COST Action
Final Achievement Report

FA1302: Large-scale methane measurements on individual ruminants for genetic evaluations

(10/12/2013 to 09/12/2017)

The Action was approved by the Committee of Senior Officials (CSO) on 16-5-2013 and has the MoU reference COST 016/13.

This report was submitted on 11-02-2018 by the Action Chair on behalf of the Management Committee in fulfilment of the requirements of the rules for COST Action Management, Monitoring and Final Assessment.

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Action leadership and participants

Leadership positions

Position	Name	Contact details	Country of work affiliation
Chair	Dr Yvette de Haas	Yvette.deHaas@wur.nl +31317480505	Netherlands

Position	Name	Contact details	Country of Nomination
Vice Chair	Dr Jan Lassen	jan.lassen@agrsci.dk +4587157936	Denmark

Working groups

#	WG Title	# of participants	WG Leader	Country of nomination
1	Methane-determining factors	66	Dr Björn Kuhla b.kuhla@fbn-dummerstorf.de	Germany
2	Comparison and calibration of measurements	85	Prof Phil Garnsworthy Phil.Garnsworthy@nottingham.ac.uk	United Kingdom
3	Proxies for methane emission	64	Dr Enyew Negussie enyew.negussie@mtt.fi	Finland
4	Benefit for producers	61	Dr Eileen Wall eileen.wall@sruc.ac.uk	United Kingdom
5	Knowledge and management exchange (KME)	12	Ms Miriam van Straten miriam.vanstraten@effab.info	Netherlands

Other key leadership positions

Position	Name	Contact details	Country of work affiliation
STSM Coordinator	Dr Marcin Pszczola	marcin.pszczola@gmail.com	Poland

Participants

COST members having accepted the MoU

AT	20/06/2013	**BE**	23/07/2013	**DK**	03/06/2013	**FI**	18/06/2013	**FR**	05/07/2013
DE	17/06/2013	**EL**	19/01/2016	**IE**	22/07/2013	**IL**	30/09/2016	**IT**	29/08/2013
LT	18/11/2013	**NL**	20/06/2013	**NO**	23/08/2013	**PL**	24/06/2013	**PT**	17/09/2013
SK	13/10/2014	**SI**	25/08/2013	**ES**	27/06/2013	**SE**	02/09/2013	**CH**	03/07/2013
TR	13/05/2014	**UK**	30/05/2013	**MK**	11/12/2013				

Other participants

Institution Name	Country

Summary

Main aim/ objective

The main objective of the Action is to reduce environmental footprints of animal-derived food using methane mitigation strategies through animal breeding. The Action aims at harmonising large-scale methane measurements using different techniques; agreeing on identified easy to record proxies for methane emissions for genetic evaluations; and on approaches for incorporating methane emissions in breeding strategies.

The Action addressed this as described below

When the idea of METHAGENE was born in 2012, many researchers of different disciplines were targeting to reduce the environmental footprint of animal-derived food using methane mitigation strategies. These strategies included nutrition, microbiological understanding, and improving the animal. Achieving this was very urgent, and there was a need to learn from each other and to create synergies and concensus. Now that METHAGENE has finished, we are proud that we have gained a lot of new insights and that together we moved further than everyone could have moved alone. The open discussions involving several disciplines ensured that all aspects were taken into account when defining the methane-determining factors. These factors are important to incorporate when setting up an experiment to record the enteric methane of ruminants. In short, an animal nutritionist should take the variations between animals into account, and the geneticist, contrarily, should take the effects of the different diets into account. This became also clear during the Awareness meeting that was organised to clarify that sometimes different terms are used in different fields for the same meaning, or opposite, that different meanings are given to the same word, but also to clear the sky for the prejudices of one discipline for another. The open atmosphere in METHAGENE allowed to have these open discussions. The methane-determining factors were the basis for the search for the best proxy for methane. A group of experts met twice, once in warm Catania (+25C) and once in cold Finland (-25C). This group has published an invited review on the several proxies and how to use them. The expert meetings built trust to share data for a joint analysis on the added value of one proxy above the other one. That is the big advantage of a COST Action, that people get to meet each other and enlarge their network. Especially in an area like this, where data recording is scarce, the only way to move forward is to collaborate and collate data, but that is not easy to arrange when people don't know each other. Several groups have recorded data, but all use different protocols and/or techniques to record the enteric methane of ruminants. Within METHAGENE we have reviewed the techniques and compared them. That results in a unique meta-analysis that will help researchers and breeding companies in the future to collate a large enough dataset for accurate estimates of genetic parameters. These genetic parameters are necessary for incorporating a reduction of the enteric methane in national breeding programmes. Within METHAGENE we have shown the effect of several current breeding programmes on the enteric methane emission, and we have shown what's needed to counteract that effect. However, as long as there is no incentive (e.g., a carbon tax), an environment-friendly breeding programme will not be in place. However, METHAGENE has ensured that the building blocks are ready for use, when there is a need. Bringing the disciplines, experiences and expertise together was essential for this, and METHAGENE has been very successful in that.

