Measurement of methane on a large scale
&
its mitigation from smallholder livestock production systems

Enyew Negussie
Natural Resources Institute Finland
Genomics & Breeding
(Luke), Jokioinen, Finland

PART I

Methane (CH_4) measurement on a large scale

OUTLINE

- Large scale CH_4 measurement
- Experience with F10 Multigas analyzer
  - The technique
  - F10 multigas analyser setup
  - CH_4 measurement profile
- Rationale for F10
  - Estimates of genetic variation for Ch_4
- Some results & summary

Measurement of methane

Different methods of CH_4 mitigation

Low-cost, sustanable strategy

Utilize natural between animals variation

Successful mitigation requires

Definition of the phenotype

Accurate measurement techniques

Quantify between-animal variation

Accuracy

Accuracy is important to avoid incorrect inferences

Lack of fast & accurate measurement techniques

– for large scale assay

- On an individual animal basis

Difficult & labour intensive

Slow/ Expensive

Tedious & time consuming

unsuitable for large scale measurements – a requisite for genetic studies

Experience with F10 MULTI-GAS ANALYSER

Technique:Photoacoustic IR spectroscopy

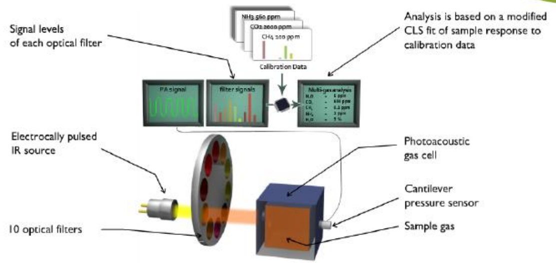
Growing interest in fast and hand-held techniques to measure CH4 phenotype

(Gasera Ltd, Turku, Finland)

GASERA

Product concept

F10 GAS ANALYZER



- Photoacoustic infrared technology provides **wide linear measurement range** and **low sample volume**
- **Cross-compensation** is accomplished by using 10 distinct spectral bands in the mid-IR region defined by narrow band-pass optical filters
- **High sensitivity with electrically pulsed IR source** due to the use of ultra sensitive patented cantilever sensor – no mechanical chopper is used!

GASERA

Why photoacoustics?

- Advantages include:
  - High sensitivity with low sample volume (only few milliliters)
  - Extremely wide dynamic range – typically from LDL to 10^5 x LDL
  - Short absorption path length – high linearity – wide dynamic range
  - Suitability for the measurement of difficult gas matrixes – e.g. with high humidity
  - Direct absorption measurement – extremely stable – long calibration period
  - No consumables required

