Meta-analysis of heritability estimates for methane emission indicator traits in cattle and sheep

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Global Awareness of Climate Change

Climate change threatens food security in S Asia

Says ADB study

BSS, *Dhaka*

Melting Himalayan glaciers and other climate change impacts pose a direct threat to the water and food security of more than 1.6 billion people in the study warns that four countries in South Asia- Afghanistan, Bangladesh, India and Nepal - are particularly vulnerable to falling crop yields caused by glacier retreat, floods, droughts, Building Climate Resilience in the Agriculture Sector", will officially be launched by the ADB on the sidelines of the United Nations Framework Convention on Climate Change meeting in Bangkok in in maize production, 12 percent in wheat and 10 percent in rice yield.

"Almost half of the world's absolute poor live in South Asia, where they tend to depend on rain-fed agricul-

Feature

Floods, droughts to be the norm

Kamcilla Pillay *reports back from the annual briefing on climate change by India's Centre for Science and Environment in New Delhi last week.*

nal homepage: www.elsevier.com/locate/crm

Climate change and livestock: Impacts, adaptation, and mitigation

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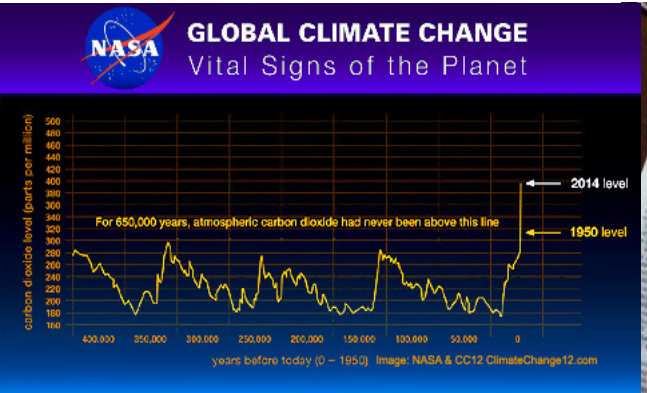
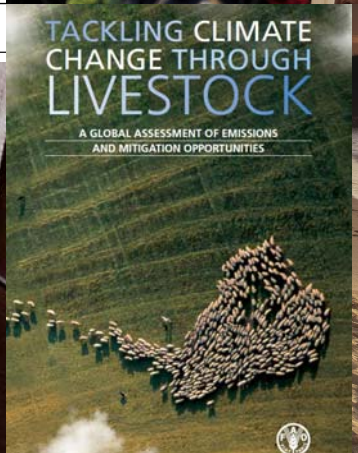
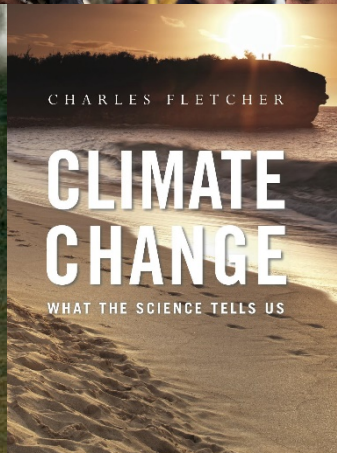
ABSTRACT

