Wageningen UR Livestock Research

Partner in livestock innovations

Report 405

Research methodology of grazing

Proceedings EGF Working Group Grazing

February 2011

LIVESTOCK RESEARCH
WAGENINGEN UR

Colophon

Publisher
Wageningen UR Livestock Research
P.O. Box 65, 8200 AB Lelystad
Telephone +31 320 - 238238
Fax +31 320 - 238050
E-mail info.livestockresearch@wur.nl
Internet http://www.livestockresearch.wur.nl

Editing
Communication Services

Wageningen UR Livestock Research and Central Veterinary Institute of Wageningen UR, both part of Stichting Dienst Landbouwkundig Onderzoek (DLO Foundation), together with the Department of Animal Sciences of Wageningen University comprises the Animal Sciences Group of Wageningen UR (University & Research centre).

Single numbers can be obtained from the website.

ISO 9001 certification by DNV emphasizes our quality level. All our research projects are subject to the General Conditions of the Animal Sciences Group, which have been filed with the District Court Zwolle.

Abstract
This report presents the main results of the first meeting of the EGF Working Group Grazing in Kiel on 29 August 2010. The theme of the meeting was “Research methodology of grazing”. There were three sessions: setting the scene, modelling of grazing and field measurements.

Keywords
EGF, Europe, grazing, research methodology

Reference
ISSN 1570 - 8616

Authors
A. van den Pol-van Dasselaar
A. de Vliegher
D. Hennessy
J.L. Peyraud
J.B. Pinxterhuis

Title
Research methodology of grazing
Report 405

LIVESTOCK RESEARCH
WAGENINGEN UR

Report 405

Research methodology of grazing

A. van den Pol-van Dasselaar
A. de Vliegher
D. Hennessy
J.L. Peyraud
J.B. Pinxterhuis

February 2011

Preface

Throughout Europe, grass is the main feed for dairy cattle. Furthermore, grazing systems are important components of the landscape in almost all European countries. A Working Group on Grazing was established during the 22nd General Meeting of the European Grassland Federation (EGF) in Uppsala in 2008. The aim of this Working Group is to exchange knowledge on all aspects of grazing research and to provide a forum for networking. Members of the group are primarily scientists. They interacted during the 2008-2010 period via surveys and emails and through direct contact.
The first meeting of the EGF Working Group Grazing was held on 29 August 2010, prior to the 23rd General Meeting of the European Grassland Federation in Kiel. This report summarizes the results of this first meeting. I would like to thank all the participants for their active participation to the meeting and the lively discussions during and after the meeting.

Dr. Ir. Agnes van den Pol-van Dasselaar
Chair EGF Working Group Grazing

Summary

This report presents the main results of the first meeting of the EGF Working Group Grazing in Kiel on 29 August 2010. The aim of the Working Group is to exchange knowledge on all aspects of grazing research and to provide a forum for networking. The theme of the meeting was “Research methodology of grazing”. There were three sessions:

- Setting the scene,
- Modelling of grazing,
- Field measurements.

The participants of the day considered grazing a topic of increasing interest both for production and for nature conservation. They concluded that the EGF Working Group Grazing should continue to exchange knowledge and methods and should continue to network.

Table of contents

Preface

Summary

1 General introduction ... 1

2 Setting the scene ... 2

2.1 Grazing in Europe 2010 ... 2

2.2 Spatial localization of grassland and grazers in Europe ... 4

2.3 Discussion on setting the scene ... 4

3 Modelling of grazing, solutions for grassland-based production systems ... 6

3.1 Development and use of the Moorepark Dairy Systems Model ... 6

3.2 Modelling herbage intake for predicting performance: the example of INRAtion software ... 6

3.3 DairyWise, a whole farm model ... 6

3.4 Evaluating grass growth models to predict grass growth in Ireland ... 6

3.5 Phenotypic plasticity, multiple species, spatial heterogeneity and grazing: plenty of challenges ... 8

3.6 Discussion on modelling of grazing/lessons to be learned ... 8

4 Field measurements ... 10

4.1 N-Alkanes: A technique to measure herbage intake in dairy cows ... 10

4.2 Grazing measurements in Swiss low- and highlands ... 10

4.3 Luxembourg FILL Pasture project 2003-2009 ... 11

4.4 Experimental design at grazing: Paddock replicates do not remove cow behaviour synchronization ... 12

4.5 Discussion on field measurements/lessons to be learned ... 13

5 Evaluation and conclusions ... 14

5.1 Evaluation of the day ... 14

5.2 Topics for the future ... 14

5.3 Report Business Meeting ... 14

Literature ... 15

Appendices ... 17

Appendix 1 Agenda of the meeting ... 17

Appendix 2 List of participants ... 18

1 General introduction

The first meeting of the EGF Working Group Grazing was held on 29 August 2010, prior to the 23rd General Meeting of the European Grassland Federation in Kiel. The topic of the meeting was: "*Research methodology of grazing"*. During the meeting several presentations were given and there was ample time for discussion. This report provides an overview of the meeting. There were three sessions. The first session "Setting the scene" is described in Chapter 2. The second session "Modelling of grazing" is described in Chapter 3. The third session "Field measurements" is described in Chapter 4, followed by some general remarks in Chapter 5. Both this report and the pdf-files presented during the meeting can be found at the EGF website under the pages of the Working Group Grazing (www.europeangrassland.org/working-groups/grazing).The program and the list of participants can be found in Appendix 1 and Appendix 2 of this report, respectively. There were participants from 15 countries (14 countries within Europe and one country outside Europe).

Prior to the meeting a survey was sent to the participants who were asked for their individual targets for the meeting. These can be summarized as follows:

- Acquire knowledge that can be used for my work
- To keep an eye on developments in the area
- To discuss questions related to grazing research
- To know the teams working on this issue
- To discuss ways to do our calculations in the same way
- To stimulate the creation of regional grazing groups
- Make clear methodological problems
- Contacts/network international group of experts
- Good insight into actual modelling research
- To know how other researchers deal with the problem measurement

2 Setting the scene

2.1 Grazing in Europe 2010

Agnes van den Pol-van Dasselaar (Wageningen UR Livestock Research, the Netherlands) presented "Grazing in Europe 2010" (Van den Pol-van Dasselaar, 2010a). In this presentation an overview of grazing was given. Advantages and disadvantages of grazing were presented. Furthermore, trends in grazing were described and discussed. The presentation is summarized below by the author.