Set up of F10 analyser

Daily prodn

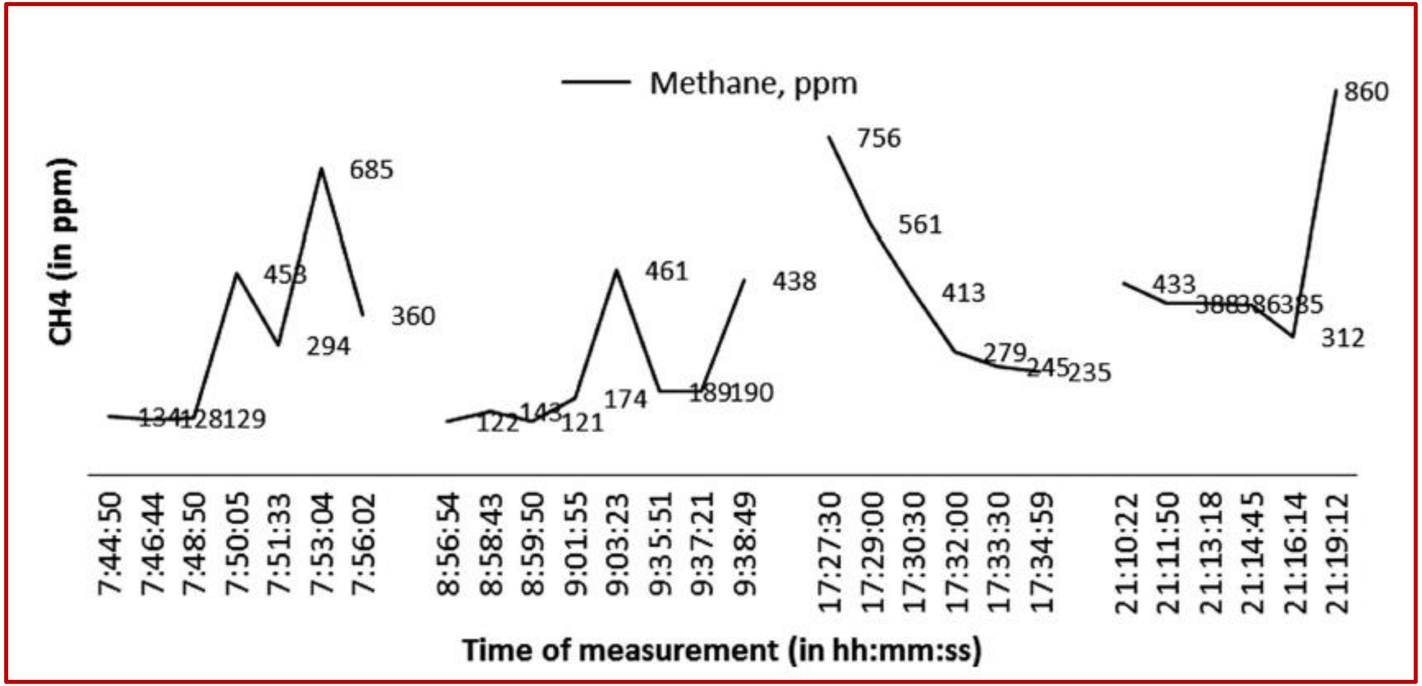
Daily feed intake, production etc traits can be recorded

CH4 monitoring

- Gasses measured CH_4, CO_2, H_2O & Acetone
- from breath of cows during visit to feeding kiosks
- Multi-point sampling
- CH_4 measurements saved in internal memory, capacity 1yr

F10 CH_4 measurement profile

- Direct CH_4 measurements are highly variable
- It varies within animal, day and time
- CH_4:CO_2 is an alternative phenotype



Validation of the F10 analyser

Animal (2017), **11**:5, pp 890–899 © The Animal Consortium 2016
doi:10.1017/S1751731116002718

animal

Non-invasive individual methane measurement in dairy cows

E. Negussie[1†], J. Lehtinen[2], P. Mäntysaari[3], A. R. Bayat[3], A.-E. Liinamo[1], E. A. Mäntysaari[1] and M. H. Lidauer[1]

[1]*Biometrical Genetics, Natural Resources Institute (Luke), Myllytie 1, 31600 Jokioinen, Finland;* [2]*GASERA Ltd, 20520 Turku, Finland;* [3]*Livestock Technology, Natural Resources Institute (Luke), Myllytie 1, 31600 Jokioinen, Finland*

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Table 3 *Concordance analyses for the validation of photoacoustic IR spectroscopy (PAS-F10) against open-circuit calorimetric chamber measurements of methane (CH_4) output in dairy cows*

Parameters	PAS-F10 CH_4 measurements: Week before chamber *v.* chamber	Week after chamber *v.* chamber	Week before and after chamber combined *v.* chamber
Sample size	21	21	21
Mean CH_4 (PAS-F10) (l/day)	552.6	544.1	548.6
Interclass correlation coefficient	0.74	0.73	0.87
95% CI*	0.44 to 0.89	0.41 to 0.89	0.70 to 0.95
Concordance correlation coefficient†	0.70	0.69	0.84
95% CI‡	0.41 to 0.85	0.37 to 0.86	0.65 to 0.93