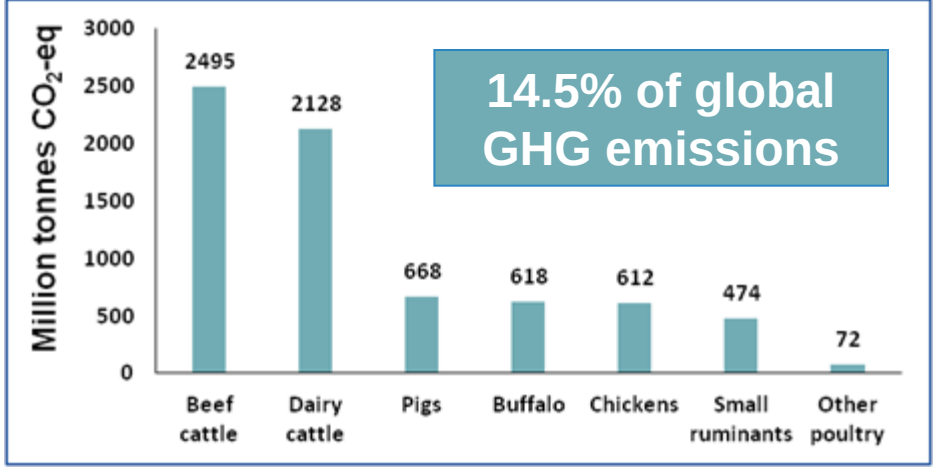


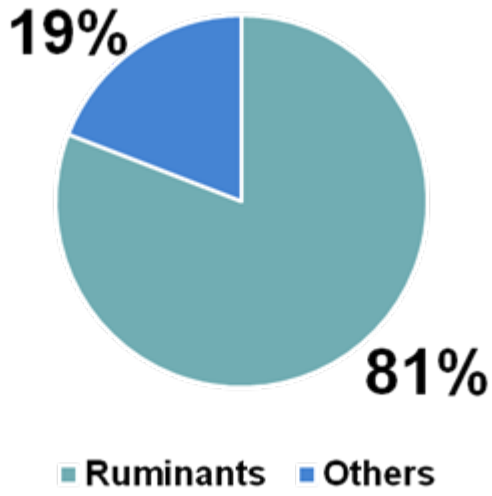




Livestock Contribution

Global estimates of emissions by species:

