PRIFYSGOL ABERYSTWYTH UNIVERSITY

Sefydliad y Gwyddorau Biolegol, Amgylcheddol a Gwledig
IBERS ABERYSTWYTH
Institute of Biological, Environmental and Rural Sciences

Reducing greenhouse gas emissions from ruminants

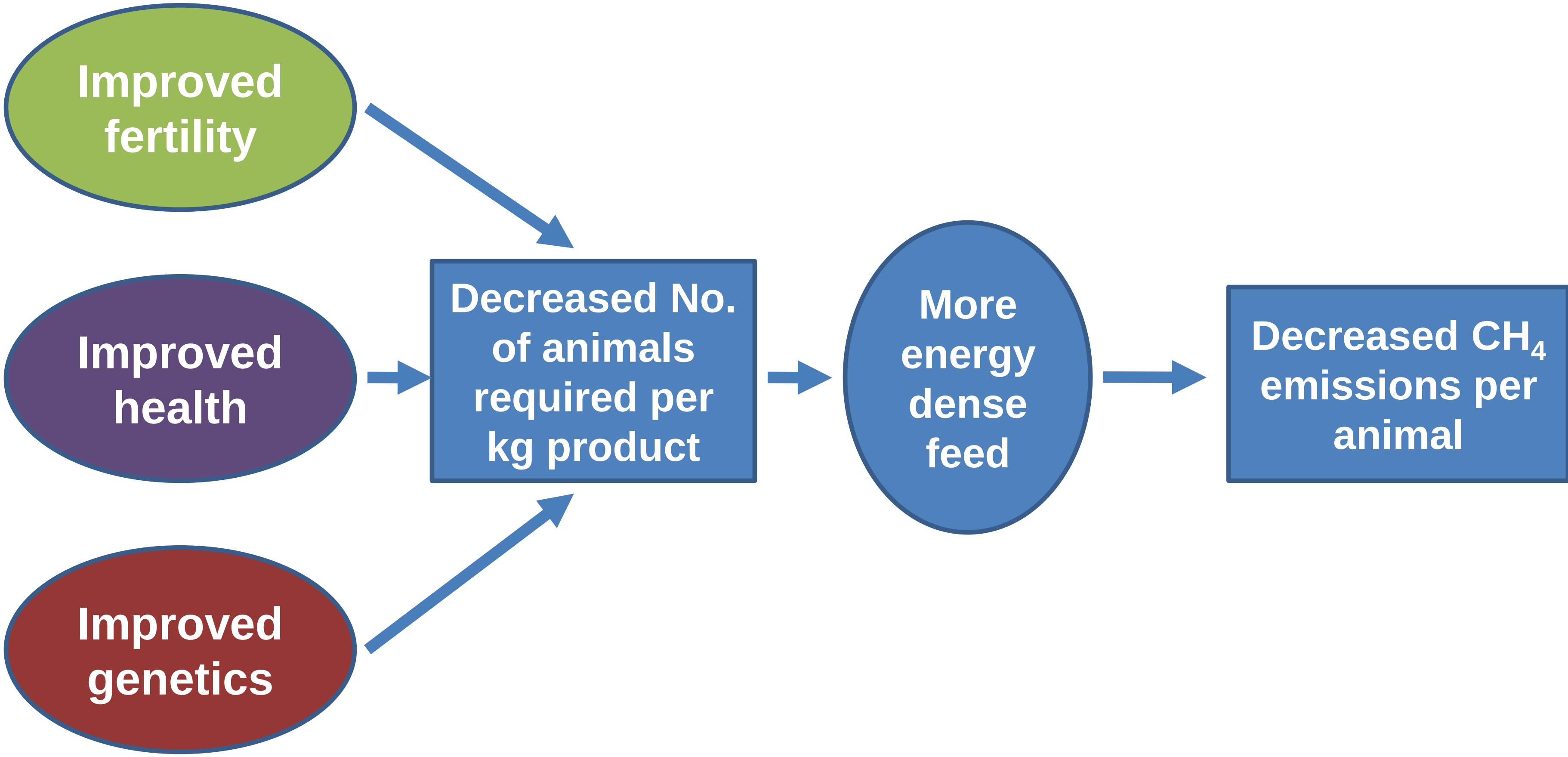
Jamie Newbold


Positive proof of global warming.
18th Century
1900
1950
1970
1980
1990
2006

Potential for mitigation of GHG emissions from livestock

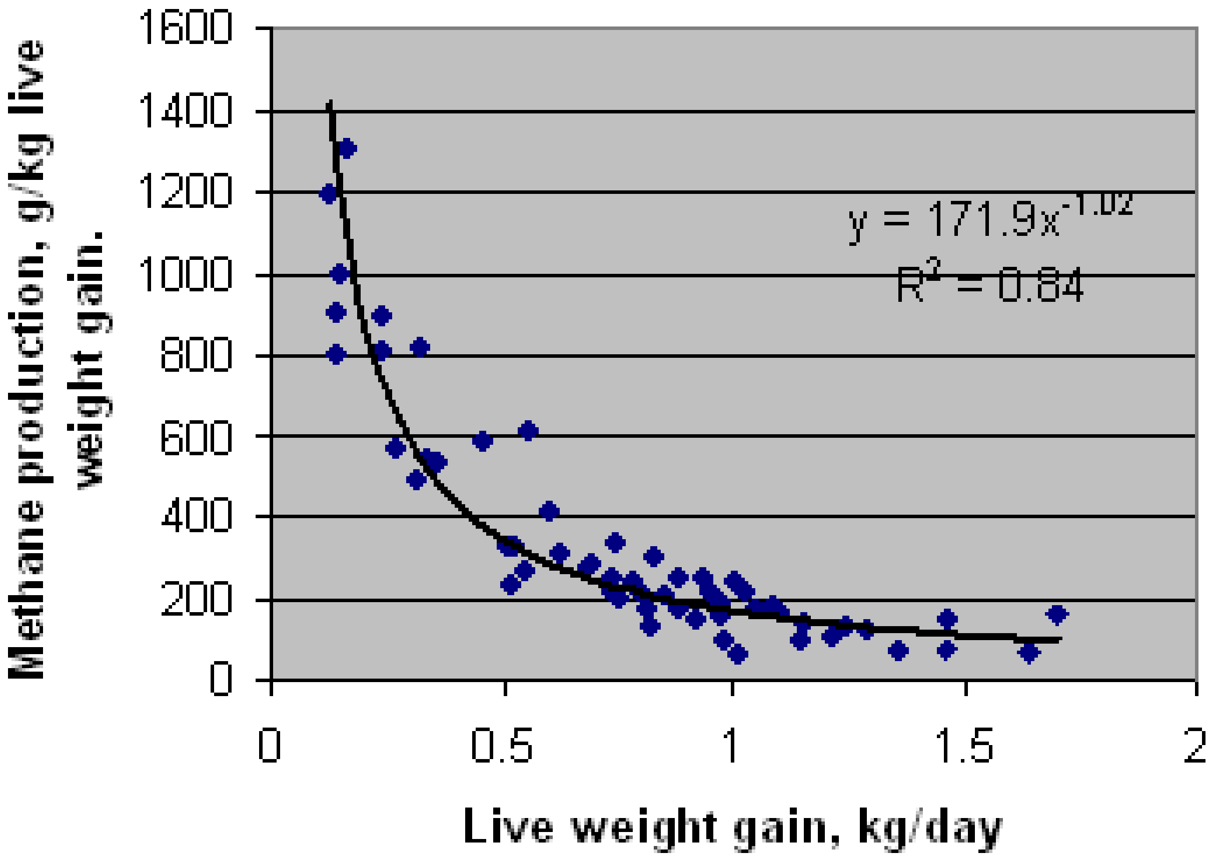
- ✓ Lifestyle change (i.e. less reliance on products with a high carbon cost associated with their production and reducing food waste)
- ✓ Changing farming practice
- ✓ Using new technologies

(Gill et al. 2009. *Mitigating climate change: the role of domestic livestock*. **Animal** doi:10.1017/S1751109004662)



Routes for impact of management and technology interventions designed to improve productivity on GHG emissions from livestock (Gill et al. 2009)

The relationship between live weight gain (LWG) of cattle and methane production per kg of gain



(Kurihara et al 1997, Klieve. and Ouwerkerk 2007, Howden and Reyenga 1999)