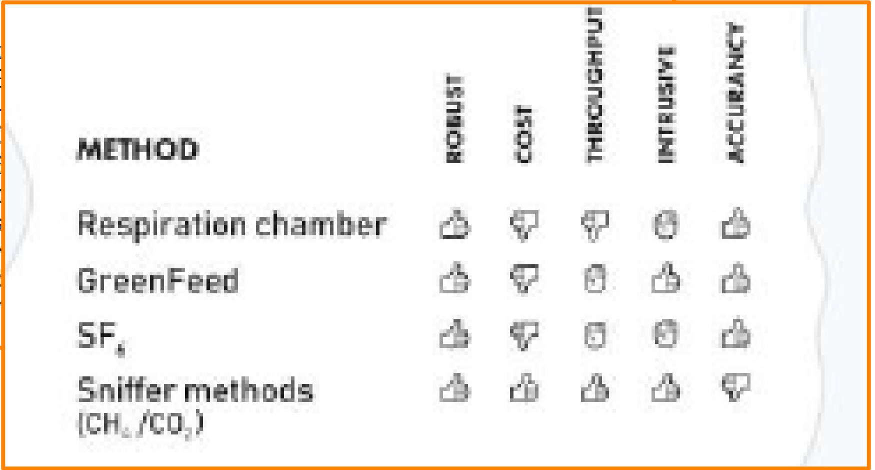
PAS-F10 = method for CH4 measurement using the F10 multigas analyzer (GASERA Ltd, Turku, Finland) which is based on PAS technique.
*95% (lower to upper) confidence interval for interclass correlation.
†Concordance analysis (Lin, 1989).
‡95% (lower to upper) confidence interval from concordance analysis.

Review: Large-scale indirect measurements (proxies)

J. Dairy Sci. 100:2433–2453
https://doi.org/10.3168/jds.2016-12030

Invited review: 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

E. Negussie,*[1] Y. de Haas,† F. Dehareng,‡ R. J. Dewhurst,§ J. Dijkstra,# N. Gengler,‖ D. P. Morgavi,¶ H. Soyeurt,‖ S. van Gastelen,# T. Yan, and F. Biscarini††‡‡**
*Biometrical Genetics, Green Technology, Natural Resources Institute Finland (Luk
†Animal Breeding and Genomics Centre of Wageningen Livestock Research, PO B
‡Valorisation of Agricultural Products, Walloon Agricultural Research Center (CRA-
§Scotland's Rural College, King's Buildings, West Mains Road, Edinburgh EH9 3J
#Animal Nutrition Group, Wageningen University and Research, PO Box 338, NL-6
‖Agriculture, Bio-engineering and Chemistry, Gembloux Agro-Bio Tech, University o
¶UMR1213 Herbivores, INRA, Vetagro Sup, 63122, Saint-Genès-Champanelle, Fr
**Agri-Food and Biosciences Institute, Hillsborough, Co. Down BT26 6DR, United K
††Department of Bioinformatics, PTP Science Park, Via Einstein Loc. Cascina Cod
‡‡Faculty of Bioscience and Technology for Food, Agriculture and Environment, Un



Combining proxies upto ~35% increase in accuracy

J. Dairy Sci. 105
https://doi.org/10.3168/jds.2021-20158

Integrating heterogeneous across-country data for proxy-based random forest prediction of enteric methane in dairy cattle

Enyew Negussie,[1*] Oscar González-Recio,[2] Mara Battagin,[3] Ali-Reza Bayat,[4] Tommy Boland,[5] Yvette de Haas,[6] Aser Garcia-Rodriguez,[7] Philip C. Garnsworthy,[8] Nicolas Gengler,[9] Michael Kreuzer,[10] Björn Kuhla,[11] Jan Lassen,[12] Nico Peiren,[13] Marcin Pszczola,[14] Angela Schwarm,[15] Hélène Soyeurt,[9] Amélie Vanlierde,[16] Tianhai Yan,[17] and Filippo Biscarini[18]

- An intersection between climate change, machine learning and precision agriculture, and focuses on the application of advanced predictive modelling to tackling greenhouse gas emissions from livestock farming.
- Use of on-farm routinely recorded data coupled with state-of-the-art machine-learning algorithms has the potential to yield very accurate predictions of methane emissions.
    - This provides a great potential for building a globally representative large scale CH_4 emission database on the basis of which accurate regional and intercontinental inventories as well as concerted global greenhouse gas mitigation strategies could be developed.

