes, alcohols, hydroxy acids, thiols, sulphur compounds, α-keto acids, esters, ammonia and carboxylic acids. Most are unstable and some need only be present at a few parts per billion (ppb) to have an impact on flavour/aroma. One of the most important findings recently was the discovery that it is not the production of free amino acids that is a rate limiting factor in cheese flavour but, rather, the lack of aminotransferase enzymes involved in the transamination of amino acids to α-keto acids. α-keto acids are highly odour active but, even more importantly, they are precursors for hydroxy acids, aldehydes, alcohols, esters, carboxylic acids and sulphur compounds.

Glycolysis

The metabolism of lactose (glycolysis) is also very important in Cheddar cheese production as it controls the pH, a critical aspect of all cheese production. It has huge implications for physical, microbial and biochemical events during production and ripening. In Cheddar cheese, mesophilic starter lactic acid bacteria are added to the milk at the start of the manufacturing process. Their main role is to ferment lactose to primarily L-lactic acid (L-lactate). Once a required pH is reached the whey is drained from the curd. Most of the remaining lactose partitions with the whey and only approximately <1.5% is left in the curd. The bacteria continue to act on residual lactose during the Cheddaring process, but only small decreases in pH are evident after salting and pressing. Salt has a significant influence on activities of starter. Levels of salt in moisture in the cheese are very important indices of cheese quality, due to its impact on residual lactose in cheese curd during ripening, and the metabolic and enzymatic activities of starter bacteria and adventitious NSLAB.

L-lactate contributes directly to the flavour of young cheese, but can also be degraded by NSLAB to acetate, ethanol and CO_2. Acetate is highly odour and flavour active and is present in Cheddar cheese. Ethanol can impact on flavour directly or indirectly as it is a precursor for other flavour compounds known as esters. Citrate is also metabolised in Cheddar cheese, however, after whey drainage only 0.2-0.5% remains in the curd. Citrate metabolism produces acetate, diacetyl, acetoin, butanediol and CO_2, which can all influence cheese flavour/aroma. The extent of citrate metabolism in Cheddar cheese during ripening is unclear, but it is thought that excessive citrate metabolism can result in textural defects. Other potential carbohydrate sources exist in cheese, such as bound carbohydrates associated with the milk fat globule membrane, some associated with casein and ribose.

Lipolysis

The extent of lipolysis in Cheddar cheese is relatively low compared to many other varieties, but it would be incorrect to discount its impact on cheese flavour and aroma. Milk fat uniquely contains a high proportion of volatile fatty acids, which in free form have very low flavour thresholds (butyric, caproic, caprylic, capric and lauric acids). The pH of the cheese has a huge impact on the perception of these short chain free fatty acids, as their conversion to neutral non-volatile salts increases as pH decreases. Therefore, small differences in pH can have a significant impact on their flavour perception in cheese. Milk fat consists primarily of triacylglycerols (98%) and free fatty acids. The extent of free fatty acids varies depending upon the diet, breed and stage of lactation of the cow. It appears that in Cheddar cheese most of the free fatty acids arise from the milk and the activity of esterases of starter lactic acid bacteria in the vat, with a limited increase during ripening.

The contribution of NSLAB towards lipolysis during ripening in Cheddar cheese is thought to be limited. If total free fatty acid levels exceed about 2,500 parts per million (ppm), rancidity becomes pronounced. However, it has also been shown that the extent of proteolysis influences the perception of rancidity. Free fatty acids are also precursors for very volatile components such as methyl ketones, lactones, esters and secondary alcohols. The importance of methyl ketones to Cheddar cheese flavour is unclear, but they are produced by enzymatic oxidative decarboxylation of fatty acids and can

T Food

Varian 3800 GC with cryogenics and flame ionisation detector and Varian 3800 GC with multi injection Combi PAL autosampler, cryogenics and Varian Saturn 2000 mass spectrometer.

be further reduced to secondary alcohols, which are also flavour active. Esterases from starter bacteria are now known to produce esters via a transferase reaction, which uses both water and alcohol as acyl acceptors. These compounds are associated with fruity aroma/flavours and are often present in cheese. Lactones are thought to result from the hydrolysis of hydroxy fatty acids but their formation remains unclear.

The interaction of all flavour- and odour-active compounds from proteins, carbohydrates and lipids is also not well understood. Most are water-soluble but some are fat-soluble. Their different stabilities, solubility and dynamic nature make it difficult to determine those of most importance, even though the flavour and aroma of most individual compounds have been well characterised.

MFRC has established links with commercial and academic sensory analysis facilities to aid our overall understanding of the complexity of cheese flavour.

Instruments of flavour chemistry

Most volatile compounds associated with cheese flavour are characterised by gas chromatography (GC). GC flame ionisation detection (FID) is very useful for identification of individual free fatty acids and ketones. However GC mass spectrometry (MS) enables most volatile compounds to be characterised. A very important technique for aroma analysis is GC-Olfactory, which is used in conjunction with GC-FID and/or GC-MS. This technique allows the identification of key aroma components in real time. The operator familiar with cheese aroma sniffs an outlet port from the GC, which is simultaneously captured by an FID or MS detector.

High performance liquid chromatography (HPLC), in association with absorbance, refractive index or charged aerosol detection, are also very useful in the identification of some volatile and most non-volatile flavour components, such as peptides, free amino acids and sugars.

MFRC has recently refurbished its flavour chemistry laboratory. The facilities include a GC-FID, GC-Olfactory and GC-MS with associated cryogenics. In addition, MFRC also has the capacity to concentrate cheese flavours by purge and trap, or by an automated Combi PAL injection system that utilises liquid, headspace or solid phase microextraction (SPME) to ease identification and quantification of key cheese flavour/aroma compounds. The laboratory is also equipped with two HPLC systems, one with absorbance and the other with charged aerosol detection.

Sensory analysis

To optimise quantifiable flavour chemistry data it is necessary to statistically link it to descriptive sensory analysis carried out by experienced taste panels. MFRC has established links with commercial and academic sensory analysis facilities to aid our overall understanding of the complexity of cheese flavour.

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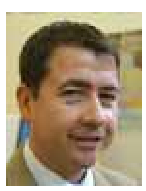


Stress test

STEPHEN BYRNE, SUSANNE BARTH and ALEXANDRE FOITO explore the genetic and biochemical reasons for abiotic stress response in ryegrass.

Tools are being developed by researchers at Oak Park to assist in the breeding of perennial ryegrass lines with increased tolerance to various abiotic stress conditions. Any stress in a plant resulting from a non-living environmental factor is referred to as an 'abiotic stress', and plants have to face various kinds of these stresses during their growth, such as drought and low nutrient supply. Unlike animals, plants do not have the luxury of moving to more favourable environmental conditions when things get tough, and depend on internal alterations to help them tolerate stressful conditions. Climate change predictions postulate the advance of warmer and dryer summers. The development of ryegrass varieties that can achieve high yields under limited water conditions would be advantageous under these conditions.

There are also important environmental concerns associated with the overuse of nitrogen and phosphorus. Varieties with an increased nitrogen and phosphorus use efficiency would be of both economic and environmental benefit.

Genes responsible for the stress response

Conventional breeding programmes rely on large-scale screening of plants. If the genes responsible for tolerance to abiotic stresses can be identified, and molecular markers developed from these genes, then ryegrass lines containing these superior genes can be rapidly identified in large breeding programmes in a process known as marker assisted selection. Ryegrass is an outbreeding species, and is thus highly heterozygous, thereby complicating genetic analysis. However, at Oak Park we have the advantage of possessing highly homozygous and contrasting inbred lines, facilitating the pinpointing of the genetic causes of stress responses. The question we are asking is: 'what genes are responsible for the different levels of stress tolerance?' In answering this, we take a 'transcriptomics' approach, where we look at what genes are being expressed (genes that are switched on) under different stress conditions. Once we find these genes, they will be converted into molecular markers, which will allow us to map their position on a genetic linkage map that shows the relative position of genetic markers along a chromosome.