Potential for mitigation of GHG emission from livestock

- ✓ Lifestyle change (i.e. less reliance on products with a high carbon cost associated with their production and reducing food waste
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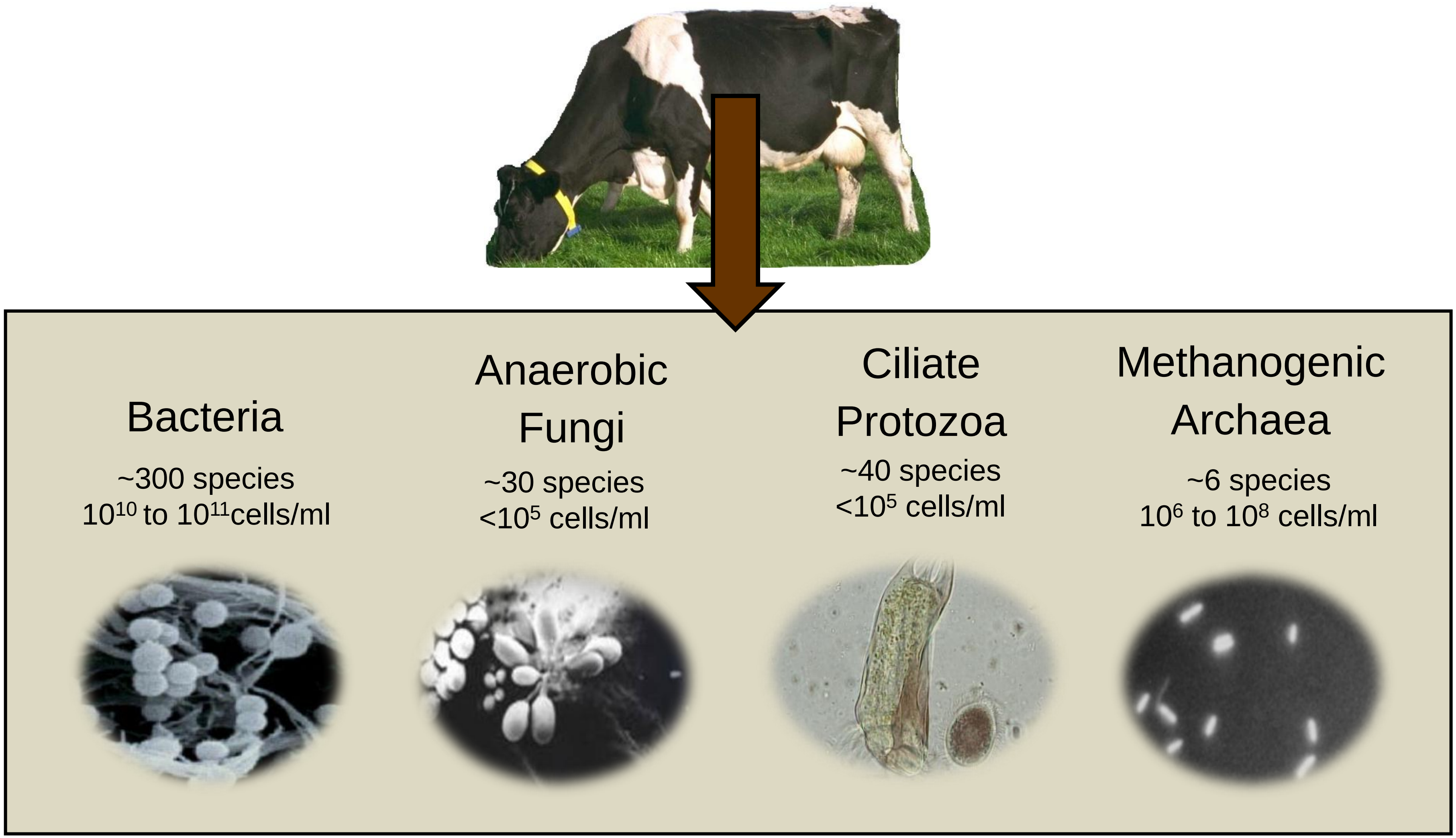


The rumen microbiota is essential for ruminants to effectively utilise dietary material.