A survey amongst scientists of the EGF Working Group Grazing (not only the scientists attending the meeting, but all scientists with interest in this Working Group) provided the current levels of grazing used in the countries in which participants work:

- Norway, Sweden, Finland: welfare legislation, six weeks to four months outside, decreasing
- Denmark: 84% in 2001, 70% in 2003, 40-50% in 2008, 35-45% in 2010, decreasing
- Ireland: 99% in 2010, staying consistently high, grass based seasonal systems dominate
- UK: 95% in 2005, decreasing
- The Netherlands: 95% in 1990, 75-80% in 2010, slow decrease
- Belgium, 95% in Flanders in 2010, decreasing
- Luxembourg, 90% in 2008, 75-85% free access in 2010, but 10% real grazing
- Germany: along the alps and low mountain range 85% in 2010, other regions grazing is marginal, decreasing
- France: decreasing in the more intensive area, but not in humid mountains
- Switzerland: 70-80% in 2010
- Poland: decreasing
- Czech Republic: 20% in 2010, sharp decrease in 1990-2008, currently slight increase
- Slovenia: 25% in 2010, stable or decreasing
- Portugal: 50% in 2010, increasing
- Spain: 20% in 2010 in NW, rest 0%, slow increase
- Greece: 15% in 2010, slow increase

The decline in the popularity of grazing is supported by current trends in livestock farming in Europe. Average herd size increased during the last number of years and the number of automatic milking systems increased. Grazing of large herds can be difficult to manage. And even though grazing in combination with an automatic milking system is possible, the general consensus is that it is difficult to manage. The average milk production per cow increased and farmers with high yielding cattle like to control feed rations. Again, control of feed rations is more difficult in grazing situations. In countries where grass growth is delayed in summer, another reason for less grazing may be the uncertainty of grass supply to meet the feed demand of grazing cows. Finally, reasons for less grazing may be better grassland utilization, the need to reduce mineral losses and arguments with respect to labour. The latter is a particularly important factor for many farmers. In most countries, there are few tools available to support farmers in grazing. Simple and easy-to-use grazing systems and practical management tools have to be developed to support farmers in grazing management (Van den Pol-van Dasselaar *et al*., 2008; Van den Pol-van Dasselaar, 2010b).

The trend of less grazing in Europe is expected to continue. In Northern Europe, grazing is practiced more often than in Southern Europe. However, in Northern Europe the percentage grazing is also decreasing rapidly. Is this a matter of concern?
The grazing system affects various aspects like grassland productivity, animal welfare, environment, economy, labour and even society. Grazing has advantages and disadvantages (see Table). The importance attached to the various effects of grazing is very personal. Restricted grazing scores well on the whole.

The effect of grazing (unrestricted grazing, restricted grazing, no grazing) on various aspects. The score ranges from - - to ++, with ++ signifying that the system concerned scores positive for the point in question, e.g. high health, low losses (Van den Pol-van Dasselaar *et al*., 2008; Van den Pol-van Dasselaar, 2010b).			
	Unrestricted	Restricted	No grazing
Grass yield and grass use	-	+	+
Balanced diet	-	+/-	++
Natural behaviour	++	++	+
Animal health	++	+	+/-
Nitrate leaching, N_2O emission	-	+	++
Ammonia volatilisation	++	+	+/-
N losses	-	+	++
P losses	-	+/-	+
Energy use, CH_4 emission	+	-	- -
Fatty acid composition of milk	++	+	+/-
Labour: hours work per year	++	+	+
Economics	+	+	-
Image of dairy farming	++	+	-

There are economical, practical and personal motives behind the decline in grazing. The personal preferences of the farmer primarily determine the grazing system used. Grazing systems used differ between countries. A survey in Europe revealed that rotational grazing is practiced the most often. When grazing is practiced, cows graze mainly during the day. During the night, cows are indoors and get supplemental feeding. The number of hours grazed per year and per day is decreasing. In some countries (e.g. the Netherlands, Denmark, Belgium) a new development in grazing is the mobile automatic milking system, which is able to milk the animals in the field. This system is currently being tested in research projects.

In several European countries grazing is an issue for society. When asked, scientists responded to the question of whether grazing is a societal issue or not, as follows:

- Norway, Sweden, Finland: Yes, welfare, positive image
- Denmark: Yes, welfare
- Ireland: No, grazing is taken for granted
- The Netherlands: Yes, animal welfare, culture, biodiversity, landscape
- Belgium: Not yet
- Luxembourg: Yes, synonym with animal health, animal welfare, sustainable agriculture, but also with old-fashioned, non-productive, unpractical and utopic milk production. No for the general public (they see enough suckler cows in the field)
- Germany: Important for tourists, especially in Alps and low mountain ranges, organic farming, animal welfare
- France: Yes, landscape, biodiversity, natural behaviour, animal welfare (milk pack and cheese box often show grazing cows)
- Switzerland: Yes, especially alpine grazing, positive image and part of the culture
- Poland: Not really an issue
- Czech Republic: No
- Portugal: Yes, animal welfare, improved soil characteristics of animal products, landscape, forest fire prevention, biodiversity conservation, soil erosion prevention, CO_2 sequestration
- Spain: Not really an issue, however milk packs show grazing cows

2.2 Spatial localization of grassland and grazers in Europe

Alex de Vliegher (ILVO, Belgium) presented “Spatial localization of grassland and grazers in Europe” (De Vliegher and Van Gils, 2010). In this presentation, results of an inventory on roles and utility of grasslands in Europe were presented. Importance, functions and utility of grassland in Europe was studied at the catchment and landscape levels from economic, agronomic and environmental point of view. Important aspects were:

- Spatial localization of grassland within landscapes,
- Interaction between grassland, arable crop and other landscape elements,
- Incorporation of different farming systems, pedo climatic and socio-economic conditions.

In the presentation, several maps of Europe were shown to indicate the aspects described above. The study was part of the EU FP7-project MultiSward, in which multi-species swards and multi scale strategies for multifunctional grassland-based ruminant production systems are studied (www.multisward.eu).

2.3 Discussion on setting the scene

A new development in grazing research is the development of tools to support farm management. In Ireland for instance there are tools available to improve grazing in spring and autumn and thus extend the grazing season. Also in other countries, tools are available or under construction.

De Vliegher and Van Gils (2010) showed which European areas are favourable for dairy production. Some questions were raised about the criteria to decide whether a region is favourable or not for milk production. It was explained that processing and consumption of milk were also included. Further information can be found in Smit *et al*. (2008).

There are different definitions for temporary grasslands available. De Vliegher and van Gils (2010) used the following definition: temporary grasslands are grasslands less than 5 years old and included in a rotation system with other crops.

Results from the survey of Van den Pol-van Dasselaar (2010a) showed different percentages for grazing in different countries. What we need are unanimous definitions on grazing. Zero-grazing means the animals are fed fresh grass inside; summerfeeding means animals are fed silage year round. But grazing is a more diffuse concept.