Metabolomics

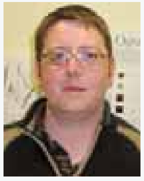
This work will be complemented by a 'metabolomics' approach, which is being carried out in collaboration with Dr Derek Stewart of the Scottish Crops Research Institute in Dundee. Metabolites are the end products of gene expression and a number of technologies exist to examine the metabolomic profiles of diverse samples such as gas chromatography-mass spectrometry (GC-MS) and nuclear magnetic resonance (NMR). We will look at the changes in global metabolites in response to the different abiotic stress conditions discussed above. We anticipate that this will allow us to pinpoint metabolites that are produced in response to an applied stress and possibly play a role in improving a plant's tolerance to a range of abiotic challenges.

The metabolomic, gene expression and physiological data will be related to develop an overall picture of the ryegrass response to abiotic stresses of environmental and economic importance. Subsequently, this will allow the development of functional tools that will assist us in developing varieties to meet the future needs of forage production in Ireland.

Using real time PCR facilities at Oak Park to examine the gene expression profiles of candidate genes for abiotic stress tolerance.

Stephen Byrne and **Dr Susanne Barth** are Research Officers in the Biotechnology Unit of the Teagasc Crops Research Centre in Oak Park. **Alexandre Foito** is a Teagasc Walsh Fellow.

This project is funded by the Department of Agriculture and Food under the Research Stimulus Fund.



Applying 'omics' technologies to grassland improvement

Genotypic analysis can accelerate the plant breeding process. SUSANNE BARTH, STEPHEN BYRNE, ULRIKE ANHALT and BICHENG YANG describe work they are carrying out in this area on perennial ryegrass.

Grasslands are of vital economic importance to Irish agriculture and perennial ryegrass *(Lolium perenne L.)* is the principal forage species for high yielding and good nutritional value grasslands. Perennial ryegrass belongs to the Poaceae family and is an outbreeding (breeding outside the breed or variety) grass species, where a single cultivar consists of a wide range of unique genotypes. Thus there are generally more similarities within than among populations. In addition, each individual of a perennial ryegrass population in its wildtype is highly heterozygous with regards to its genetic constitution. Ryegrass is usually a diploid species with seven chromosomes in the haploid chromosome set. There are two sets of chromosomes in a diploid individual, but tetraploid varieties with four sets of chromosomes have also been developed since the 1960s.

Grass breeding has traditionally relied on the selection of superior genotypes, mainly with phenotypic selection methods. Breeding of outbreeding forage species, including perennial ryegrass, is a highly time- and labour-consuming process. Using genotypes (genetic makeup) instead of purely phenotypes (physical or biochemical characteristics) for the selection would be a distinct advantage to accelerate breeding. Marker assisted selection (MAS), based on genotypic selection, has the potential to speed up the breeding process for traits based on single/oligo and poly genes (quantitative trait loci: QTL – stretches of DNA that are closely linked to the genes that underlie the trait in question).

Work on QTL is heavily based on statistical methods to pinpoint the positions of multiple loci on a genetic map and to estimate the magnitude of effects and likelihoods. MAS is an indirect method for efficient selection for a trait of interest co-segregating with a genetic marker. These markers should ideally be used in the early stages of the breeding process to save time and costs **(Figure 1)**. Traits targeted for improvement with MAS for perennial ryegrass are: biomass and seed yield; improved nutritional quality; persistency; disease resistance; and abiotic stress resistance.

On some occasions, the DNA-related experimental approaches, called genomics, are not sufficient to accelerate the progress in identifying suitable DNA markers and, thus, superior individuals. MAS is complemented by a range of other 'omics' techniques – transcriptomics, proteomics and metabolomics – to work on trait genetics.

Transcriptomics is devoted to analysing the transcribed genomic information at RNA level for a certain condition and time point in a cell. Whole transcriptomics analysis is carried out with tools called microarrays (lining up all the expressed complement of a genome), and partial studies involving expressed libraries for certain traits and lines are used, e.g., subtracted libraries. Proteomics investigates the expressed protein complement of a genome and is a systematic analysis of the proteome. Metabolomics is the systematic study of chemical fingerprints for cellular processes and is based on small molecule metabolite profiles.

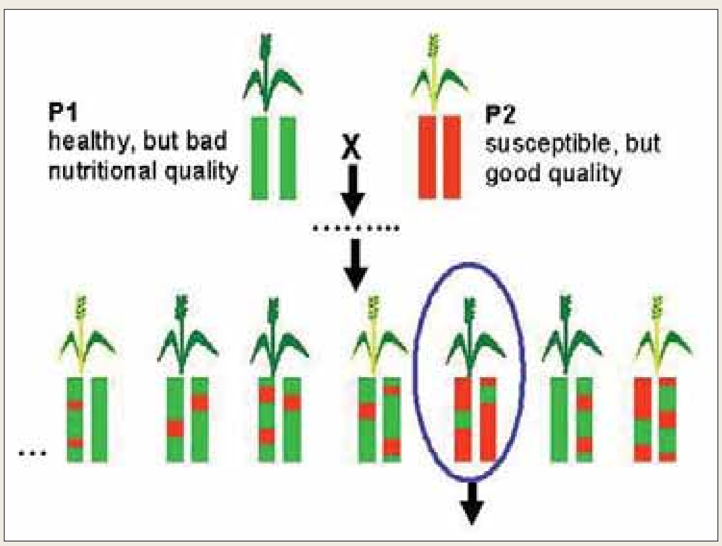


FIGURE 1.

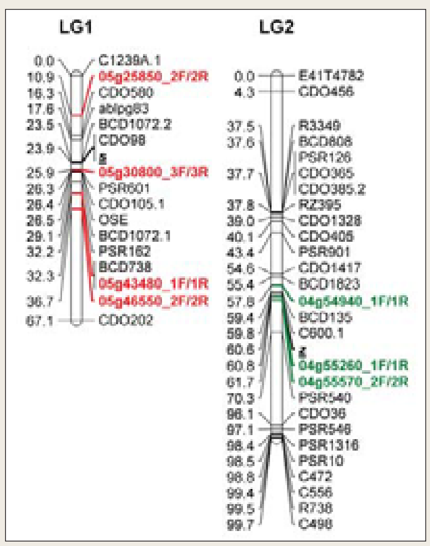


FIGURE 2.

FIGURE 1: Selection of superior individuals using MAS for further breeding (marked with circle). Each plant consists of two homologues of its haploid genome as in a diploid organism. (Image: Susanne Barth.)

FIGURE 2: Positions of S and Z loci on LG 1 and 2. STS markers developed from conserved regions of the rice genome in our previous work are highlighted in red (for S) and green (for Z). (Image: Bicheng Yang.)

Oligogenic traits

An oligogenic trait (phenotypic trait produced by two or more genes working together) that we are working on in Oak Park is self-incompatibility (SI). SI prevents plants from self-fertilisation, thus preventing efficient production of inbred lines and hybrids. If SI can be controlled, breeding of high-seed-yielding varieties could be facilitated, which is often a bottleneck in the multiplication and marketing of otherwise superior varieties. SI in perennial ryegrass is determined by the genotype of pollen itself. It is controlled by two independent genes, named S and Z, with a large number of alleles (or variants of the gene sequence). A pollen grain is incompatible when both its S and Z alleles are matched in the pistil (female organ of the flower). The S locus has been mapped to linkage group (LG) 1 and the Z locus has been mapped to LG 2 in accordance with the Triticeae (wheat) consensus map **(Figure 2)**.

We are using a mixture of: (1) comparative genomics with the exploitation of the fully sequenced and annotated rice genome for mapping and further marker development; (2) fine mapping in specific populations for S and Z; and, (3) transcriptomics methods, including specific library development for enriched libraries containing candidate genes for S and Z.