Hexose Fermentation to VFA

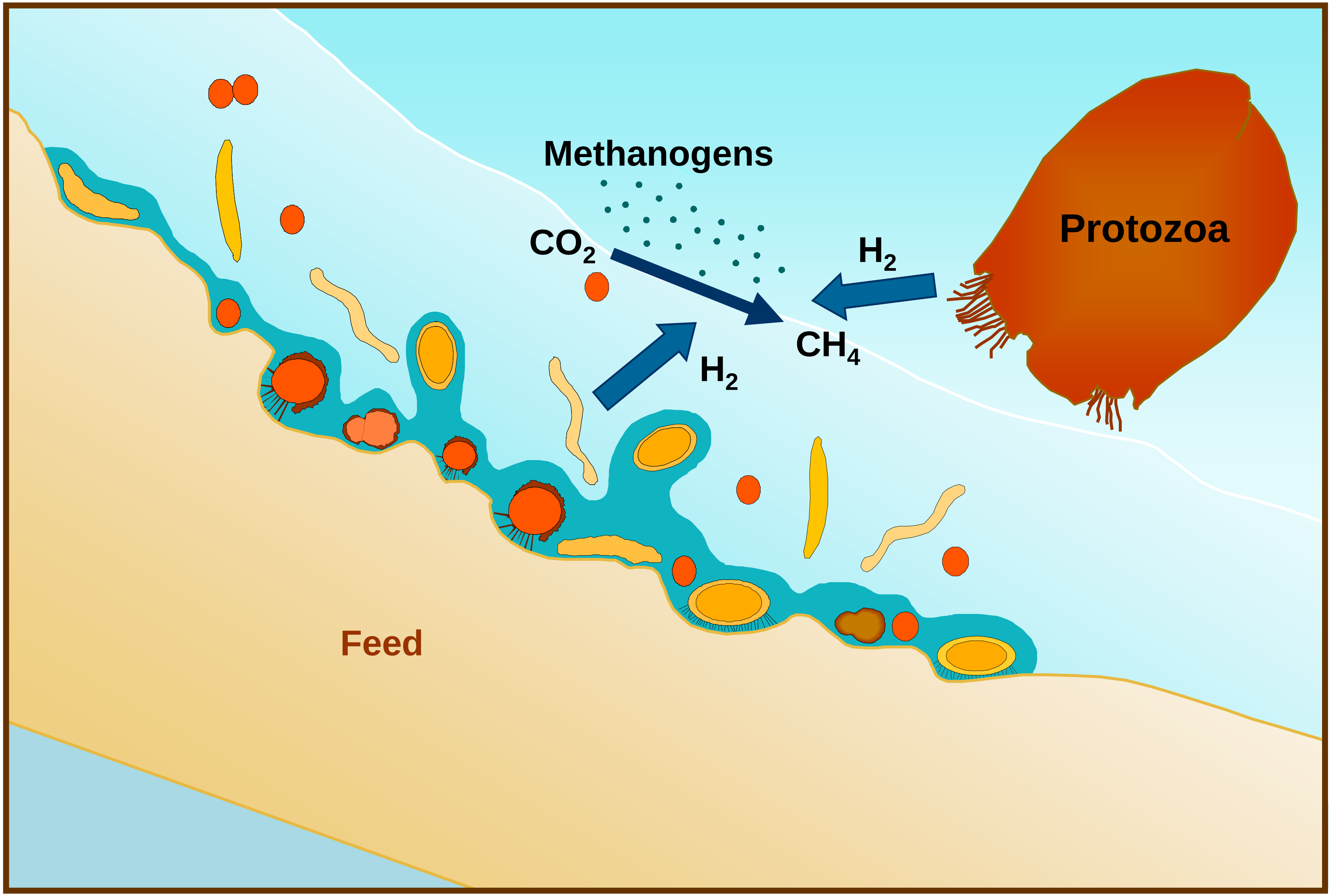
1 mole hexose

→ **2 acetate + 2 CO_2 + 8 H**

→ **2 propionate – 4 H**

→ **1 butyrate + 2 CO_2 + 4 H**

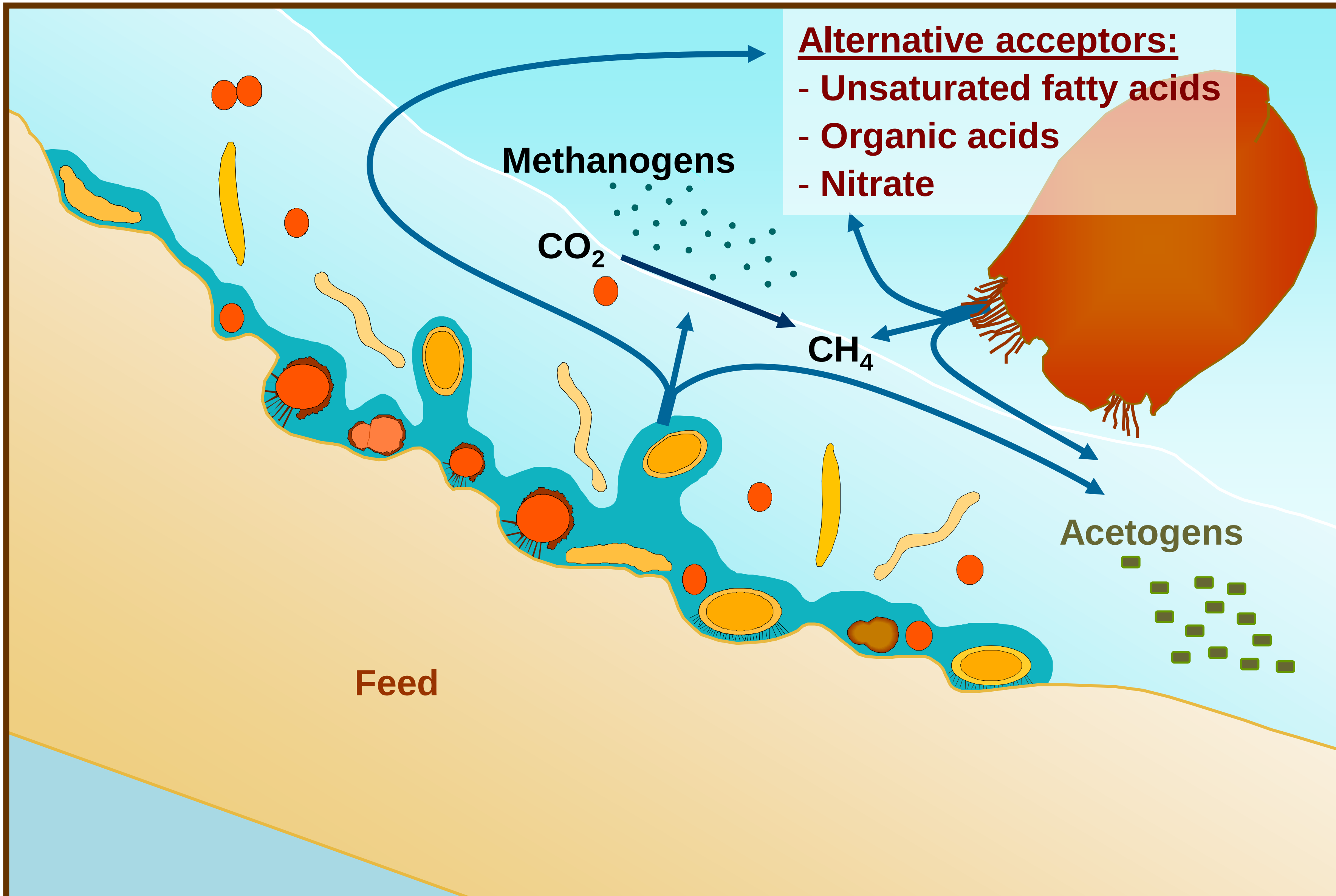
Methane production: a microbially driven process to remove hydrogen