Summary

- Comparison of hand-held and portable techniques against the gold stanadard (respiration chamber)
  - have shown mixed results
- Although several techniques have been tried & developed, the journey to find the most accurate technique for large scale CH_4 measurements, especially on an individual animal basis continues.

PART II

Mitigation of methane from smallholder livestock production systems

OUTLINE

- Emission from smallholder production systems
- LS production efficiency and emission
- Towards low carbon livestock - FAO
- ICI Ethiopia dairy genetics project (Finnish Gov't & BMG financed) project
  - Project components
  - Expected effect on emission by 2035
- Other genetic tools to reduce emissions
  - reduce wastage & genetics of feed efficiency

Increase in production: function of LS numbers

- **Indigenous animals**
    - Form the majority of production animals
    - Low producers
    - Increase in prodcution is mostly by increasing number of animals
        - social status of a person or a family measured by the number of animals he owns
        - Such beliefs/practices have unfavourable effects LS system emissions

Increase in efficiency 1st step towards low carbon livestock

FAO 2019 : Practical actions towards low-carbon livestock

Action 1. Boosting efficiency of livestock production and resource use

Action 2. Intensifying recycling efforts and minimizing losses for a circular bioeconomy

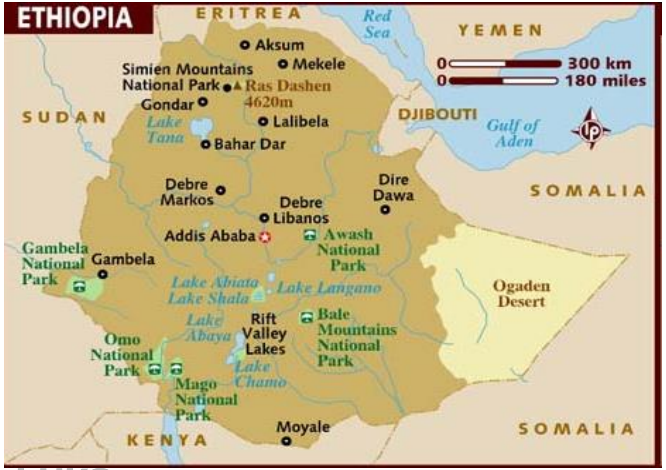
Action 3. Capitalizing on nature-based solutions to ramp up carbon offsets

Action 4. Striving for healthy, sustainable diets & accounting for protein alternatives

Action 5. Developing policy measures to drive change

ICI Ethiopia dairy project

Population ~110 mill
Cattle pop ~60 mill
Dairy cows ~10-12 mill
Milk prod/lact ~ 306 liter



1. Establish a dairy herd performance recording and advisory system

2. Build a modern computerized data base management facility at NAIC

3. Develop a locally adapted dairy cattle breeding strategies

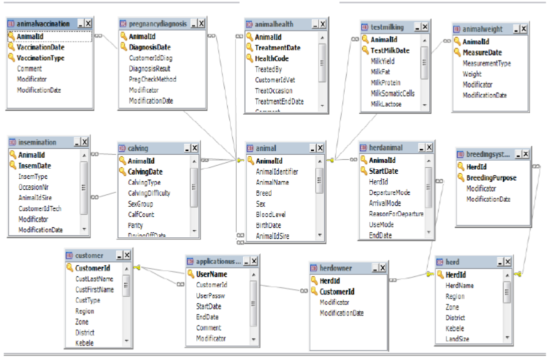
4. Strengthen the institutional and organizational capacity of NAIC