A number of suppression subtractive hybridisation (SSH) libraries have been developed and screened, and potential candidates are being evaluated using reverse transcriptase-PCR and real time-PCR.

Quantitative traits

A quantitative trait that we are working on in Oak Park is heterosis for biomass yield. Heterosis is the superiority of a hybrid against its parental lines. Biomass yield is still one of the most important traits in forage breeding programmes. This research is enabled by using a population of recombined inbred lines. We are using a mixture of techniques to enlighten the genetics of this highly complex trait, including: classical genetic mapping; QTL mapping; metabolic profiling for some of the initial lines; and proteomics. A genetic map based on molecular DNA markers consisting of 360 individuals was constructed. On this map phenotypic data of QTL for fresh and dry biomass yield, drymatter and leaf width derived from replicated greenhouse and field trials were positioned by means of statistical analysis **(Figure 3)**. It was possible to identify three regions containing major QTL for dry biomass yield explaining more than 40% of the variation of the trait. The amount of this variation was validated by high heritabilities of 66% and 68% for both environments. The heritability estimates the amount of the genotypic variation in the overall variation, including environmental effects.

In parallel, metabolite profiling was carried out in replicated experiments with the grandparents and the parental line of the F2 population using GC-MS in collaboration with Professor Oliver Fiehn in University of California Davis, USA. A total of 240 metabolites were identified, 160 of which were not present already in any metabolite database. A total of 20 of these unidentified compounds were up to 20 times up- or down-regulated in the three plant lines, and could be involved in the expression of biomass heterosis.

A further promising approach is using comparative proteomics to identify differentially expressed proteins that are potentially involved in heterosis for biomass. For total cellular proteins of three lines, such an approach showed promising initial results **(Figure 4)**.

Dr Susanne Barth and **Stephen Byrne** are Research Officers in the Biotechnology Unit of the Teagasc Crops Research Centre in Oak Park. **Ulrike Anhalt** and **Bicheng Yang** are Walsh Fellows working on SI and biomass heterosis. This research is funded by Teagasc and the National Development Plan.



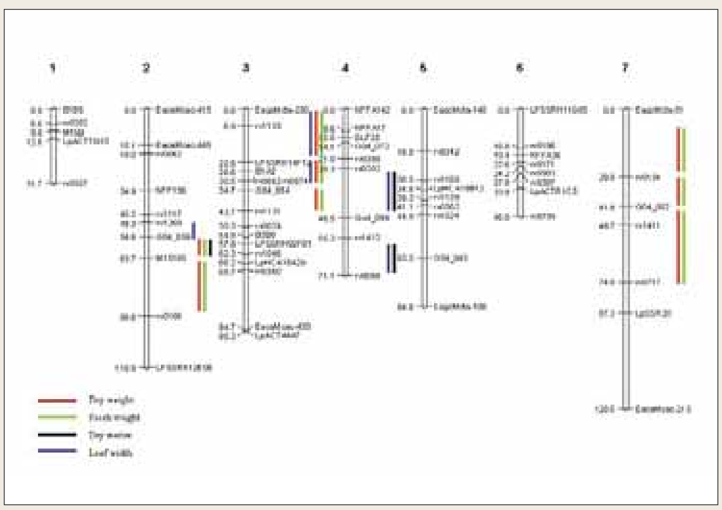



FIGURE 3: Genetic map of a perennial ryegrass F2 inbred population and QTL locations for dry weight, fresh weight, dry matter and leaf width QTL. (Image: Ulrike Anhalt.)

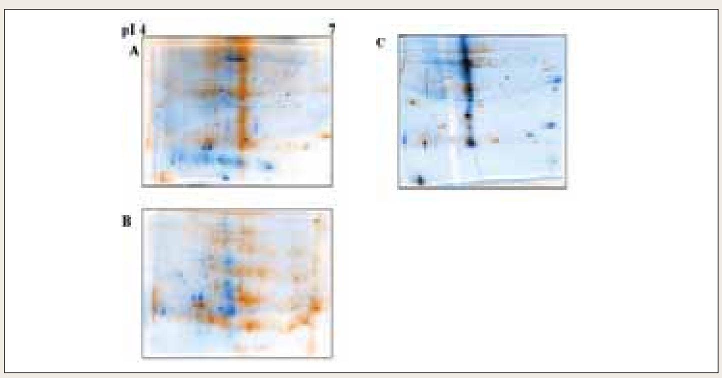


FIGURE 4: Comparative gel analyses of representative gels of parental and F1 hybrid lines for two different harvesting points during summer 2006. A: paternal lines (blue: protein pattern for the 1st harvesting time point; orange: protein pattern for the 2nd harvesting time point), B: maternal lines (blue: protein pattern for the 1st harvesting time point; orange: protein pattern for the 2nd harvesting time point), and C: F1 hybrid line (orange: protein pattern for the 1st harvesting time point; blue: protein pattern for the 2nd harvesting time point). (Image: Alica Knapik.)

Plight of the bumblebee

Irish bees are under threat from the *Varroa* mite. FINBARR HORGAN, MARY COFFEY and TOMÁS MURRAY are working on the management of this and other diseases in honeybees, and the protection of native bumblebees through the proper management and containment of imported species.

There has been a documented decline in bumblebee diversity linked to habitat loss and changing agricultural practices.

Over 80% of crop species produced in Europe are pollinated by insects. Self-incompatible crops (e.g., apples, pears and berries) are entirely dependent on pollinators for fruit production. However, even in certain self-fertile plants (e.g., oilseed rape, sunflowers, peppers and tomatoes), pollinator visitation improves the quality and quantity of fruit produced. Bees are responsible for most crop pollination and are often actively induced into crops to improve production.

In spite of their importance, the activities of bees have generally been overlooked and their service to agro-ecosystems regarded as an effortless certainty through the ages. However, since the 1990s there has been growing concern over the integrity of pollinator communities and the efficiency of their ecosystem services. For example, recent intensification of agriculture in the USA has necessitated the direct and large-scale importation of honeybees to pollinate crops such as alfalfa and almonds. Parasitic mites and the excessive use of pesticides have exacerbated this problem by causing a dramatic decline (about 50%) in the number of managed honeybee colonies throughout North America. In Europe, over this same time period, there has been a documented decline in bumblebee diversity linked to habitat loss and changing agricultural practices. Together, these trends are part of a global phenomenon known as the 'pollination crisis'.

Pollinator trends in Ireland largely reflect what has occurred in both the USA and mainland Europe. A recent long-term survey of Irish bumblebees has indicated that species that were once widespread are now increasingly restricted to the western part of the island, three species of solitary bee have already become extinct and, of the 102 species found in Ireland, 30 are considered to be under threat. Furthermore, a recently introduced parasitic mite, and the associated spread of bee diseases, has resulted in large losses of both feral and managed honeybee colonies and a subsequent decrease in the number of bees available for pollination.

In spite of their importance, the activities of bees have generally been overlooked and their service to agro-ecosystems regarded as an effortless certainty through the ages.

The horticulture industry has responded by looking to alternative, non-traditional sources for pollination services. Each year, Irish growers import hundreds of commercial bumblebee colonies from mainland Europe to improve fruit quality and yield. Therefore, in Ireland, the nature of the bee pollination service has changed quite dramatically over the last 10 years.

Bane of the beekeeper

In the late 1990s, the *Varroa* mite *(Varroa destructor)* was accidentally introduced into Ireland. *Varroa* is a minute mite (about the size of a pinhead), which parasitises honeybees. The mite feeds on the haemolymph (fluid in the body cavities and tissues) of adult and larval bees and, in temperate regions, if left untreated, it can cause colony collapse within two years. The mite, originally of Asian origin, has now spread throughout Europe and into the British Isles. In Ireland, *Varroa* was first detected in Sligo in 1998. Early attempts at containment failed and it has now spread to most parts of the country. Teagasc has conducted research on *Varroa* since the mite was first found in Ireland. This research has had three principal objectives: to document invasion and spread of the mite; to develop an integrated approach to *Varroa* management, with an emphasis on biological and biotechnical methods; and to evaluate the impact of *Varroa* on the dynamics of bee diseases.