Action website

http://www.methagene.eu/index.html

Achievement of MoU objectives, deliverables and additional outputs/ achievements

MoU objectives

The Action had the following specific objectives:

MoU objective	Level of achievement	Further information (hyperlink or other)
disseminate animal- and herd-level factors contributing to variation among animals in methane production, distinguishing between true influences and those attributable to methodology; appropriate units of measurements (e.g., grams per unit output or per unit input) and the use of common units that allow data and interpretation of the data to be compatible within and between populations	76 - 100%	An overview of all methane-determining factors is published in a report, which can be found on the METHAGENE website: http://www.methagene.eu/workinggroups/WG1/output/Final_Report_METHAGENE_WG1.pdf. The methane-determining factors are mainly related to (1) the feed intake and ration composition, (2) the rumen and rumen flora population, (3) the animal itself, like live weight, breed and genetic abilities, and (4) some factors that are hard to group under one, like lactation stage. With the unique METHAGENE consortium, consisting of several disciplines within animal science (nutritionists, physiologists, microbiologists and geneticists) made it possible to interprete the methane-determining factors correctly. The methane phenotypes, including their pros and cons, were described in an invited review for the Journal of Dairy Science: https://www.sciencedirect.com/science/article/pii/S0022030216308335. This was a concerted action of several members of the METHAGENE consortium, that resulted in this nice overview.
disseminate established protocols for calibration, comparison, harmonisation and merging large-scale methane measurement using from different techniques and measuring strategies for individual animal methane emissions	76 - 100%	An overview of methane techniques and measuring strategies is given in an invited review in Animal Science: https://doi.org/10.1017/S1751731115000968 This paper was written by several members within and outside the METHAGENE consortium. The basis was a white paper (http://www.asggn.org/publications,listing,95,mpwg-white-paper.html) written by members of the Animal Selection Genetics and Genomics Network, which is one of the research networks within the Livestock Research Group of the Global Research Alliance on Agricultural greenhouse gases. The aims of this network link closely to the aims of METHAGENE, so during the past years we have teamed up regularly and shared experiences and expertise. The main techniques to measure enteric methane emission of ruminants are (1) respiration chambers (portable ones for small ruminants), (2) breath sampling for 24 hours using SF_6 as a tracer gas (3) breath sampling during milking or feeding, sometimes using CO_2 as a tracer gas (4) lasers that can be pointed at an animal's nose/mouth, and (5) the GreenFeeder from the commercial company c-lock. All of them have pros and cons related to costs, throughput, intrusiveness, animal