When discussing grazing, people often raise the question about definitions of grazing. We need to find answers to the following questions. Do we need a standardized definition of grazing? And what could it be like? Are there limits with respect to time and to space?
The Working Group Grazing posed the following statements and questions:

- Can we define how many kg of grass dry matter (DM) a cow consumes in order to be classified as grazing?
- It is not only cows that are important. Grazing by other animals (goats, sheep, horses) is also important!
- Grazing is not only important for production, but can also be used for landscape/biodiversity purposes.

Several countries currently work with definitions of grazing:

- The Netherlands: Some dairy factories produce milk from grazing cows. They work with the following definition: dairy cattle have to be outside for at least 6 hours a day and at least 120 days a year.
- Sweden: 6 hours a day.
- Switzerland: There are welfare programs in which farmers get paid extra for giving their cows at least 3 days a week outdoor access in winter and continuous outdoor access during summer. In theory it could be on the road.
- Spain: 6 hours a day is required to have positive effects on the content of fatty acids in milk

- Denmark. Organic farmers are obliged to let their animals graze during day time. But what is the objective? E.g. does the cow need sunlight? For the pasture, grazing at night time is better.
- For other countries there are no precise definitions, but grazing is just the simplest way to reduce feeding costs and/or is a traditional way of producing milk (Ireland, France).

The group concluded that it is not possible to set one standard quantitative definition of grazing for the whole of Europe. The hours per day differ between countries according to possibilities. Grazing is the natural way of feeding for a cow, when she harvests grass and other forage from the pastures. At the same time she deposits her manure and urine in the pastures. People did agree that grazing is related to pasture intake. If there’s no pasture intake, one should not speak of grazing. For example ammonia emission can only be reduced by grazing if there is indeed a pasture present. Pasture intake is difficult to measure, it can be calculated from milk production, silage intake and concentrate level.

Challenges for grazing research in the next decade were discussed. A survey among scientists of the EGF Working Group Grazing in Europe revealed the following challenges:

- Develop new grazing systems (large herds, automatic milking systems)
- Adapt systems to climatic patterns, energy prices, environmental legislation
- Adequate and handy technology to measure grassland (quantity, quality)
- Answers to environmental aspects of grazing (e.g. CH_4 emissions)
- Modelling plant-animal interactions
- Standardize technical grazing knowledge and tools
- To enhance the positive externalities of grazing
- As always: efficient growth and utilization

3 Modelling of grazing, solutions for grassland-based production systems

3.1 Development and use of the Moorepark Dairy Systems Model

Deirdre Hennessy (Teagasc, Ireland) presented “Development and use of the Moorepark Dairy Systems Model” (Shalloo and Hennessy, 2010). In this presentation, an overview of the Moorepark Dairy Systems Model (MDSM) was given. It is a stochastic budgetary simulation model for dairy production systems in Ireland. The objective of MDSM is to represent all aspects of the production system:

- technical
- institutional
- economic

3.2 Modelling herbage intake for predicting performance: the example of INRAtion software

Rémy Delagarde (INRA, France) presented “Modelling herbage intake for predicting performance: the example of INRAtion software” (Delagarde *et al*., 2010). In this presentation, modelling of herbage intake during grazing in France was discussed. Afterwards, the discussion focused on the need to validate models. Validation is necessary, but also time-consuming. With respect to the validation of the presented model, hundreds of data on intake have been gathered using markers. The best marker depends on the situation. Delagarde does not have a preference. Quality of grass is taken into account with fill parameters. Sward height is important, because it influences quality: generally the perception is the lower the sward height, the higher the quality (digestibility, protein content). Relative herbage intake depends on daily access time but also on how much is being fed indoors.

3.3 DairyWise, a whole farm model

Gertjan Holshof (Wageningen UR Livestock Research, The Netherlands) presented “DairyWise, a whole farm model” (Holshof, 2010). In this presentation, DairyWise was introduced. Additional information on DairyWise can be found in Schils *et al*. (2007). DairyWise is an integrated whole farm model applicable for dairy farms in the Netherlands. This empirical model simulates technical, environmental and financial processes. The heart of the model is the Feed Supply Model, which incorporates:

- Herd model: feeding, reproduction and milk production,
- Grass growth model,
- Grassland management model.

Additional remarks in the discussion were that the main objective of the Feed Supply model is to simulate the forage supply of a farm to support strategic decisions (not operational). In recent years, the model has been expanded to answer questions with respect to the effect of farm management on the environment. Labour costs can also be calculated. The current model calculates the milk production from feed availability and quality.

3.4 Evaluating grass growth models to predict grass growth in Ireland

Deirdre Hennessy (Teagasc, Ireland) presented “Evaluating grass growth models to predict grass growth in Ireland” (Hennessy *et al*., 2010). This presentation is summarized below by the authors.

Dairy production in Ireland is predominantly grass-based with spring calving dairy herds. Ireland has a long grazing season, extending from early February to late November. Grass production on farms ranges from 8 – 16 t DM ha^{-1} yr^{-1}. The proportion of grazed grass in the diet of dairy cows is approximately 60-70%, with another 30-35% in the form of grass silage and the remainder is concentrate. Beef and sheep production are also predominantly grass based. Grass growth in Ireland is variable both within and between years, due largely to climatic factors, and as a result, the prediction of grass growth and supply can be challenging. While there are several grass growth models available; varying from simple empirical to multi-component mechanistic, there is a lack of development of models to accurately forecast grass growth. A grass growth predictor would be invaluable to forecast feed supply, allowing better management of feed budgets. The objective of this study was to compare the accuracy of prediction of three grass growth models using climatic and grass growth data from Teagasc Moorepark Dairy Production Research Centre over three years.

The three models selected for evaluation were developed for perennial ryegrass swards in temperate climates. The three models were (1) an English model developed and described by Johnson and Thornley (1983), this is a mechanistic model based on individual plant processes, incorporating leaf area expansion and senescence where the above-ground dry matter is divided into four compartments described by structural weight and leaf area index; (2) an Irish model described by Brereton *et al*. (1996) and modified by R. Schulte (unpublished), this static model provides a means to understanding the dynamics of a grazing management system subject to a variable herbage supply taking into account the vegetative and reproductive phase; and (3) a French model described by Jouven *et al*. (2005), this is a mechanistic model designed to respond to various defoliation regimes, perform multiple-year simulations and produce simple outputs that are easy to use as inputs for other models, in which the biomass is subdivided into four compartments taking into account their biomass, age and digestibility. The inputs to all three models are meteorological data collected at Teagasc Moorepark. The modelled data were compared to grass growth data measured at Moorepark over the three years 2005, 2006 and 2007 using the methods described by Corral and Fenlon (1978).