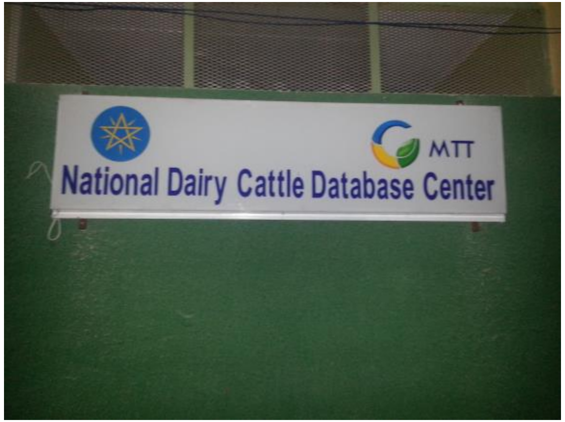
1. Dairy herd performance recording & farmers advisory system

2 National animal identification system

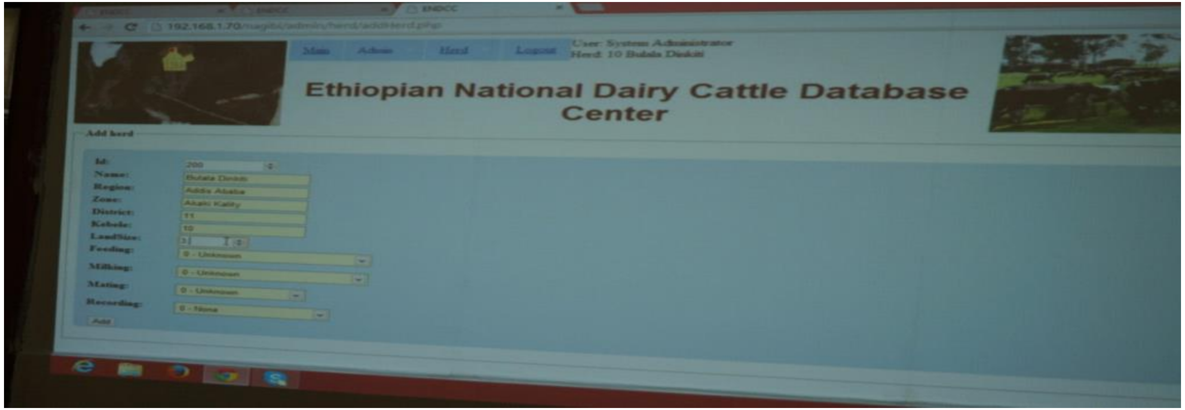
Compatible with ICAR Regulations

3 National Dairy Cattle Database Centre





Computational facility



4 National genomic evaluation and training students

Breeding Values for Top Bulls

National Ethiopian Genetic Evaluation for Dairy Cattle (Version 1.1)

Evaluation Run: December 2018

TOP BULLS		Consider for Selection:			Reliability:	
		yes			high	0.99 - 0.80
Population Mean = 100		maybe			medium	0.79 - 0.60
10 Index Points = 1.6 ltr milk/day		no			moderate	0.59 - 0.30
					low	0.29 - 0.00