		handling, robustness, accuracy, labour intensity, which are described in the review papers. Strategies to merge data measured with different techniques were presented at several METHAGENE meetings; e.g., the final meeting held in Caserta, Italy in October 2017: Presentation 4-8 on October 11, see: http://www.methagene.eu/meetings/Caserta2017.html (password: caserta) The results show that some devices are more correlated than others, but all of them are pointing in the same direction, which is good when aiming to combine data of different partners, that all use their own device and strategy. The unique METHAGENE consortium was built on trust, so that partners openly shared their data for joint analyses. This could not have done as efficiently within the COST Action.
disseminate identified easy to record and inexpensive indicator traits for methane emissions from ruminants (e.g., milk fatty acid profiles, mid-infrared spectra of milk samples, and others), without sacrificing accuracy, to be used for genetic evaluations	76 - 100%	The proxies for methane are related to (1) ingestion, (2) rumen, (3) milk composition, (4) hindgut, and (5) animals. Not surprisingly there is a strong link with the methane-determining factors. An overview of all possible proxies is published in an invited review of the Journal of Dairy Science: http://www.journalofdairyscience.org/article/S0022-0302(17)30106-6/fulltext Other papers have been published on combining one of the proxies (Mid Infrared profiles of the milk) from different countries, which was also presented at the final meeting of METHAGENE: http://www.methagene.eu/meetings/Caserta/Caserta2017_pub.php, the 13th presentation on Oct 12 (password: caserta)
disseminate approaches, necessary information and tools for EU countries for incorporating methane emissions in national breeding strategies while simultaneously taking cognisance of other animal performance characteristics	76 - 100%	Many studies have been performed since the start of METHAGENE estimating genetic parameters for enteric methane. These were all used as input to study the tools to incorporate methane emissions in national breeding strategies. Several researchers presented their work at the final meeting of METHAGENE, see also: http://www.methagene.eu/meetings/Caserta/Caserta2017_pub.php, presentation 3-8 on Oct 12 (password: caserta). Some studies will also be presented at the World Conference of Genetics Applied to Livestock Production in February 2018 in Auckland, New Zealand (www.wcgalp.com).
Stimulate research, education, exchange of knowledge and experience, and train Early Stage Researchers at training schools	76 - 100%	Each year a Training School was held, covering different topics that are addressed within METHAGENE. Teachers of within and outside the consortium were involved and trainees have evaluated the training schools very high. They were great opportunities to build their network for life: Year 1 - methane physiology for geneticists - in Dummerstorf, Germany: http://www.methagene.eu/meetings/dummerstorf2014.html (password: dummerstorf)

		Year 2 - methane data handling - in Poznan, Poland: http://www.methagene.eu/meetings/poznan2015.html (password: poznan) Year 3 - analyses of microbial data - in Porto, Portugal: http://www.methagene.eu/meetings/porto2016.html (password: porto) Year 4 - breeding programme for methane - in Umea, Sweden: http://www.methagene.eu/meetings/Umea2017.html (password: umea) In total 30 members of the consortium went on succesfull missions. Their reports are all on the website: http://www.methagene.eu/reports.html, as well as the blogs they wrote about their stay, not only about the scientific part, but also the social aspects they learnt and the network they built: http://www.methagene.eu/blog.html
Communicate and discuss relevant research in this field by organising 3 workshops, of which at least 1 will be open for EU members and other international groups outside the consortium	76 - 100%	Every year an Annual Meeting was held, where results and progress of research of members of the METHAGENE consortium was discussed. All meetings were open, and each meeting had participants from outside the consortium (Australia, New Zealand, Canada). Every meeting we welcomed new participants of groups/institutions that were not involved in METHAGENE before. This way we could enlarge the network, but it also showed that we created visibility. Many members of the METHAGENE consortium were involved in other, related, EU-projects, funded by either FP7 or H2020, and through that, the connections were made with e.g. RuminOmics, GplusE, GenTORE, and others. Through these connections, new participants joint the meetings every year.
Knowledge management and exchange (KME) with/to the scientific community, policy makers, primary producers, animal breeding organisations, and sensor technology industries. This COST Action will pursue a dissemination strategy targeted to bridge the gap between specialised research forums and non-specialised people, to more closely connect science to general public on this crucial issue	76 - 100%	Flyers and leaflets were made explaining METHAGENE in multiple languages, see also: http://www.methagene.eu/dissemination.html The Twitter-account has been very active during the 4 years of METHAGENE: https://twitter.com/methagene This created an opportunity to link with other initiatives, and also spread the word to people interested in this topic We are currently working on an infographic that shows the main results and recommendations of METHAGENE. The recommendations will be for policy makers, industry and for fellow researchers in this field.