Model predictions of grass growth rate for 2005 are shown in Figure 1. Over the three years, the model that best fits the data is the Jouven model (Table 1), although it under predicts for the winter period. The Johnson and Thornley model repeatedly over predicts grass growth from about mid-April onwards, particularly in the late spring and summer. The Irish model is over predicting grass growth during the winter period but it closely follows the observed trend during the remainder of the year.

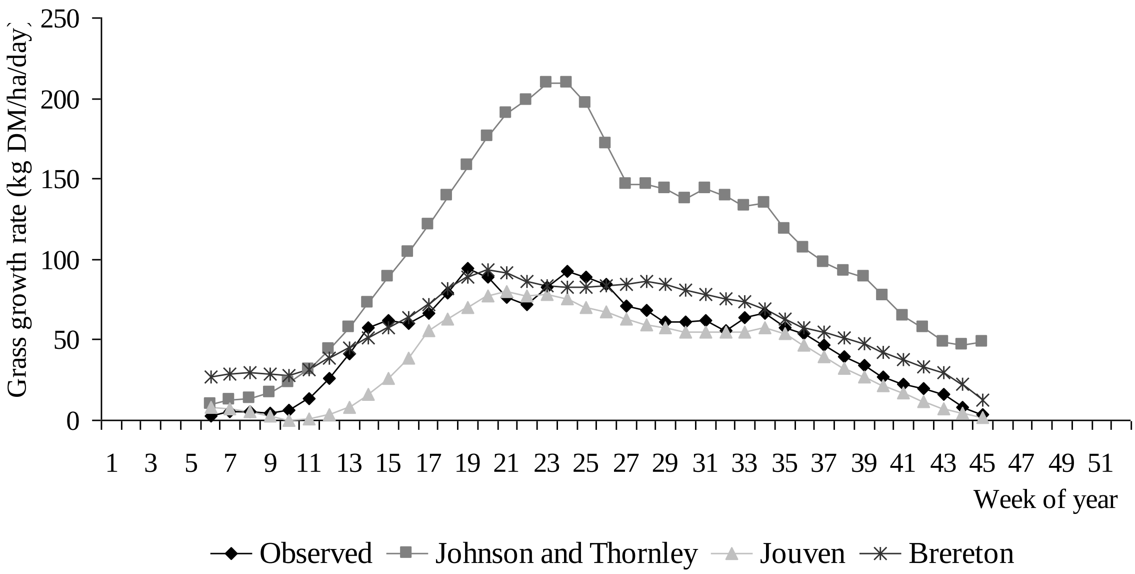

Figure 1 Example of observed and predicted Moorepark grass growth rates (kg DM ha^{-1} d^{-1}) for 2005

In the discussion following the presentation several items were addressed:

- The Johnson and Thornley model (J&T Model) constantly over-predicted grass growth because it does not include the reproductive stage of grass growth.
- Grass growth was measured on a four week interval, with a new plot cut every week (= Corral and Fenlon methodology).
- The next step is to test the model for different climatic regions of Ireland for robustness. This could perhaps be done in the future in other temperate areas of Europe too.
- The ultimate aim is to predict future grass growth. Farmers want to know the trends; they do not always need absolute figures.

3.5 Phenotypic plasticity, multiple species, spatial heterogeneity and grazing: plenty of challenges

Nick Hutchings (University of Aarhus, Denmark) presented “Phenotypic plasticity, multiple species, spatial heterogeneity and grazing: plenty of challenges” (Hutchings, 2010). In this presentation, the statements “grass is special” and “grassland management is special” were illustrated. Modelling grass, grassland and management is therefore challenging. A range of tools exist, varying in complexity, but how should we use them? Modelling grazing is complex. There is no universal approach. How to choose an appropriate level of complexity? How to link existing models? These questions led to a lively discussion. Different opinions with respect to selection of animals were presented: animals select patches according to density, animals select according to quality. Nature conservation for example works on the low end of animal density (illustrated with examples of sheep). Models tend to be attached to personal and institutional egos, it’s difficult to let go of these egos. The animal nutritionists use different parameters according to their respective countries. They do not seem to be able to get one system for the whole of the EU. But the animals themselves do not change as soon as they cross the border! Also technological difficulties arise and make linking of models very time consuming and thus expensive. Generally there are no genetic components built in models. Often farm models are based on data from experimental farms. The situation can however be very different at commercial farms. This has to be taken into account when discussing the validity of our models.

3.6 Discussion on modelling of grazing/lessons to be learned

The participants of the meeting were asked before the meeting what questions they would like to raise in the workshop with respect to modelling of grazing. The following questions were raised:

- Quantifying (daily) intake of grass
- Relationships between different parameters that can be measured with grazing, e.g. time spent and the amount of grass eaten
- How to balance between the need to represent processes in models and the need to avoid problems of complexity/data availability if too many processes are described
- Use the same calculations!!!
- Grass growth model for other plant communities than perennial ryegrass-white clover

The question with respect to quantifying (daily) intake of grass was considered to be the most important question.

During the workshop there was ample time to discuss issues raised in the presentations and to discuss topics of personal interest related to the topic. The main results of these discussions were:

- Tools (machines/monitoring devices) are needed to help operational decisions.
- Models should take into account technical, economic and social arguments/factors.
- Models are needed on different scales and with different complexity. Simple models are needed for practice and for students. The farm scale is important for the farmer. The regional scale can be important for policy makers, e.g. to monitor changes in percentage land covered by grass. It is essential to clarify the aim and the scope of models and to use the models only for this aim and scope.
- Mechanistic grass growth models are not easy to use. There is a need for more applied models, which are precise enough at the farm scale. Good grazing is a skill and we need more tools to help the farmer/advisor. These tools should not be complex!
- Grassland management tools are already available in several countries, like the spring rotation planner, feed wedge and autumn feed budget in Ireland.
- Modelling of grass quality is both important and difficult. Important components are: digestibility, protein content and leaf content for various species, cultivars and sward composition.
- Modelling of grazing of high productive dairy cows is needed.
- Weighing of factors is needed.
- Measuring spatial heterogeneity is difficult.
- With respect to grazing, both information on a yearly basis (e.g. percentage of grass used by grazing animals) and on a day-to-day basis is needed (e.g. grass converted into milk in kg milk per ha grass).