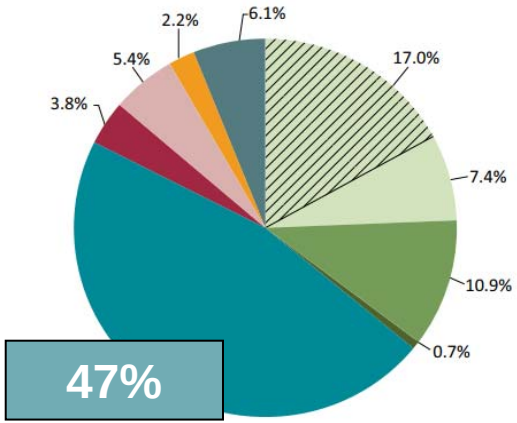




Source: FAO, Gerber *et al.*, 2013

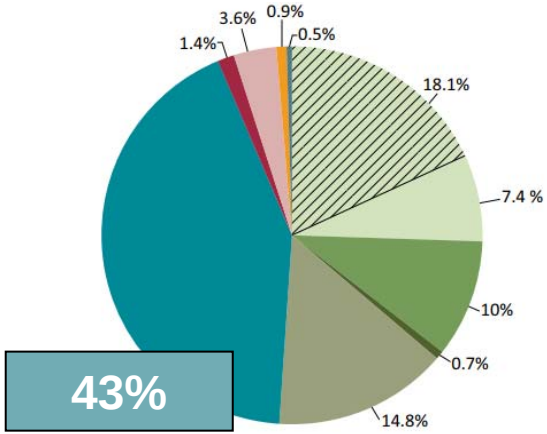
Enteric Methane

Dairy cattle



47%

Beef cattle



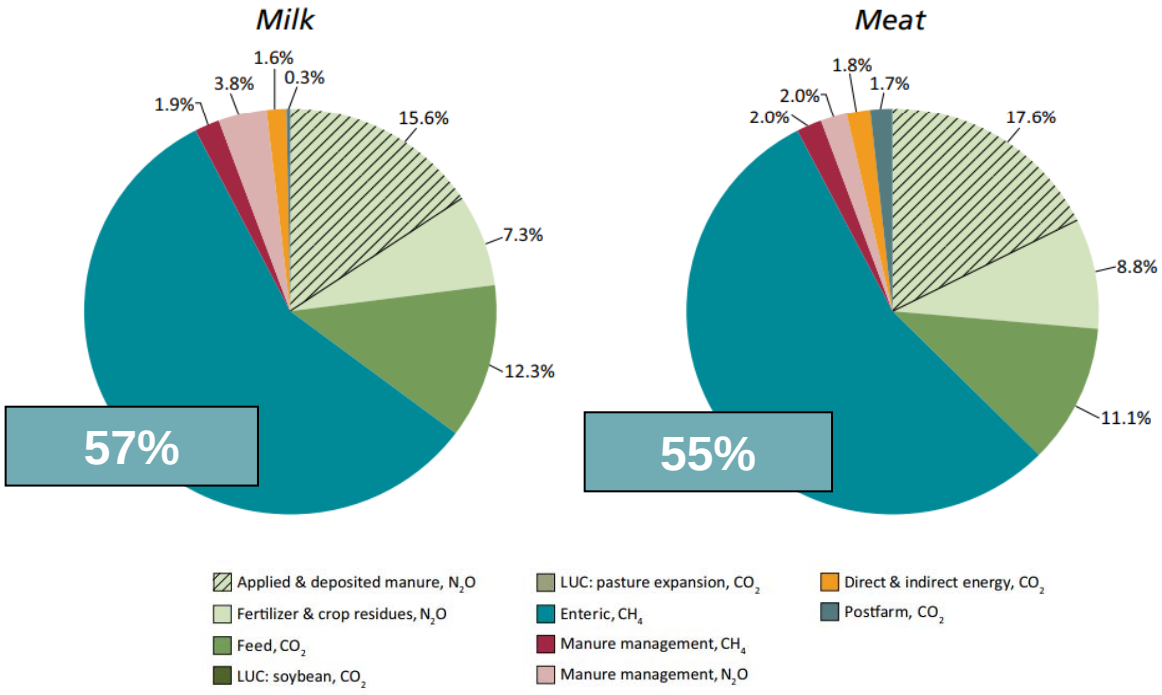
43%

Applied & deposited manure, N_2O
Fertilizer & crop residues, N_2O
Feed, CO_2
LUC: soybean, CO_2
LUC: pasture expansion, CO_2
Enteric, CH_4
Manure management, CH_4
Manure management, N_2O
Direct & indirect energy, CO_2
Postfarm, CO_2