Deliverables

The Action reported the following deliverables:

Deliverable	Timing of deliverable	Further information (hyperlink or other)
Invited review for Journal of Dairy Science on "Large-scale indirect measurements for enteric methane emissions in dairy cattle: A review of proxies and their potential for use in management and breeding decisions"	Delivered	http://www.journalofdairyscience.org/article/S0022-0302(17)30106-6/fulltext
Invited review for Journal of Dairy Science on "Phenotypes to genetically reduce greenhouse gas emissions in dairying"	Delivered	http://www.journalofdairyscience.org/article/S0022-0302(16)30833-5/fulltext
Report on website on "Possible factors associated with variation in methane production identified"	Delivered	http://www.methagene.eu/workinggroups/WG1/output/Final_Report_METHAGENE_WG1.pdf
Invited by the Animal board to review "Genetic possibilities to reduce enteric methane emissions from ruminants"	Delivered	https://doi.org/10.1017/S1751731115000968
Report on website on "description of protocols for collection, harmonisation, comparison, calibration and storage of methane emission measurements"	Not delivered, but foreseen within 2 years	
Report on website on "joint analyses of direct methane and identified proxies"	Not delivered, but foreseen within 2 years	
Report on website describing "Benefit for producers when methane emissions is included in breeding goals within EU dairy cow populations described and quantified"	Not delivered, but foreseen within 2 years	
Flyers in multiple languages describing what METHAGENE is, and also what COST Actions are	Delivered	http://www.methagene.eu/dissemination.html

Additional outputs/ achievements

N/A

Projects

N/A

Other outputs / achievements

N/A

Impacts

The Action reported the following impact(s):

Description of the impact, i.e. what will change, and for whom, as a result of what the Action achieved	Type of impact	Timing of impact
Common units and descriptors for large-scale methane emissions and other traits in individual methane measurements in ruminants	• Scientific / Technological	Achieved
Identified indicator traits for methane emissions from ruminants to facilitate cost-effective inclusion of environmental traits in national and EU breeding strategies	• Scientific / Technological	Achieved
Combining data of enteric methane emissions recorded with different equipments	• Scientific / Technological	Foreseen within two years
Established protocols for calibration, comparison and merging data from different techniques and measurement strategies which can be used beyond this project in optimally designing future experiments	• Scientific / Technological	Foreseen within two years
National breeding programmes that include a reduction of enteric methane emissions	• Scientific / Technological • Economic • Societal	Foreseen five-to-ten years
Critical contribution to the objective of the objectives set in the 2015 Paris COP meeting to reduce GHG emissions in the long term, with specific targets set for 2020, in order to reduce predicted global warming and reduce environmental footprints of animal-derived food	• Scientific / Technological • Economic • Societal	Foreseen five-to-ten years

Dissemination and exploitation of Action results

Dissemination and exploitation approach of the Action

The Action's dissemination and exploitation approach as well as all activities undertaken to ensure dissemination and exploitation of Action results and the outcomes of these activities are described below.

A flyer describing the aims of the METHAGENE COST Action and a leaflet describing the benefits of COST Actions in general was made, and translated in many languages, also for local distribution. See also: http://www.methagene.eu/dissemination.html

Dissemination meetings funded by the Action

The Action funded Dissemination Meetings as shown below:

Title	European Association of Animal Production		
Date	30-08-2015 to 04-09-2015	**Country**	Poland
Event	Climate smart cattle farming and breeding - this was a joint session with other EU-projects (RuminOmics and OptiBarn), and we filled 2 sessions in the programme on Monday Morning, August 31st.		

Title	Disseminating METHAGENE at GGAA-conference		
Date	14-02-2016 to 18-02-2016	**Country**	Australia
Event	METHAGENE was presented both at a satellite of 6th Greenhouse Gas and Animal Agricultural conference (http://www.asggn.org/news,listing,114,summary-of-asggn--lrg-satellite-meetings-ggaa2016.html) and with a poster at the conference		

Other dissemination activities

The Action also undertook the following dissemination activities:

Activity	submitting a call text for the H2020-2018-2020 programme through the Animal Task Force
Target	H2020, EU members
Outcome	The Societal Challenge 2 (SC2) Work Programme for 2018-2020 responds to some of the key challenges our planet is facing for the years to come: adapting to and mitigating climate change; ensuring food security; safeguarding the natural resource base, promoting alternatives to fossil-based economies and sustainably using marine resources while protecting the oceans. "adapting to and mitigating climate change" is specifically mentioned, as the first challenge to face. Therefore there will be opportunities to use the METHAGENE consortium for a new consortium submitting a proposal to H2020
Link	-