Since its initial detection and identification, beekeepers have sent hive scrapings for analysis and detection of *Varroa* to Teagasc. Together with a comprehensive nationwide sampling programme carried out in 2005, this survey has plotted the invasion history of the mite **(Figure 1)**. Through communication with beekeepers and samples sent to the bee diagnostic service, indications are that most of the last *Varroa*-free apiaries identified in 2005 have since become infested. In Ireland, the mite is primarily controlled by the chemical pesticide Bayvarol®, which has an efficiency of >90%. The regular application of pesticides leads to the development of resistance in mites. Resistance to Bayvarol® has not been reported in the Republic of Ireland to date, but is currently a serious problem in Europe, including the United Kingdom.

Research at Teagasc is developing alternative *Varroa* management strategies that are suitable for Irish climatic conditions. Apiguard®, a thymol-based product extracted from the plant thyme (*Thymus* spp.), is the most effective autumn treatment, but in some instances may require oxalic acid as a follow-up winter treatment. Oxalic acid occurs naturally in honey; however, it is not yet registered for use in Irish honeybee colonies. Furthermore, biotechnical methods such as brood-trapping and mesh-floors, if incorporated into bee husbandry, can reduce mite population growth.

Increased viral diseases

Varroa infestation has been associated with an increased incidence of viral diseases in bees. A number of bee viruses have been described (e.g., deformed wing virus [DWV], acute bee paralysis virus [ABPV], black queen cell virus [BQCV], chronic bee paralysis virus [CBPV], Kashmir bee virus [KBV] and sacbrood virus [SBV]), but their status in Ireland is unknown. Because *Varroa* was still a relatively recent introduction when the nationwide survey was conducted in 2005, it was possible to sample hives in both *Varroa*-infested and non-infested regions. Stored samples at Oak Park will facilitate examination of the effects of *Varroa* on disease incidence and, using polymerase chain reaction- (PCR) based techniques, will allow determination of the nature of an association between the mite and viral bee diseases. To date, DWV has been isolated successfully. Ongoing work is focusing on isolating three other adult bee viruses – KBV, ABPV and CBPV – and determining their frequency of occurrence in Irish bee colonies. By improving *Varroa* management and understanding the dynamics of bee diseases, Teagasc research aims to contribute to increased honeybee densities in the Irish countryside.

Varroa has resulted in large losses of both feral and managed honeybee colonies.

This research aims to improve the management of imported bumblebees such that crop productivity is sustained and potential negative effects of bumblebee importation on the native Irish fauna are minimised.

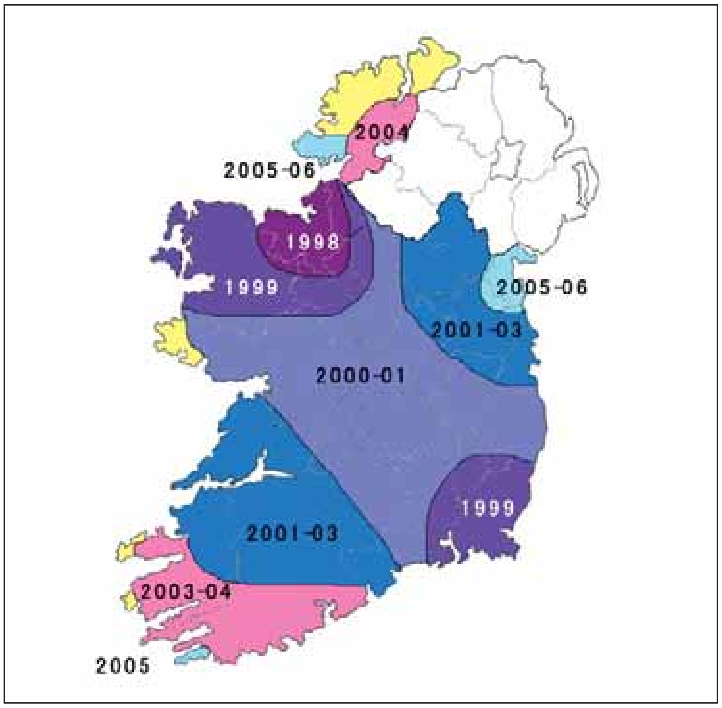


FIGURE 1: Proposed spread of Varroa destructor *in the Republic of Ireland.*

Colony collapse disorder

The terms colony collapse disorder (CCD) and vanishing bee syndrome (VBS) were coined to describe the large-scale regional die-off of entire beehives and bee colonies. The phenomenon was first noted among colonies of the western honeybee in North America; however, recently, similar die-off patterns have been observed in Europe, initially in Switzerland and Germany and then on a larger scale in Poland and Spain. CCD is characterised by the complete absence of adult bees in colonies that contain capped brood and ample food stores (bees will not normally abandon well-stocked hives with capped brood). During 2006 and 2007, CCD has apparently reached new proportions in North America, with unprecedented losses of honeybee colonies. The causes of the syndrome are unknown but theories include: increased pathogen loads associated with mites; malnutrition; poisoning due to novel pesticides and Bt-transgenic crops; and disorientation due to electromagnetic radiation. One theory suggests that CCD is caused by suppression of the bee's immune system due to mites and other unidentified stresses, combined with an increased incidence of disease associated with *Varroa* or other ectoparasites. However, research so far has given no conclusive evidence for any single cause of CCD and reasons for the phenomenon remain a mystery. Research attention into the disorder is likely to increase globally in the coming years as growers are faced with huge reductions in bee populations and potential losses in fruit production.

Protecting native pollinators

Bumblebees are suggested to pollinate over 40% of fruit crops and are significantly more efficient than other pollinating insects at low temperatures and under wet conditions. It is largely because of this that bumblebees began to be reared for commercial trading in the late 1980s. Now, after 20 years of research and development, there is a sustained global trade in commercial bumblebees worth billions of euro annually. Each year, Irish fruit growers import hundreds of bumblebee colonies from mainland Europe to improve fruit yields and extend the production season. These bumblebees are mainly used for pollinating greenhouse strawberries, but some are also used to pollinate peppers, tomatoes and outdoor crops. The bees can also be potentially used as vectors for biological control antagonists of such common berry diseases as gray mould *(Botrytis cinerea).* Therefore, bumblebee importation has numerous benefits for the fruit grower, and may counteract the effects of declining honeybee densities.

In spite of its size, the trade in bumblebees is currently unregulated in Ireland, and indeed in much of the world. In Europe, the imported bees are *Bombus terrestris*, a species that occurs widely throughout the continent. However, *B. terrestris* includes a number of recognised subspecies, including *B. terrestris audax*, which is restricted to the British Isles **(Figure 2)**. The origin of imported bees is unclear, but they are not native to the British Isles. Recent studies indicate that poor regulation of the bumblebee trade can have consequences for native bees, including the native *B. terrestris* subspecies. Studies in both Canada and Japan have shown that imported bumblebees have been responsible for spreading both parasites and diseases to native bumblebee species. Imported bumblebees can also out-compete native bumblebees as, in general, native species are relatively less efficient foragers and have a lower reproductive output. These factors – disease and competition – could further contribute to the decline of native species.

Pollination crisis

Recently, Teagasc Oak Park and Kinsealy, together with the Institute of Technology Carlow, have commenced a project funded by the Department of Agriculture and Food under the Research Stimulus Fund on the management of imported bumblebees. This research will be conducted in the context of the 'pollination crisis', but is also directed toward improving the pollination efficiency of imported bees in greenhouses.