- Since grazing is influenced by many factors (e.g. climate, national policies, culture), these factors need to be incorporated in the models. Do we know all the factors concerned?
- The basics of all models should be the same, but do we know what the basics are?
- The model is just as good as the underlying data. An interesting discussion was whether the field data fed the model or whether the model shows the gaps in available field data.
- A good long-term model starts with a good short-term model.
- A lot of the available data are from short-term experiments. Information from “old swards” (e.g. never reseeded) is valuable. Sward persistency may change in the long-term. The effect of biodiversity may become visible in the long-term only. Grass sward makes the difference in the long-term.
- Creation of common databases of European grasslands, including old swards, could be greatly enhanced by financers like the EU.
- Common methodology is needed, starting with collaboration between countries with similar production systems.

4 Field measurements

4.1 N-Alkanes: A technique to measure herbage intake in dairy cows

Mary McEvoy (Teagasc, Ireland) presented “N-Alkanes: A technique to measure herbage intake in dairy cows” (McEvoy, 2010). This presentation is summarized below by the author.

Herbage intake is considered one of the main constraints of ruminant production. Traditionally the most commonly used method is the sward cutting method. This method is mainly used to determine dry matter intake (DMI) of groups of animals and large variation has been reported. An alternative to this is the *n*-alkane method. This method was developed by Mayes *et al*. (1986) and then modified by Dove and Mayes (1991) and later by Dillon (1993). The *n*-alkanes are long-chain hydrocarbons present in the cuticular wax of plants. Plants contain mixtures of *n*-alkanes with chain lengths ranging from 21 to 35 carbons. Odd-numbered carbons predominate. Additionally, there are definite species differences in the pattern of alkane concentrations.

The procedure involves animals being dosed twice daily for twelve consecutive days with a paper pellet (Carl Roth, GmbH, Karlesruhe, Germany) containing 500 mg of dotriacontane (C_{32}-alkane). The first 6 days of dosing ensures a stable excretion pattern prior to sampling. During the final 6 days, faecal samples are collected in both the morning and evening, either in the field by following the cows and collecting the sample when voided, or by collecting rectal grab samples when the cows are in the collecting yard prior to milking. In addition, herbage, representative of that grazed (following close observation of the grazing animals selection), is manually collected from each paddock prior to the morning grazing on days 6-11 (inclusive) of the intake measurement period. Following collection, both faecal and herbage samples are stored at -20°C prior to drying and milling. *N*-alkane analysis is undertaken on the prepared sample and the ratio of C_{33} (tritriacontane) concentration in the herbage and faeces to the amount of dosed C_{32} is used to estimate DMI. Sources of error in this method include i) diurnal pattern of *n*-alkane excretion; to overcome this dosing should occur in both the am and pm; ii) inaccurate sampling of herbage; iii) incorrect concentration of alkane offered to the animal or poor consumption if offered in a concentrate; iv) incorrect sample preparation. Care should be taken to ensure the risk of these errors arising is eliminated. The method provides reliable estimates of individual animal DMI and can also be used to estimate diet composition.

In the discussion following the presentation several items were addressed:

- Field sampling of faeces is used to reduce the frequency of handling of cows. This method does require close following of the cows concerned.
- It is possible to use the *n*-alkane technique for different species (up to 6), but you have to know the alkane composition of these individual species. Dove suggests analysing more long chain alkanes if you have multi-species swards (Dove, 2010).

4.2 Grazing measurements in Swiss low- and highlands

Eric Mosimann (Agroscope, Switzerland) presented “Grazing measurements in Swiss low- and highlands” (Mosimann and Meisser, 2010). This presentation is summarized below by the authors.

In order to enhance grazing management skills, measurements have been done on lowlands and mountain pastures. At each site, grass growth was determined on fenced portions of the pastures including two plots mowed alternatively every 14 days. Simultaneously, grass samples were collected for digestibility analyses and sward density was assessed using a plate pasture meter. This tool was used to measure grass height in the paddocks as a means of evaluating the farm cover. Measured farm cover evolution has then been related to the balance between forage supply (grass growth) and grass intake by cattle. The obtained values allow a comparison between years, grazing systems and regions. They are useful to manage stocking rates and to identify improvement factors based on target sward heights.

The measurements were briefly illustrated by four examples:
- Dairy cows: intensive rotational grazing in the lowlands (Matran, 600 m above sea level)
- Dairy cows: extensive continuous grazing in a mountain area (Cerney, 1200 m above sea level.)
- Beef fattening: intensive continuous grazing in the lowlands (Moudon, 600 m above sea level)
- Beef/sheep fattening: extensive rotational grazing in a mountain area (Frêtaz, 1200 m above sea level).

In the discussion following the presentation, the following item was addressed:
- The sward height target is very low (3.5 cm) in rotational grazing, both in lowland (always) and highland (in autumn), either intensive or extensive.

4.3 Luxembourg FILL Pasture project 2003-2009

Henri Kohnen (Lycée Technique Agricole, Luxembourg) presented “Luxembourg FILL Pasture project 2003-2009” (Kohnen, 2010). Special attention was paid to the “pasture ruler” developed in this project. This is a tool to estimate and evaluate pasture intake with high merit cows. The presentation is summarized below by the author.

Introduction
The FILL (“Fördergemeinschaft Integrierte Landbewirtschaftung Luxemburg”) set up a program during 2003 to 2008 to promote management with high merit dairy cows. Project aims were (1) to analyse causes (economic, pasture quality, animal factors) of insufficient grazing of dairy cows, (2) to optimize pasture quality, (3) to optimize pasture intake, and (4) to identify the milk response to an increase of pasture intake.

Materials and Methods
Typical dairy farms with high merit Holsteins cows with all year calving were selected. Average herd size was 35-55 cows and average milk yield was 8000-9000 kg milk cow^{-1} $year^{-1}$. Feed sources were grass and/or maize silage and purchased feed concentrate, and stocking rate was 1.5 - 3.5 cows ha^{-1} under temperate European climate with an average mean precipitation of 800-1000 mm yr^{-1}.
During the grazing season, daily milk produced, daily supplementation and daily milked cows were noticed. Pasture intake was calculated based on an equation proposed by Chase and Sniffen. Total dry matter intake (DMI) was calculated by

$$DMI = 0.0185\ BW + 0.305\ FCM \qquad (1)$$

with DMI = dry matter intake in kg cow^{-1} d^{-1}, BW = body weight in kg, FCM = fat corrected milk in kg cow^{-1} d^{-1}.
Pasture intake was calculated by subtracting daily supplementation from calculated total DMI. Additionally to these field observations, published data from dairy cows on pasture were reviewed to evaluate the effect of supplementation on intake and milk production.