Source: FAO, Gerber *et al.*, 2013

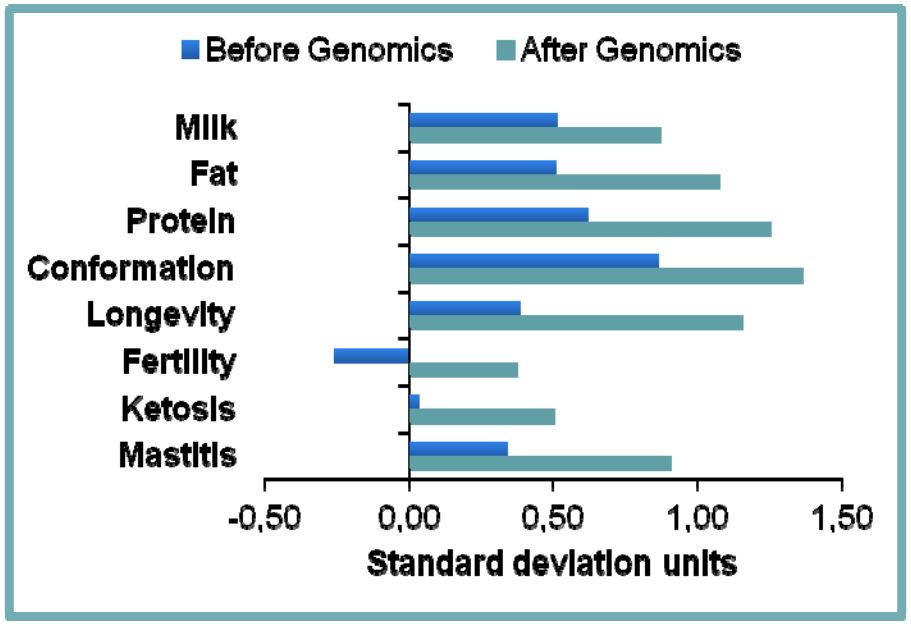
Enteric Methane

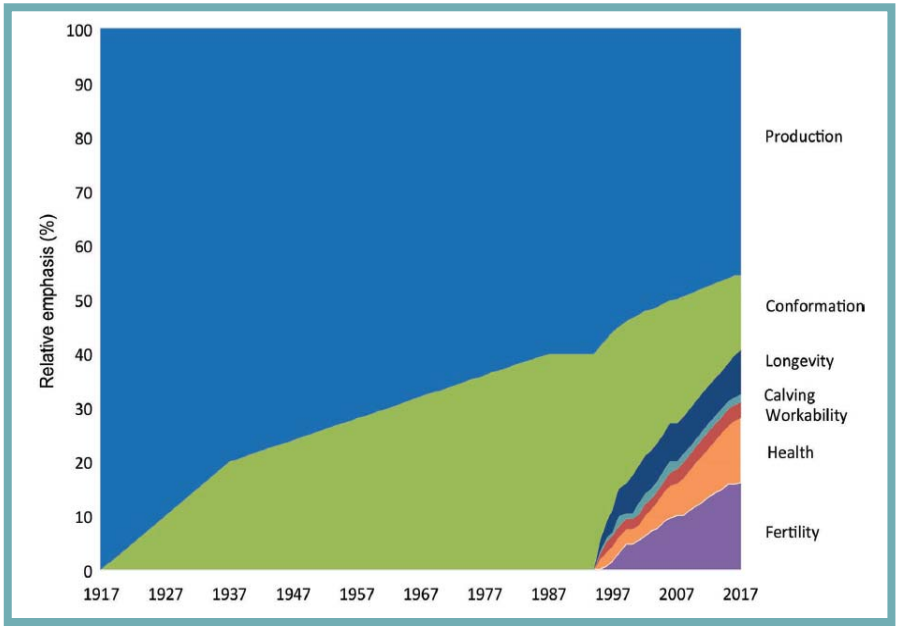
Small ruminants



Source: FAO, Gerber *et al.*, 2013

A New Era of Genetic Selection





Source: Brito et al., 2017; Miglior et al., 2017

For New Challenges: Novel Breeding Goals

- Various efforts around the world (e.g., de Haas *et al.*, 2017; Negussie *et al.*, 2017)
  - Numerous breeds/species
  - Alternative measurement equipment and protocols
  - Different indicator traits and prediction equations
- Reliable h^2 estimates: large across-generation datasets
- Methane emission seems to be heritable (e.g., Pickering *et al.*, 2015; de Haas *et al.*, 2016)
  - Are there significant differences across breeds/species and indicator traits?

Objective

To perform a meta-analysis to obtain a quantitative synthesis of previous findings, which are key for the development of more precise breeding objectives and selection strategies

Papers and Emission Traits

- 18 papers (2011 to 2017): 60 h^2 estimates
- Groups of methane emission traits:
  - Methane intensity (**MI**): g CH4/kg/L of milk/day
  - Methane yield (**MY**): g CH4/kg of DMI
  - Methane production (**MP**): g/day
  - Residual methane (**RM**) traits: computed as actual minus expected methane production
  - Directly measured (**DIR**) or based on prediction equations (**PRED**)

Methodology

- Important sources of variation:
  - Publication year, number of records, species/production purposes (i.e., dairy and beef cattle or sheep), breed, indicator trait, unit of measurement, measurement procedure, duration of measurement and statistical model
- The SE associated with h^2 estimates: to weight each estimate
  - approximate SE: Sutton *et al*., (2000)
- Random-effects model (Borenstein *et al*., 2009)
- *Metafor* package (Viechtbauer, 2010) available in R