The research objectives are:

1. To determine the extent of the bumblebee trade to Ireland;
2. To improve pollinator efficiency through spatial and timing considerations;
3. To reduce bee-drift from greenhouses by understanding and exploiting bee orientation cues;
4. To reduce bee escape and integration into wild populations by informing growers of proper hive disposal methods and containment of queens and drones;
5. To determine the risk of hybridisation between native and imported bees; and
6. To evaluate the potential for introduced bees to carry diseases that may be passed to native bumblebees or honeybees.

Much of the research programme for 2007 will concentrate on issues of hybridisation between the native and introduced bumblebee subspecies. Hybridisation has been demonstrated in the laboratory and is expected to affect the integrity of native bee populations. In collaboration with Dr Thomae Kakouli-Duarte and Antonio Sergio Moreira at the Institute of Technology Carlow, it is intended to construct a phylogenetic tree of *B. terrestris* in Europe; this will examine the status of Irish *B. terrestris audax* as a separate subspecies and evaluate the requirements for its protection. Bee samples from throughout

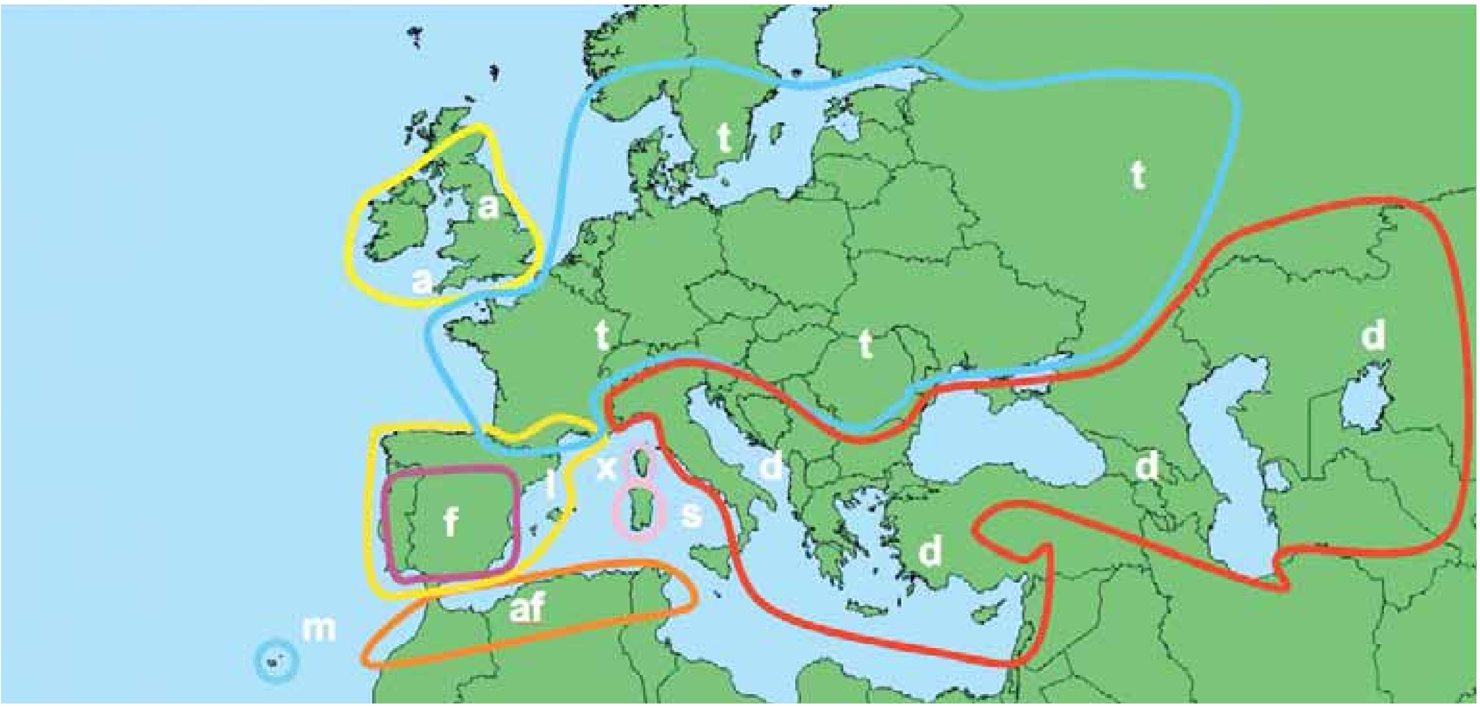


FIGURE 2: Probable boundaries of nine subspecies of B. terrestris. *a*, audax; *t*, terrestris*;* *l*, lusitanicus*;* *f*, ferrugineus*;* *d*, dalmatinus*;* *x*, xanthopus*;* *s*, sassaricus*;* *af*, africanus*;* *m*, maderensis*;* *A further subspecies*, canariensis, *occurs on the Canary Islands.*

Europe are being analysed using microsatellite and mitochondrial DNA (mtDNA). mtDNA is maternally inherited. Thus, unlike nuclear DNA, in which the genes are rearranged by approximately 50% each generation (due to recombination), there is usually no change in mtDNA from parent to offspring by this mechanism. Because of this, and the fact that its mutation rate is higher than nuclear DNA, mtDNA is a powerful tool for tracking matrilineages, and has been used to track species back hundreds of generations. Bee sampling sites during 2007 will be predominantly located in Northern Europe and will concentrate on the English Channel and Irish Sea as potential geographical barriers to gene flow between British, Irish and mainland European bumblebees. Further sites will be sampled in the Balkans and Greece by Ioannis Anagnostopoulos (Municipality of Florina, Greece). These sites are included because some commercial bumblebee breeding programmes are believed to have been initiated with bees from these regions. Results from this research will be integrated into an informal dissemination programme directed at growers to heighten awareness of bumblebee conservation issues and to improve the management of imported bumblebees such that crop productivity is sustained and potential negative effects of bumblebee importation on the native Irish fauna are minimised.

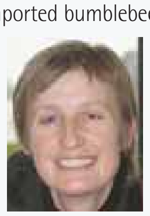
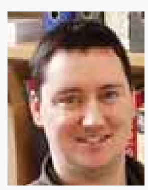
Bees and crops

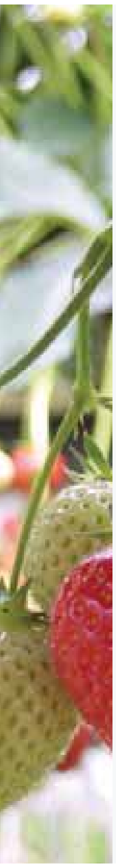
Teagasc research into the protection of pollinators is aimed at increasing pollinator abundance, while at the same time maintaining the diversity of pollinator communities. Ireland has over 100 species of bees, including 20 different bumblebee species. The research described here concentrates on just two synanthropic bee species (*Apis mellifera* and *Bombus terrestris*). Because of their association with human populations and altered habitats (*B. terrestris* tends to forage and nest in urbanised areas, whereas most honeybees are propagated and maintained by beekeepers), these species are among the most important pollinators of crops. Therefore, the effective management of *Varroa* and associated diseases in honeybees, as well as the protection of native bumblebees through the proper management and containment of imported species, is expected to improve pollination efficiency and contribute to sustained increases in crop productivity.

Acknowledgements

Varroa research is funded through the Department of Agriculture and Food (DAF) under a grant from El Fondo Europeo de Orientación y de Garantía Agrícola (FEOGA); research on bumblebee management is funded by DAF through the Research Stimulus Fund Programme. We thank Richard Dunne and Pat Maloney (Teagasc, Kinsealy) for their support in *Varroa* research.

Dr Finbarr Horgan (Teagasc, Oak Park and Kinsealy) is a Research Officer specialising in horticultural entomology. **Dr Mary Coffey** (Teagasc, Oak Park) has conducted research into the spread and management of *Varroa* since 2003. **Tomás Murray** has recently joined Teagasc at Oak Park and together with Dr Eamonn Kehoe (Teagasc, Kinsealy), Dr Thomae Kakouli-Duarte and Antonio Sergio Moreira (Institute of Technology Carlow) will conduct research into the management of imported bumblebees. E-mail: finbarr.horgan@teagasc.ie.