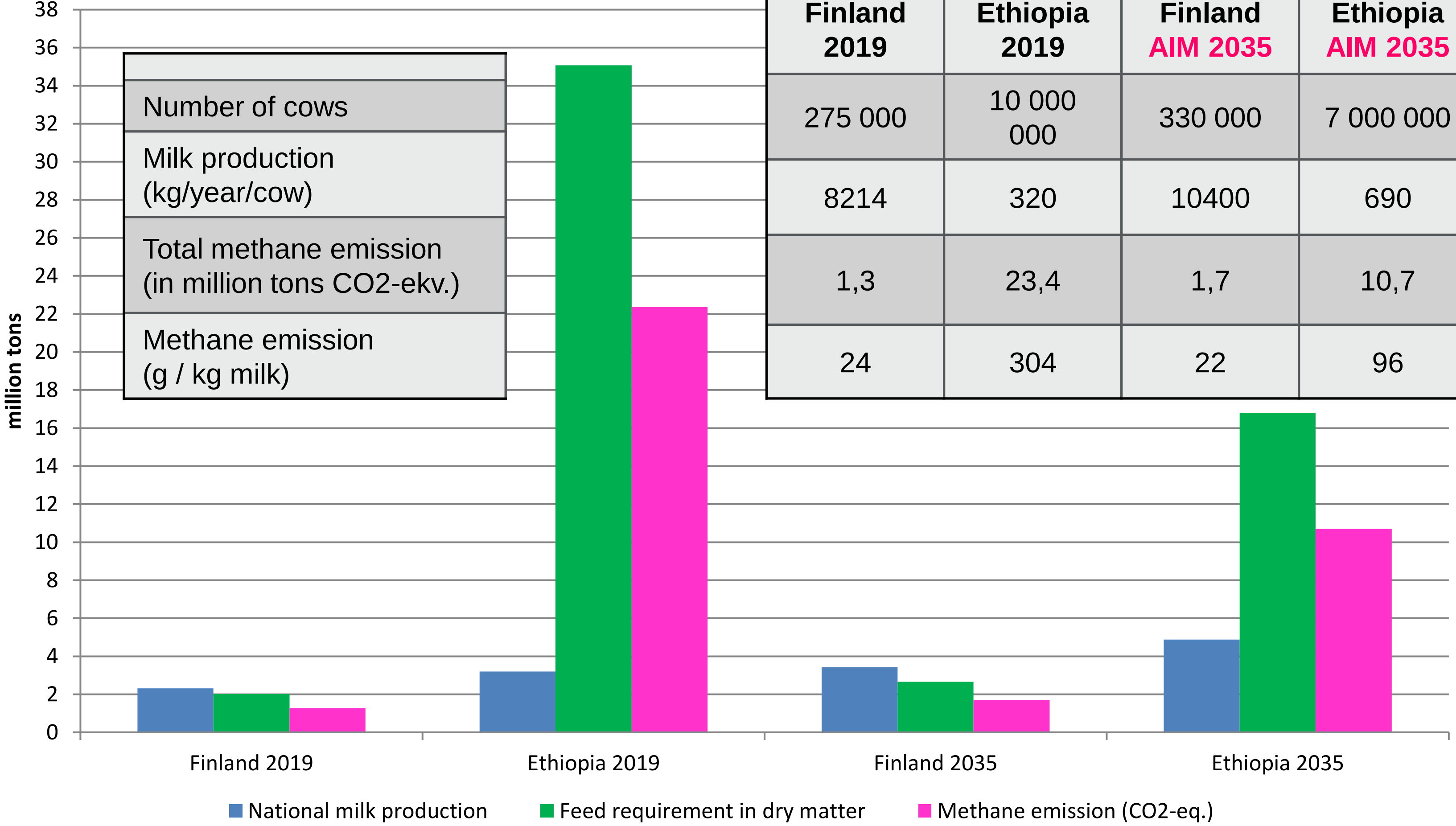
Bull ID	Birth Year	Breed	Herd	Num. Progeny	Breeding Value Index for Milk	Reliability of Breeding Value
3099	1900	Holstein	33	25	121	0.70
2176	1900	Holstein	33	22	120	0.68
7033	1900	Holstein	33	11	117	0.51
3868	1900	Holstein	33	13	117	0.55
10-091	1998	Holstein	33	32	116	0.75
7003	2007	Holstein	33	16	115	0.60
10-017	1993	Holstein	33	6	114	0.27
7005	1900	Holstein	33	11	114	0.51
10-038	1994	Holstein	33	24	113	0.69
10-329	1991	Holstein	33	9	113	0.46

Project partners

Luke
LUONNONVARAKESKUS

ADGG
African Dairy Genetic Gains
More productive and profitable dairy cows

	Finland 2019	Ethiopia 2019	Finland AIM 2035	Ethiopia AIM 2035
Number of cows	275 000	10 000 000	330 000	7 000 000
Milk production (kg/year/cow)	8214	320	10400	690
Total methane emission (in million tons CO2-ekv.)	1,3	23,4	1,7	10,7
Methane emission (g / kg milk)	24	304	22	96



Summary

- Sustainable intensification of production will be one sustainable means to reduce LS system emissions in DC
- There is a need for a lot of work to understand the diverse productions systems and develop suitable mitigation strategies
- A global problem needs global solutions. Interdisciplinary approach is the best way forward.

Thank you !