Methodology – cont'd

- Degree of heterogeneity among studies:
  - I^2 index (Higgins *et al*. 2003)
  - Q statistics (Cochran, 1954)
- 95% confidence intervals for each estimate
- Four scenarios were investigated:
  1) Sheep and cattle data and the 4 trait groups
  2) Cattle studies and the 4 trait groups
  3) Sheep studies
  4) Cattle data and assessment method (i.e., DIR and PRED)

Results

- A total of 16 (beef cattle), 36 (dairy cattle) and 8 (sheep) h^2 estimates:
  - 33 estimates based on direct measures of methane
  - 27 estimates based on prediction equations

- Limited number of estimates available per factor (e.g., breed, country, measurement methods)
  - no appropriate estimate of the significance of these factors

Cattle and Sheep Estimates

Trait	h^2	95% CI	Test of heterogeneity		
			I^2 (%)	Q	*P-value*
MI	**0.19 ± 0.02**	**0.15 – 0.23**	**5.65**	**2.91**	**0.71**
MP	0.24 ± 0.02	0.20 – 0.27	81.74	84.35	< 0.0001
MY	0.21 ± 0.03	0.14 – 0.26	86.44	178.65	< 0.0001
RM	**0.17 ± 0.03**	**0.12 – 0.22**	**0.00**	**0.38**	**0.98**
ALL	0.22 ± 0.01	0.19 – 0.24	83.53	281.22	< 0.0001

ALL: all traits considered together, **MI:** methane intensity, **MP:** methane production, **MY:** methane yield, and **RM:** residual methane

Cattle data

Trait	h^2	95% CI	Test of heterogeneity		
			I^2 (%)	Q	*P-value*
MI	**0.19 ± 0.02**	**0.15 – 0.23**	**5.65**	**2.91**	**0.71**
MP	0.25 ± 0.02	0.22 – 0.29	75.52	53.39	0.0026
MY	0.23 ± 0.03	0.16 – 0.29	88.02	148.07	< 0.0001
RM	**0.17 ± 0.03**	**0.12 – 0.22**	**0.00**	**0.37**	**0.98**
ALL	0.23 ± 0.01	0.21 – 0.26	82.99	223.82	<0.0001

ALL: all traits considered together, **MI:** methane intensity, **MP:** methane production, **MY:** methane yield, and **RM:** residual methane

Results

Scenario	Trait	h^2	95% CI	Test of heterogeneity		
				I^2 (%)	Q	*P-value*
Only sheep	ALL	0.14 ± 0.02	0.10 – 0.18	42.5	11.58	0.12
Only cattle	**DIR**	**0.21 ± 0.01**	**0.18 – 0.23**	**0.00**	**15.15**	**0.91**
	PRED	0.26 ± 0.02	0.21 – 0.30	93.37	200.78	< 0.0001

DIR: direct measured traits, **PRED:** traits calculated based on prediction equations; **ALL:** all traits considered together

Trends across scenarios

Scenario	Trait	h^2	95% CI	Test of heterogeneity		
				I^2 (%)	Q	*P-value*
Cattle + sheep	MI	0.19 ± 0.02	0.15 – 0.23	5.65	2.91	0.71
	RM	0.17 ± 0.03	0.12 – 0.22	0.00	0.38	0.98
Only cattle	MI	0.19 ± 0.02	0.15 – 0.23	5.63	2.93	0.72
	RM	0.17 ± 0.03	0.12 – 0.22	0.00	0.39	0.97
Only cattle	DIR	0.21 ± 0.01	0.18 – 0.23	0.00	15.15	0.91

DIR: directly measured traits, **MI:** methane intensity, and **RM:** residual methane

Summary

- Methane Emission traits are under moderate genetic control
- Homogeneous h^2 estimates across studies for Methane Intensity, Residual Methane and Directly measured traits
- Practical implications when deciding which traits to use in selection programs, especially when international collaboration might be involved
- More investigation in this area is warranted

Acknowledgments

THE Efficient Dairy GENOME PROJECT

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