Designing the perfect strawberry plant

Summer is here again and with it comes homegrown strawberries for us to enjoy. But what is the science behind the effort to produce the perfect Irish strawberry? EAMONN KEHOE describes a new project at Kinsealy Research Centre aimed at producing the perfect strawberry plant.

The fruit-growing season in Ireland has changed fundamentally over the last decade. In the past, the strawberry season lasted from June to July. Today, through new technology, the season has been extended from April to November. In fact, the strawberry growing business in Ireland is worth an estimated €22 million per year. The industry is expanding in volume terms at a rate of about 15% per year, making it a highly valuable sector of Irish commercial horticulture.

Strawberry plant imports

The most popular strawberry grown in Ireland is the Dutch cultivar Elsanta. Irish strawberry growers used to import the vast majority of their Elsanta strawberry plants from the Netherlands and the United Kingdom each year. This was because the Irish strawberry propagators could only supply 'bare root' plants and only for the early part of the season. However, plants for use in protected cropping must be given a cold store treatment (vernalisation) before planting. Also, plants required for fruit production later in the season must be held in cold store for up to 60 days before being planted. Until recently in Ireland, we did not have the proper cold store facilities to carry out any of these measures, thus further justifying the importation of plants.

'Tray plant' production

There is now a demand for the use of strawberry 'tray plants', especially in protected strawberry production. Tray plants have gained in popularity and have formed an important part of the growing system among growers in the Netherlands, Belgium, France, the UK and Italy. Tray plants are more suited for glasshouse cropping than bare root plants. This is because the tray plant is able to cope with the hotter conditions experienced in a glasshouse environment. Tray plants are also produced from runners, which a mother plant produces in the spring. Runner tips are cut from these runners and are stuck into modular peat trays.

Runners offer many advantages compared to soil-grown bare root plants. Runners and cuttings are grown on substrates, reducing the risk of infection by root diseases to a minimum. Plant nutrition can be controlled completely, plants can be more easily lifted during frost and wet conditions, and the roots remain intact in comparison to bare root plants. This improves plant storability and establishment after cold storage. Tray plants also produce 10-20% more large fruits than bare root plants, which also reduces picking costs substantially.

Strawberry tray plants growing in the nursery.

Far left: Tray plants producing fruit in Kinsealy.

Left: Tray plants close to harvest time – showing well developed uniform root system.

Figure 1: Primary inflorescence
The quality of the primary inflorescence can be microscopically determined at a very early stage to ensure only good quality plants are selected.

Tray plant research

At present, very little knowledge exists regarding tray plant production technology in Ireland. Research is now being undertaken at Kinsealy to establish and test a tray plant production system for Irish strawberry propagators. The main cultivar being tested is Elsanta. This system aims to help both the growers who are already propagating this type of plant and those who may wish to set up such a plant production system in the next few years. Already, a number of growers in Ireland have invested in new modern facilities to produce these plants.

As well as establishing a system for the propagators, a large part of the project will concentrate on trying to better understand strawberry plant flowering. Strawberry flower induction is sensitive to temperature, photoperiod (interval in a 24-hour period in which the plant is exposed to sunlight), and to several agronomic and nutritional factors. The aim is to improve the cultural knowledge and understanding of the physiological control of axillary meristems (flower structures), which can enhance strawberry fruit production. It may also be possible to programme axillary meristems to a particular grower's requirements and, even more crucially, for a particular part of the growing season. The quality and stage of flower development within the strawberry plant can also be checked by taking some plant samples at plant harvest time and dissecting them under a stereo microscope (**Figure 1**).

Expected benefits

By successfully growing their own plants, growers should have less reliance on imported strawberry plants. The quality of these imports can sometimes be very poor and plant disease risks are very high (e.g., *Phytophtora*, *Xanthomonas fragariae*). The knowledge transfer from this research should allow growers to grow and supply quality strawberry plants for the full length of the Irish season. Strawberry yields should also be higher than that of traditional bare root plants and with higher quality fruit. There is also the added bonus of possibly exporting these plants to other European strawberry growers in the future.

Dr Eamonn Kehoe is a soft fruit specialist based at Teagasc, Enniscorthy, Co. Wexford, and whose research is being conducted at Kinsealy Research Centre. E-mail: eamonn.kehoe@teagasc.ie. Eamonn is working on this project in collaboration with Professor Davide Neri and Dr Gianluca Savini, Università Politecnica delle Marche, Ancona, Italy through the COST group 'Euroberry 863'.

Irish organic farming: unblocking the bottlenecks


Strong demand is driving growth in organic poultry production.

Ireland is lagging behind its European counterparts in organic production. GER SHORTLE describes how Teagasc is developing an organic programme to give impetus to the sector.

Demand for organic food continues to grow, with the area of organically farmed land increasing worldwide. Europe and North America are the main markets for organic food, and in the UK and France annual growth rates of over 40% were recorded in the 1999-2002 period. The Soil Association, the UK's biggest organic certifying body, has reported a 30% growth in UK organic sales in 2006.

Ireland continues to lag behind most of our EU partners in organic market share and area farmed. In 2004, home market shares were 5% in Denmark, 2.6% in Germany, 1.8% in the Netherlands and 1.3% in France. In Ireland, the share was approximately 1%. Over 3.6% of the utilised agricultural area (UAA) in the EU is farmed organically, whereas Ireland has 0.9% in organic production. Our nearest neighbour, the UK, had reached 3.6% of UAA by 2006. Seven EU member states have shares of between 6% and 10% of their UAA under organic management. Only three countries were below 1% – Ireland, Cyprus and Poland.

Irish organic farming

Although organic farming has been practiced in Ireland for over 25 years, growth of the sector has been slow. At the end of 2006, there were over 1,100 organic producers in the country, farming 40,000ha. The National Steering Group for the Organic Sector (working under the auspices of the Department of Agriculture and Food) has set a target of 3% of UAA to be managed organically by 2010. This is ambitious, given the current position, and may need to be revised. The organically farmed area in Ireland grew rapidly between 2003 and 2006, bringing the area to almost 40,000ha – a 40% increase in three years. This coincided with the introduction of REPS 3 (Rural Environment Protection Scheme). REPS 4 will be introduced in 2007, and will include additional incentives for organic farming, especially tillage.

Grassland predominates on Irish organic farms and the Department of Agriculture and Food's 'Census of Irish Organic Production' (2002) shows that two-thirds of organic producers had cattle enterprises, while one-third had a sheep enterprise. A total of 23 of the farms with cattle had a dairy enterprise, although only about 15 of these were of a commercial scale. The production of vegetables, fruit, cereals, poultry, goats and pigs was confined to a small number of holdings and mostly on a small scale. However, the produce from these holdings was of high value and made a substantial contribution to income, especially when sold direct through outlets such as farmers' markets and box-delivery schemes.

Ireland continues to lag behind most of our EU partners in organic market share and area farmed.

Constraints on expansion

Many farmers consider conversion, but only a small proportion of those go ahead with it. The main constraints to expansion could be summed up as a lack of infrastructure. It is a classic 'chicken and egg' situation: farmers and growers are concerned that they will have difficulty finding an outlet for produce and a reliable source of affordable inputs; and processors, wholesalers and retailers are concerned about continuity of supply from a small, fragmented supplier base. The best way to tackle this situation is through the provision of research-based organic advice and training. This helps to build farmers' confidence in converting to organic production and leads to more conversions, as well as better production on existing organic farms. With more products and a more reliable supply, confidence in organic food would grow in the processing sector. Thus the interdependent producers and processors could expand together.