Results
Experimental data which have been published in the literature were analysed with respect to FCM/DMI. From this, a regression has been calculated exhibiting the linear relationship between relative pasture intake contribution to total DMI and FCM following the simple linear function of y= a+bx with y = FCM and x = DMI from pasture. Further, it was found that “b” is nearly constant for all studies and is independent of level of FCM, environment, experimental conditions and amount of supplementation whereas “a” is constant for a specific study and so expresses a physiological limit for daily milk production. These limits are defined by animal factors (mostly genetic merit, days in milk) and pasture factors (pasture quality and conditions). For all data, an average potential line and a maximum potential line could be defined in the coordinate system of a chart. The section between these two lines can be used to evaluate daily milk performance of dairy cows on pasture.
In the same chart, additional lines could be calculated to determine the relation between intake of either supplementation with feed concentrate (kg cow^{-1} d^{-1}) or from pasture, as expressed in equation 2 and 3, *i.e.* for feed concentrate

$$y = \frac{sDMI * 100}{(100 - x) * 0.305} - \frac{0.0185 * LW}{0.305} \quad (2)$$

with y = daily milk, x = pasture intake (% of total DMI), sDMI= supplementation (kg cow^{-1} d^{-1}) and BW = body weight,

and for pasture intake (kg cow^{-1} d^{-1})

$$y = \frac{100 * pDMI}{0.305x} - \frac{0.0185 * BW}{0.305} \quad (3)$$

with y = daily milk, x = pasture intake (% of total DMI), pDMI = pasture intake (kg cow^{-1} d^{-1}), BW = body weight.

These equations allow the prediction of pasture intake of a dairy herd when daily milk production and respective supplementation is known. Further, the overlay with the potential lines allows to evaluate the performance and to predict the daily milk response to changes in daily supplementation. Polynomes in equation (2) and (3) have been transferred into a coordinate system illustrating the relations between the above mentioned factors. This led to an extension tool ("pasture intake calculator", PIC) that facilitates the evaluation of dairy farm feed sources and permits the development of a feeding strategy based on pasture.
Results from pilot farms of the FILL-project confirm that this approach is applicable to reality. After the first year of observation and subsequent reduction of supplementation according to recommendation, the positions of pilot farms in the coordinate system moved towards increasing pasture and decreasing supplementation with either no or only marginal decreases in milk production.

Conclusions
The pasture calculator presented here improves the communication between farmer and advisor as well as between teacher and student. It illustrates simply the relation among production factors and so supports decisions that help to maximise the use efficiency of resources (pasture *vs* feed concentrate). With respect to increasing scarcity of resources world-wide, this tool also helps to improve utilisation of home grown low-input forage as a step towards sustainable land-use for animal production.

In the discussion following the presentation, the following items were addressed:
- The pasture ruler has been sold for only 10 Euro, farmers got it for free.
- The formula used for dry matter intake (DMI) is a simple one, not taking into account the "Fill" parameter as the French do. This simple formula works in practice.
- It is also used for indoor rations, it has however not been validated for indoor rations.

4.4 Experimental design at grazing: Paddock replicates do not remove cow behaviour synchronization

Rémy Delagarde (INRA, France) presented "Experimental design at grazing: Paddock replicates do not remove cow behaviour synchronization" (Delagarde, 2010). In this presentation, synchronization of grazing cows was compared within herds, between adjacent herds and between non adjacent herds. Delagarde ended with both negative and positive conclusions.
Negative conclusions:
- Herds should not be regarded as independent on the basis of their synchronization
- To use herds instead of cows does not solve the problem of grazing synchronization
- Stop research or statistical analyses …

Positive conclusions:

- Synchronization of grazing activities in dairy cows is mainly due to external factors (90%)
- Synchronization should not be used as an argument to define independence of data
- We should continue to use the individuals as statistical units
- Grazing research should continue!

In the discussion following the presentation Delagarde mentioned new experiments on synchronization which have been conducted to establish the distance at which synchronization still occurs. Results are not ready yet. It seems that with a distance of 500 m the decrease was only 15%. After the morning milking, the cows were given a new paddock, but it was not only the milking that was a synchronization factor. We should stop analysing synchronization, and conclude that synchronization will always occur due to external factors as e.g. time of the day.

4.5 Discussion on field measurements/lessons to be learned

The participants of the meeting were asked before the meeting what questions they would like to raise in the workshop with respect to field measurements. The following questions were raised:

- How to measure pasture production on large grazing areas with a reasonable work load?
- Can light interception be used as a tool to establish sward targets?
- What's the best way to measure grazing differences between cattle and sheep?
- How to measure herbage intake? (sample size, (chemical) methods)
- How to monitor grazing preferences?
- How to evaluate swards, especially in relation to patches?

During the workshop there was ample time to discuss issues raised in the presentations and to discuss topics of personal interest related to the topic. The main results of these discussions were:

- Focus on the underlying question! (it is always nice to know how things work, but only useful when it contributes to answering underlying questions). Researchers need to listen to what farmers/advisors need. What needs to be measured in order to develop simple models for the practical farmer?
- In field measurements, it is necessary to cope with heterogeneity and with the effect in the long-term. Not only data on monocultures, but also on mixed swards and natural swards are needed. Data are for example lacking on productivity of swards with a mixture of species.
- Not all measurement techniques are applicable on mixed species swards.
- Field measurements are needed to understand performance (e.g. expressed as beef production, milk production, health).
- Grazing preferences of free-ranging animals, like horses, are subject of study in Poland.
- Measurements are needed to explain selective grazing. What are the reasons/motivations for the cow?
- What kind of species do the animals prefer? (e.g. preference for *Lotus corniculatus* is well-known). Preferences relate to selection. Preferences may change during the season. Some participants are sure that more species in a pasture will lead to better milk quality.
- But also: which animal does fit which pasture?
- Synchronization of sheep and cows in the same paddock is an interesting subject.
- Consensus on definitions is needed to compare results of different studies and to use results from others (illustrated by an example of sward height measurements).
- It would be useful to use management tools, like the pasture ruler, in different countries and compare the results. Even though countries are different, general rules may apply.
- A list of existing techniques would be useful. Further standardization of measurements and techniques is needed.
- Methods like N-alkanes and alcohols to measure herbage intake have great potential, and great demand!
- New farming systems, e.g. automatic milking in combination with grazing, should be thoroughly studied.