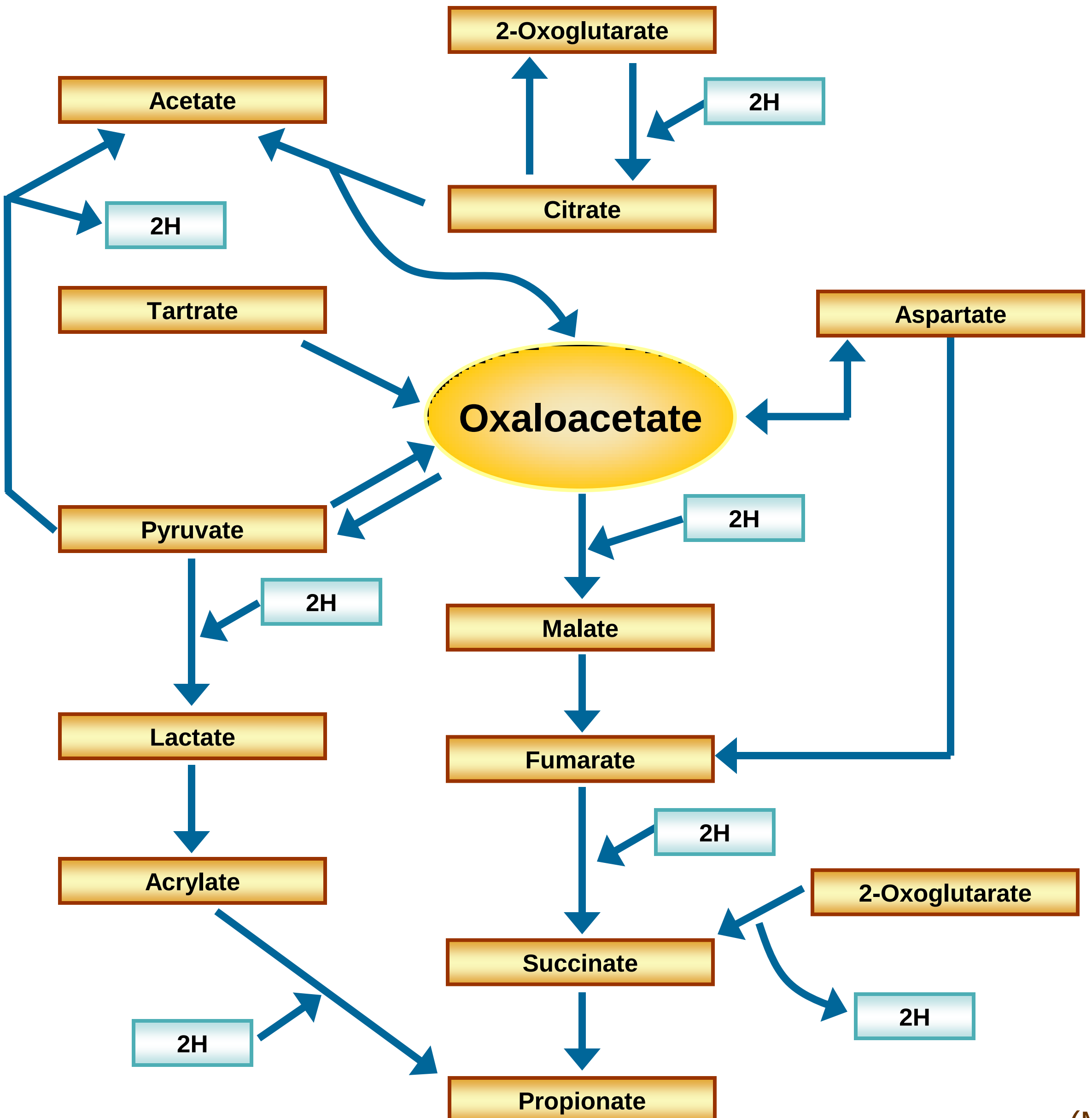


Ruminants lose between 3 – 8% of GE as methane

Providing alternative sinks for