Artificial fertilisers are not allowed in organic production and undersupply of plant nutrients is potentially the biggest constraint. Tillage and horticultural crops remove most nutrients and pose particular problems in maintaining nutrients. Grass-based production occupies the vast bulk of organic land and removes relatively little phosphorus and potassium. However, since clover is the nitrogen source that drives the system, specific organic grassland management guidelines are needed.

A suckler cow and calf at the Johnstown Castle Organic Unit.

Organic winter oats, May 2007.

Tillage

The situation in organic tillage illustrates the constraints faced by the sector as a whole. In 2006, tillage crops were grown on 72 organic farms. This represents about 1.5% of organically managed land. Most of the produce is kept on the farms for home consumption, with a small amount sold to other farmers. A negligible amount of Irish organic grain is bought by merchants or processors, with the bulk of organic cereals and almost all organic proteins used being imported.

Animal feeds make up the largest part of the Irish market for organic cereals and proteins. Due to the scarcity of concentrated organic animal feed across the EU, a derogation was introduced, which allows a limited amount of conventional feedstuffs in organic diets. For herbivores, such as cattle and sheep, this derogation ceases at the end of 2007, and for all other animals at the end of 2011. Most Irish organic farmers use the derogation, so when it ceases there will be a substantial extra demand for organic ingredients in an already undersupplied market. Add to this the expected expansion in organic milk, farmed fish and meat production, and there is potentially an annual Irish demand for at least an additional 18,000 tonnes of ingredients. This represents a potential eight-fold increase in organic tillage area. The impending shortfall in cereal and protein supply is the biggest and most immediate constraint on the expansion of the sector. Supplies are already tight, leading to very high prices, which could threaten the financial viability of organic animal production.

How research can help

Teagasc has been generating and disseminating information on organic farming since it established its first organic research unit in 1990 at Johnstown Castle in Wexford. Since then, substantial resources have been added to organic research, with the addition of units at Oak Park in Carlow and Athenry in Galway. Teagasc is increasing its organic staff resources in 2007 and is currently devising an Organic Programme, which will focus on the constraints identified above and give added impetus to the sector.

The sustainable management of organic soils will form a central theme in the research programme. Inadequate supplies of nitrogen, phosphorus and potassium have their most immediate impact on tillage, but will also restrict grass growth in the longer term. Research will focus on the establishment and maintenance of clover-rich swards and the optimum use of legumes in fertility building break-crops to provide nitrogen for tillage crops. Phosphorus and potassium research will concentrate on optimising recycling of nutrients and identifying best practice in the use of organic sources of these elements. As well as nutrients, tillage research priorities include economic methods of weed, disease and pest control.

The development of grassland management methods is also a priority of the programme and is linked to the development of management strategies for dairy, beef and sheep production. Breed suitability for organic production, animal health issues and the economics of organic farming are other themes.

Through focusing on these constraints, Teagasc aims to unblock the main bottlenecks in the expansion of the organic sector. This will be achieved through an integrated research, advisory and training programme, which will help to move Ireland into the mainstream of European organic production where we can compete with the best.

Ger Shortle is a Research Officer at Teagasc, Johnstown Castle. He has worked in organic advice, training and research for the past seven years; first converting the college farm at Mellows Centre, Athenry, while Principal of the college, and for the past two years at Johnstown Castle Research Centre Organic Unit. This research is funded through Teagasc's research programme. E-mail address: ger.shortle@teagasc.ie.

Tackling nutrient loss head on: catching the nutrients that got away

The Water Framework Directive requires that all surface water bodies achieve "at least good status" by 2015. Therefore, agricultural research must strive to integrate activities on the farm with research activities outside the farm gate to meet these requirements. A Teagasc, EPA and NUIG cross-disciplinary team is developing methods to tackle this problem at groundwater, soiled water and surface water levels.

Barley bale construction.

At European level, present strategies to reduce nutrient loss to water focus on preventing the movement of phosphorus and nitrogen from land, by increasing nutrient uptake efficiency, tracing and reducing leaks and pathways of nutrients, and improving nutrient management. The loss of these valuable soluble and particulate non-recycled nutrients may contribute to a decline in water quality, in particular; cause damage to the environment, in general; and also, add to farming costs. Through mitigation measures, these nutrients may be recaptured and utilised again, or may be converted into forms less harmful to the environment. Such emerging strategies utilise technologies in other disciplines such as hydrogeology and engineering to intercept and trap pollutant flow paths.

Remediation and control of nutrients can occur in the field or the farmyard. Teagasc, Johnstown Castle, and National University of Ireland, Galway (NUIG) have initiated research to develop a range of technologies to reduce nutrients in groundwater, soiled farmyard water and surface waters. Examples of these technologies include denitrification trenches, horizontal flow biofilm reactors and use of ochre.

Groundwater – denitrification trench

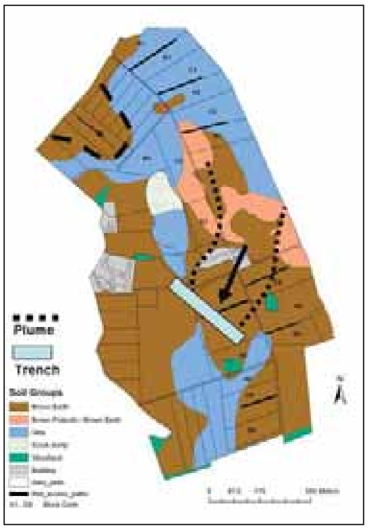
One such method is the use of permeable reactive barriers (PRB). These systems entail placing a carbon-rich mixture, such as woodchip, into the shallow sub-surface to passively intercept migrating contaminated groundwater and treat the nutrients as they pass through the system. The barrier is covered with topsoil, reseeded and is invisible at surface level. The success of such a system depends on a thorough site investigation carried out prior to its installation, which should include: the quantification of the groundwater directional flows and their nutrient concentrations; the construction of seasonal watertable contour maps; and the determination of soil types and their hydraulic conductivities.

In order to develop a groundwater map, a suitable monitoring network must first be designed and installed, which will be used as a framework for establishing site suitability, plot location and orientation, and to account for nutrient concentrations in different areas. This broad monitoring network should also accommodate the superposition of denser networks within its boundaries for more detailed work.

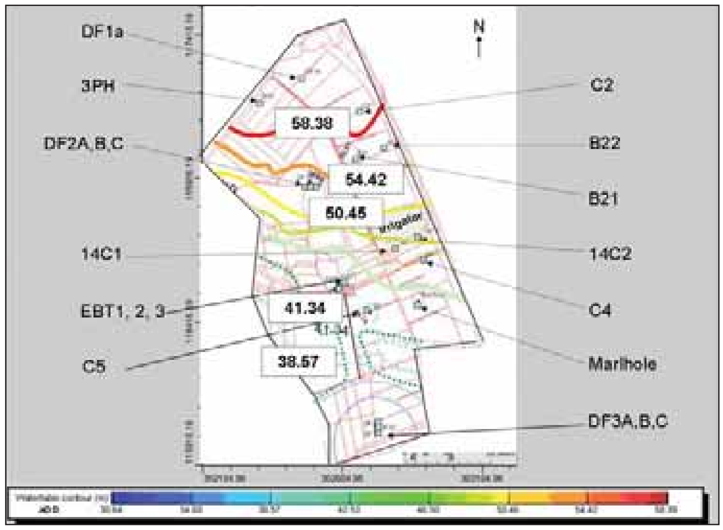
Soiled water – HFRB

With the introduction of the Nitrates Directive on January 1, 2007, the remediation of soiled water on farms has become an important and urgent research area. Teagasc, Johnstown Castle, and NUIG are now developing solutions aimed at recycling soiled water on farms that will significantly reduce storage requirements and future water charges. To achieve this, a horizontal flow biofilm reactor (HFBR) technology – developed at NUI, Galway for the treatment of synthetic wastewaters – is being investigated for on-site dairy washwaters. A HFBR comprises a stack of dimpled plastic sheets that permit the flow of wastewater along each sheet, and from sheet to sheet, down through the stack. As soiled water is pumped on to the top of the HFBR, microorganisms grow on the plastic sheets and remove the nutrients from the wastewater, improving its quality.