5 Evaluation and conclusions

5.1 Evaluation of the day

The general opinion with respect to the meeting was positive. It is good to know people and to know what they are working on. Some people suggested that there should be more focus on the topics (not too broad, but more specific), others liked the opportunity to discuss general topics. In general, further exchange between researchers was highly encouraged. People from countries where grazing is not common, but increasing, should for example not hesitate to contact people from countries where grazing is abundant. Methods or models from these countries could be adopted and adapted to their own circumstances. The participants of the day considered grazing a topic of increasing interest both for production and for nature conservation. They concluded that the EGF Working Group Grazing should continue to exchange knowledge and methods and should continue to network.

5.2 Topics for the future

Prior to the meeting, the participants were asked what topics they would like to discuss in future workshops. The following topics were suggested:

- Influence of grazing on environment, landscape and biodiversity
- Which pastures do fit which animals the most?
- Automation (control systems, use of information technology)
- Standardization of measurements and modelling
- Advantages and disadvantages of grazing
- Why is grazing so important/does it lead to better products, better animal health
- Maximising grass intake
- Solutions for trends in the future (like large herds, automatic milking)

At the workshop an additional topic was added to this list:

- Which animal fits the pasture at stake?

Furthermore, participants concluded that the topics of the current workshop do not end here: research methodology remains an interesting topic.

Other activities of the Working Group Grazing could be:

- Connect to other meetings
- Make an inventory of all European Grazing projects and on farm researches
- European website with actual grass-growth rates
- Define and analyse European grazing regions

5.3 Report Business Meeting

The results from the Working Group Grazing were briefly reported in the Business Meeting of the European Grassland Federation on 2 September 2010. The aim of the EGF Working Group (to exchange knowledge on all aspects of grazing research and to provide a forum for networking) was repeated and the topics of the meeting were mentioned. Finally, it was announced that the results of the Working Group would become available on the website of EGF (www.europeangrassland.org/working-groups/grazing). In the coming years, the EGF Working Group Grazing will continue to exchange knowledge and methods, and will continue to network.

Literature

Brereton, A.J., S.A. Danielov and D. Scott, 1996. Technical Note No. 197. Agrometeorology of Grass and Grasslands for Middle Latitudes. World Meteorological Organisation 839, 36 pp.

Corral, A.J. and J.S. Fenlon, 1978. A comparative method for describing the seasonal distribution of production from grasses. Journal of Agricultural Science 91: 61-67.

De Vliegher, A. and B. van Gils, 2010. Spatial localisation of grassland and grazers in Europe. Presentation at the first meeting of the EGF Working Group Grazing in Kiel on August 29, www.europeangrassland.org/working-groups/grazing

Delagarde, R., 2010. Experimental design at grazing: Paddock replicates do not remove cow behaviour synchronization. Presentation at the first meeting of the EGF Working Group Grazing in Kiel on August 29, www.europeangrassland.org/working-groups/grazing

Delagarde, R., P. Faverdin, C. Baratte and J.L. Peyraud, 2010. Modelling herbage intake for predicting performance, the example of INRAtion software. Presentation at the first meeting of the EGF Working Group Grazing in Kiel on August 29, www.europeangrassland.org/working-groups/grazing

Dillon P., 1993. The use of n-alkanes as markers to determine intake, botanical composition of available or consumed herbage in studies of digesta kinetics with dairy cows. Ph.D. thesis, National University of Ireland, Dublin, Ireland

Dove, H. (2010). Keynote: assessment of intake and diet composition of grazing livestock. In: Proceedings 4th Grazing Livestock Nutrition Conference. B.W. Hess, T. DelCurto, J.G.P. Bouwman and R.C. Waterman (Eds). West. Sect. Am. Soc. Anim. Sci., Champaign, IL: 31-54.

Dove, H. and R.W. Mayes, 1991. The use of plant wax alkanes as marker substances in studies of the nutrition of herbivores: a review. Aust. J. Agric. Res. 42: 913-952.

Hennessy, D., C. Hurtado-Uria, L. Shalloo, R. Schulte, L. Delaby and D. O'Connor, 2010. Evaluating grass growth models to predict grass growth in Ireland. Presentation at the first meeting of the EGF Working Group Grazing in Kiel on August 29, www.europeangrassland.org/working-groups/grazing

Holshof, G., 2010. Dairy Wise, a whole farm model. Presentation at the first meeting of the EGF Working Group Grazing in Kiel on August 29, www.europeangrassland.org/working-groups/grazing

Hutchings, N., 2010. Phenotypic plasticity, multiple species, spatial heterogeneity and grazing; plenty of challenges. Presentation at the first meeting of the EGF Working Group Grazing in Kiel on August 29, www.europeangrassland.org/working-groups/grazing

Johnson, I.R. and J.H.M Thornley, 1983. Vegetative crop growth model incorporating leaf area expansion and senescence, and applied to grass. Plant, Cell and Environment 6: 721-729.

Jouven, M., P. Carrere and R. Beaumont, 2005. Model predicting dynamics of biomass, structure and digestibility of herbage in managed permanent pastures. 1. Model description. Grass and Forage Science 61: 112-124.

Kohnen, H., 2010. Luxembourg FILL Pasture project 2003-2009. Presentation at the first meeting of the EGF Working Group Grazing in Kiel on August 29, www.europeangrassland.org/working-groups/grazing.

Mayes, R.W., C.S. Lamb and P.M. Colgrove, 1986. The use of dosed and herbage n-alkanes as markers for the determination of herbage intake. J. Agric. Sci., Camb. 107: 161-170.

McEvoy, M., 2010. N-Alkanes: A technique to measure herbage intake in dairy cows. Presentation at the first meeting of the EGF Working Group Grazing in Kiel on August 29, www.europeangrassland.org/working-groups/grazing

Mosimann, E. and M. Meisser, 2010. Grazing measurements in Swiss low- and highlands. Presentation at the first meeting of the EGF Working Group Grazing in Kiel on August 29, www.europeangrassland.org/working-groups/grazing

Schils, R.L.M., M.H.A. de Haan, J.G.A. Hemmer, A. van den Pol-van Dasselaar, J.A. de Boer, A.G. Evers, G. Holshof, J.C. van Middelkoop and R.L.G. Zom, 2007. DairyWise, A Whole-Farm Dairy Model. J. Dairy Sc. 90: 5334-5346.

Shalloo, L. and D. Hennessy, 2010. Development and use of the Moorepark Dairy Systems Model. Presentation at the first meeting of the EGF Working Group Grazing in Kiel on August 29, www.europeangrassland.org/working-groups/grazing

Smit, H.J., M.J. Metzger and F. Ewert, 2008. Spatial distribution of grassland productivity and land use in Europe. Agricultural Systems 98: 208-219.