H+ disposal in the rumen

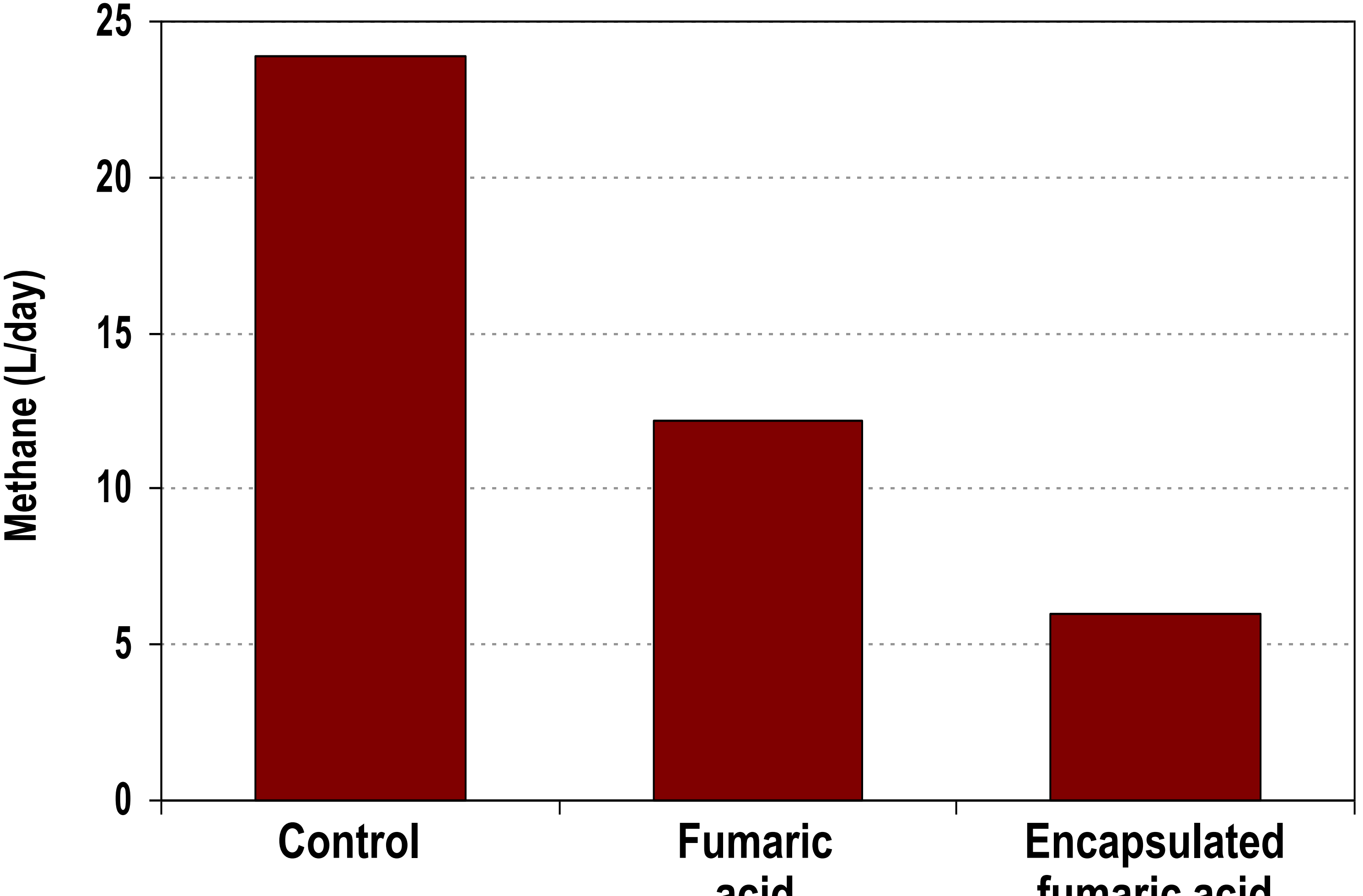
Methods of methane mitigation: → *Redirect H_2 flow*