Activity	Joint Networks Meeting with networks related to the Livestock Research Group of the Global Research Alliance on agricultural greenhouse gases (http://www.globalresearchalliance.org/research/livestock/activities/networks-and-databases/) in Reading, UK on June 26th 2015.
Target	Members of several networks within the Livestock Research Group of the Global Research Alliance on agricultural greenhouse gases. The networks relate to the reduction of Agricultural greenhouse gases from different disciplines: nutrition, microbiology, housing, manure, breeding.
Outcome	Through better collaboration, the Networks will increase awareness of, and access to, databases and protocols, will be better placed to explore the whole farm system, and will avoid duplication of effort. Funding was raised as a barrier to progressing the Networks but a number of potential funding routes

	were identified. Other issues discussed on the day included the need to build stronger links with industry, to create multi-disciplinary research proposals, encourage smaller active groups within the Networks and engage early-career scientists. Participants agreed that this was a productive workshop and they would be keen to attend another which had greater involvement from PhD students and post-docs. In the meantime better communication between Networks needs to be supported (e.g. webinars, sharing newsletters).
Link	http://www.methagene.eu/meetings/reading2015.html

Activity	A one-day satellite meeting on “Breeding for lower emitting animals” was organised together with the ASGGN attached to the World Conference of Genetics Applied to Livestock Production in Vancouver, Canada
Target	Animal breeders with an interest for breeding for reduced enteric methane emissions
Outcome	Enlarging the METHAGENE network with researchers from around the world with the same interest, resulted in shared experiences and expertises and new ideas to solve the issues. Joint papers are resulted from this
Link	http://www.asggn.org/publications,listing,106,asggn-2014-meeting-vancouver.html

Activity	Awareness meeting "let geneticists and nutritionists talk"
Target	animal breeders and animal nutritionists with an interest to reduce enteric methane of ruminants
Outcome	The METHAGENE consortium includes many experts from different fields. During the discussion we had in the past years of METHAGENE we noticed that sometimes different terms are used in different fields for the same meaning, or opposite, that different meanings are given to the same word in different fields. That complicates the communication between and understanding of each other. Also, the different fields have different perspectives; which widens up the view, but also complicates the appreciation of each other. To tackle all these issues, an Awareness-meeting was held in Gembloux, Belgium, on January 31st and February 1st. The programme included perceptions, definitions and jargon, but also in depth background knowledge on both animal nutrition and animal breeding. Good discussions were held among the participants and it was clear that the disciplines cannot work alone, so the investment in understanding each other better is a big one for the future. It is a process with progress and the path is paved a little more for the next generations, also through the multidisciplinary Training Schools and STSMs we have (had) within METHAGENE.
Link	http://www.methagene.eu/meetings/Gembloux2017.html (password: gembloux)

Exploitation activities

The Action undertook the following activities to ensure exploitation (use, in particular in a commercial context) of the Action’s achievements:

No input provided by the Action

Action Success(es)

The Action’s two most significant successes were the following:

- The METHAGENE consortium has established that data of several partners were combined for a preliminary genetic evaluation (aim of WG4). This encompassed the establishment of proctocols how to combine data recorded with different techniques (aim of WG2) and the agreement of a common trait definition (aim of WG1)
- The METHAGENE consortium as established that a joint analyses of proxies for enteric methane is performed (aim of WG3). This provides insight in which combination of proxies can help in collecting data for a genetic evaluation in the (near) future.

Action Expenditure

The table below shows the budget allocated to the Action for each Grant Period:

#	Grant Period	Start Date	End Date	Budget allocated to Action (EUR)
1	CAGA-FA1302-1	1-2-2014	30-11-2014	100,000.00 (EUR)
2	CGA-FA1302-2	1-12-2014	30-9-2015	56,323.12 (EUR)
3	CGA-FA1302-3	1-10-2015	30-4-2016	116,345.50 (EUR)
4	AGA-FA1302-4	1-5-2016	30-4-2017	130,847.00 (EUR)
5	AGA-FA1302-5	1-5-2017	9-12-2017	79,100.01 (EUR)