Van den Pol-van Dasselaar, A., T.V. Vellinga, A. Johansen, E. Kennedy, 2008. To graze or not to graze, that's the question. In: Biodiversity and Animal Feed. Future Challenges for Grassland Production. A. Hopkins, T. Gustafsson, J. Bertilsson, G. Dalin, N. Nilsdotter-Linde, E. Spörndly (Eds). Grassland Science in Europe Volume 13: 706-716.

Van den Pol-van Dasselaar, A., 2010a. Grazing in Europe 2010. Presentation at the first meeting of the EGF Working Group Grazing in Kiel on August 29, www.europeangrassland.org/working-groups/grazing

Van den Pol-van Dasselaar, A., 2010b. Grazing in Europe. In: Proceedings 4th Grazing Livestock Nutrition Conference. B.W. Hess, T. DelCurto, J.G.P. Bouwman and R.C. Waterman (Eds). West. Sect. Am. Soc. Anim. Sci., Champaign, IL: 198.

Appendices

Appendix 1 Agenda of the meeting

Meeting of the EGF Working Group Grazing:
"Research methodology of grazing", Kiel, August 29, 9.00 - 17.00
(coffee breaks at 10.30 and 15.00, lunch at 12.30)

PLACE: Campus Kiel University, lecture room A in the Audimax, Christian-Albrechts-Platz 2, 24118 Kiel

Setting the scene
- Introduction (welcome to the participants, targets, procedures and program), getting to know each other
- Grazing in Europe in 2010 (based on the 2009/2010 survey among EGF-members) (Agnes van den Pol-van Dasselaar, Wageningen UR Livestock Research, the Netherlands)
- Spatial localization of grassland and grazers in Europe (Alex de Vliegher, ILVO: Institute for Agricultural and Fisheries Research, Belgium)
- General discussion on definitions of grazing. Do we need a standardized definition of grazing? And what could it be like? Are there limits with respect to time and to space?

Modelling of grazing, solutions for grassland-based production systems
- The Moorepark Dairy Systems Model (Laurence Shalloo, Teagasc, Ireland)
- Modelling herbage intake for predicting performance: the example of INRAtion software (Rémy Delagarde, Philippe Faverdin, Christine Baratte and Jean-Louis Peyraud, INRA, France)
- Modelling of grazing in DairyWise (Gertjan Holshof, Wageningen UR Livestock Research, the Netherlands)
- An evaluation of three grass growth models to predict grass growth in Ireland (Deirdre Hennessy, Teagasc, Ireland)
- Phenotypic plasticity, multiple species, spatial heterogeneity and grazing; plenty of challenges (and a few answers) (Nick Hutchings, Aarhus University, Denmark)
- Group discussion on issues raised in the presentations
- Lessons to be learned (general discussion)

Field measurements
- N-alkanes: A technique to estimate herbage intake in dairy cows (Mary McEvoy, Teagasc, Ireland)
- Grazing measurements in Swiss low- and highlands (Eric Mosimann and Marco Meisser, Agroscope, Switzerland)
- Luxembourg FILL Pasture project 2003-2009 with focus on Pasture ruler: Tool to estimate and evaluate pasture intake with high merit dairy cows (Henri Kohnen, Lycée Technique Agricole, Luxembourg)
- Experimental design at grazing: paddock replicates do not remove animal behaviour synchronization (Rémy Delagarde, INRA, France)
- Group discussion on issues raised and on important topics of research methodology, practical solutions for problems encountered in grazing research
- Lessons to be learned (general discussion)

Evaluation of the day, topics for the future
- Concluding remarks
- Follow up of the meeting
- Agreements
- Report to EGF
- Closure

Appendix 2 List of participants

Alex	De Vliegher	ILVO	Belgium
Domicio	Nascimento Jr.	Universidade Federal de Vicosa	Brazil
Andre	Sbrissia	Santa Catarina State University	Brazil
Jan	Gaisler	Crop Research Institute	Czech Republic
Lenka	Pavlu	Crop Research Institute	Czech Republic
Vilém	Pavlu	Crop Research Institute	Czech Republic
Nick	Hutchings	Aarhus – Agroecology	Denmark
Frank	Oudshoorn	Aarhus - Biosystems Engineering	Denmark
Andres	Olt	Estonian University of Life Sciences	Estonia
Rémy	Delagarde	INRA	France
Lucio	Pérez-Prieto	INRA	France
Jean Louis	Peyraud	INRA	France
Martin	Gierus	CAU-Kiel	Germany
Martina	Hofmann	Saxon State Agency for Environment, Agriculture and Geology	Germany
Johannes	Isselstein	University of Göttingen	Germany
Sabrina	Jerrentrup	University of Göttingen	Germany
Edmund	Leisen	Landwirtschaftskammer NRW	Germany
Karl-Heinz	Südekum	Universität Bonn	Germany
Stefan	Thurner	Bavarian State Research Centre for Agriculture	Germany
Deirdre	Hennessy	Teagasc	Ireland
Mary	McEvoy	Teagasc	Ireland
Paul	Phelan	Teagasc	Ireland
Dorothee	Kloecker	Giessen – CONVIS	Luxembourg
Henri	Kohnen	LTA Ettelbrück	Luxembourg
Piotr	Stypinski	Warsaw University of Life Sciences (SGGW)	Poland
Noémia	Farinha	Instituto Politécnico de Portalegre	Portugal
Antonio	Gonzalez-Rodriguez	Xunta Galicia	Spain
Ana Isabel	Roca Fernández	Agrarian Research Centre of Mabegondo	Spain
Nilla	Nilsdotter-Linde	Swedish University of Agricultural Sciences	Sweden
Maja	Pelve	Swedish University of Agricultural Sciences	Sweden

Eva	Spörndly	Swedish University of Agricultural Sciences	Sweden
Lotten	Wahlund	Swedish Institute of Agricultural and Environmental Engineering	Sweden
Olivier	Huguenin	Agroscope	Switzerland
Tasja	Kälber	ETH Zurich	Switzerland
Andreas	Luescher	Agroscope	Switzerland
Eric	Mosimann	Agroscope ACW	Switzerland
Fredy	Schori	Agroscope Liebefeld-Posieux	Switzerland
Klaas	Van der Hoek	RIVM	The Netherlands
Gertjan	Holshof	Wageningen UR Livestock Research	The Netherlands
Bert	Philipsen	Wageningen UR Livestock Research	The Netherlands
Ina	Pinxterhuis	Wageningen UR Livestock Research	The Netherlands
Agnes	van den Pol-van Dasselaar	Wageningen UR Livestock Research	The Netherlands

Wageningen UR Livestock Research

Edelhertweg 15, 8219 PH Lelystad T 0320 238238 F 0320 238050

E info.livestockresearch@wur.nl I www.livestockresearch.wur.nl