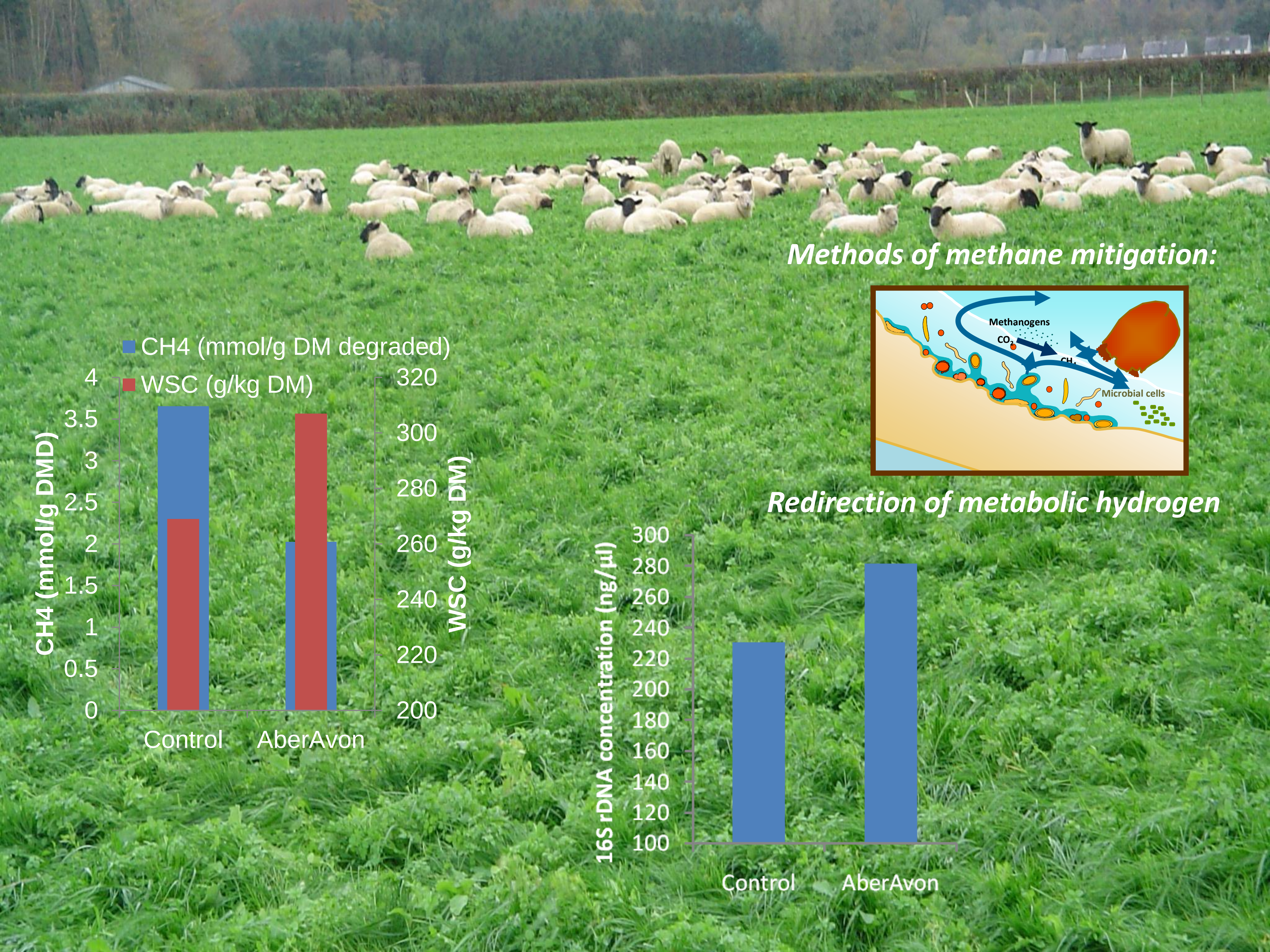


(McAllister & Newbold)