This horizontal flow biofilm reactor (HFBR) device was developed at NUIG for the treatment of synthetic wastewaters.



Contamination migration intercepted by denitrification trench.



Water table contour map of Johnstown Castle dairy farm and well locations.

The use of woodchip as a biological filter is also being investigated. The woodchip may later be incorporated back into the soil as a potential source of nutrients.

Removal of phosphorus from soiled water and surface waters generally involves 'trapping', by chemical binding of phosphorus. One such binding material is ochre, an acid mine by-product, which can be added to surface ponds (ochre ponds) to actively strip phosphorus from run-off or soiled water. Similar mitigation barriers may also be incorporated into subsurface barriers for groundwater remediation, or to surface buffer strips. Exhausted ochre may be dried, crushed and used as a phosphorus fertiliser.

Surface waters – barley flotation devices

Where nutrients have escaped and reached surface waters, such as lakes, they may contribute to eutrophic conditions, which promote the growth of algae. Algal blooms reduce the oxygen content of water, thus inhibiting the growth of some aquatic vegetation and limiting the available food and cover for fish, birds and many aquatic invertebrates. An example of a eutrophic lake is the artificial lake system at Johnstown Castle (Wexford), where the total phosphorus concentrations ranged from 53-70µg/l, the source of which has been traced back to originate from outside the estate. We are currently evaluating the efficacy of barley flotation devices on these lakes, which have been reported to inhibit algal growth under eutrophic conditions. The bales consist of barley placed in tightly packed netting with floats on the inside. The decomposition of barley straw in water (after five weeks) produces and releases many compounds, some of

Ochre for phosphorus stripping.

which have been reported to control algae populations by preventing the growth of new algal cells. As 'old' algal cells naturally die off, the algal population is controlled, as long as the controlling compounds are being produced. Removal of algae gives beneficial aquatic vegetation an opportunity to become established. Results to date indicate that the barley

T Environment

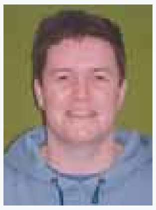
The garden lake at Johnstown Castle with barley bales.

The castle lake at Johnstown Castle post barley bale treatment.

devices are also acting as sediment traps, improving water clarity. As an added benefit, they provide water birds with roosting and feeding sites. As some degree of nutrient or sediment loss is inevitable for most farm systems, we are developing an integrated approach to nutrient remediation that simultaneously tackles nutrients that got away in surface and sub-surface water bodies. An example of such an integrated approach would be willow coppicing on a farm providing woodchip for a denitrification trench placed sub-surface along a buffer strip, with phosphorus control in the form of a gabion, pond or in-stream structure. This would not only contribute to prevention of nutrient loss, but would additionally have the potential to create farm habitats and augment farm ecology and biodiversity.

Owen Fenton is a Research Officer working in the area of soil hydrology, especially groundwater contamination from agricultural sources and remediation/control technologies, at Teagasc Johnstown Castle. E-mail: owen.fenton@teagasc.ie.

Dr Bernard Hyde is a Scientific Officer whose work involves air emission inventories of acid and greenhouse gases at the Environmental Protection Agency. E-mail: b.hyde@epa.ie.



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John Regan is a Teagasc Walsh Fellow in the Department of Civil Engineering, NUI, Galway, studying sediment and nutrient losses in runoff from tillage soils. E-mail: john.regan@nuigalway.ie.

Dr Michael Rodgers is a senior lecturer (soil mechanics and environmental engineering) in the Department of Civil Engineering, NUI, Galway. E-mail: Michael.rodgers@nuigalway.ie.

T Events

Science Events

May

May 23 *Tullamore Court Hotel, Tullamore, Co. Offaly*

Organic conference

This conference, organised by the Teagasc Rural Development Unit, will address the issues facing organic farmers and the industry, including market prospects, converting to organic, nutrient cycling and grassland management.
patrick.barry@teagasc.ie Tel: 059 918 3502

May 24 *Ashtown Food Research Centre, Dublin 15*

RELAY workshop

Blown Pack Spoilage of Meat workshop.
breda.mulvihill@teagasc.ie

June

June 13 *Four Seasons Hotel, Carlingford, Co. Louth*

Renewable Energy – A Role for the Regions

Organised by the Border, Midland and Western Regional Assembly.
Speakers include Duncan Stewart, RTÉ presenter, and representatives of Airtricity, Teagasc and Dundalk IT.
fflynn@bmwassembly.ie

June 21 *Teagasc Moorepark, Fermoy, Co. Cork*

Moorepark '07 Dairy Open Day

The theme for this major dairy open day is 'Irish dairying winning on a world stage'. With milk quotas due to be phased out, this event will provide direction on how farmers can compete in the future. The latest dairy production research, along with developments in food research, will be presented. Research topics to be covered will include: milk production systems; grazing management; SCC; milk quality and composition; labour efficiency; animal health and welfare; genetics; fertility; increased nutrient efficiency; and food research.
margie.egan@teagasc.ie/
pfrench@teagasc.ie

July

July 15-20 *University College Cork*

16th International Farm Management Congress

This congress will be of interest to all involved and interested in agriculture and broader rural development initiatives. Many of the topics covered will be of interest to farmers, farm managers, farming organisations and researchers, and will have particular relevance to government and state development agencies.
www.ifma16.org
General information: contact@ifma16.org
Paper submission: ifma16@ucc.ie

August

August 26-29 *University College Dublin, Belfield*

EAAP 2007

58th annual meeting of the European Association for Animal Production. This meeting will be of interest to those working on animal breeding, production and management issues.
www.eeap2007.ie
eeap2007@ovation.ie

August 30 *Teagasc Oak Park, Carlow*

Bioenergy 2007 – Fuelling Ireland's Future

This event aims to promote solid biomass (forestry, willow, miscanthus) and to create and boost the confidence of all players in the supply chain from growers and suppliers to users. This is a joint Teagasc/SEI/COFORD/WIT event. It is aimed at farmers and growers, the agri-community, policy makers, energy users, trade and the general public.
www.teagasc.ie/events barry.caslin@teagasc.ie

September

September 12-14 *University College Cork*

First International Symposium on Gluten-Free Cereal Products and Beverages

Coeliac disease is one of the most common lifelong disorders in the western world. It is a condition in which an individual's body reacts badly to the protein fraction of gluten or related proteins. This is the first symposium to be held on this topic.
www.glutenfreecork2007.com
fitu@ucc.ie

September/October

September 29 - October 4 *The Burlington Hotel, Dublin*

2007 International Dairy Federation World Dairy Summit

'Dairying – can it manage change?' is a relevant theme in the light of the competitive pressures being felt internationally and the technological initiatives considered necessary to create added value opportunities based on milk. Symposia will cover areas of global trade, marketing, dairy science and technology, nutrition and health, farm management and functional foods issues. The increasing importance of 'food and health' will be covered extensively in the 'Nutrition' and 'Functional Foods' symposia.
www.wds2007.com
Phil.Kelly@teagasc.ie
Updates: info@wds2007.com

October

October 18 *Cork*

Open Innovation Seminar

Half-day seminar featuring an international speaker with direct experience of open innovation. Other speakers will include key Irish companies and research groups, who will also share their hands-on knowledge and experience of innovation.
www.enterprise-ireland.com
Jim.Cuddy@enterprise-ireland.com

November

November 11-18 *Nationwide*

Science Week

Part of Forfás' Discover Science & Engineering (DSE) initiative, the week aims to increase interest in science, technology, innovation and engineering among students, teachers and members of the public.
www.scienceweek.ie
Teagasc Science Week events: catriona.boyle@teagasc.ie