Methane production by lambs supplemented with fumaric acid



Wallace et al. (2006)

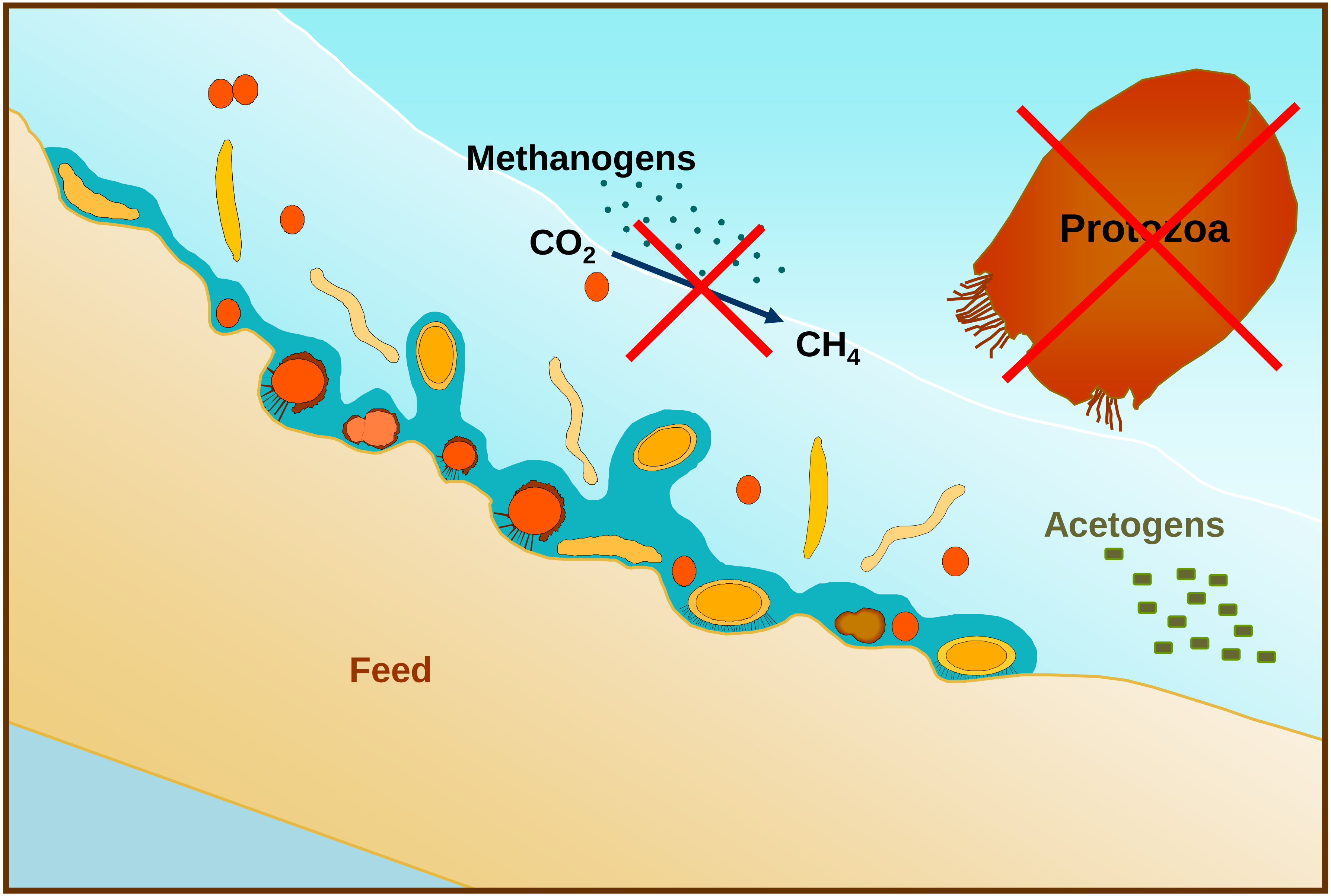

Methods of methane mitigation:
Methanogens
CO2
CH4
Microbial cells
Redirection of metabolic hydrogen
CH4 (mmol/g DM degraded)
WSC (g/kg DM)
CH4 (mmol/g DMD)
WSC (g/kg DM)
0
0.5
1
1.5
2
2.5
3
3.5
4
200
220
240
260
280
300
320
Control
AberAvon
16S rDNA concentration (ng/µl)
100
120
140
160
180
200
220
240
260
280
300
Control
AberAvon

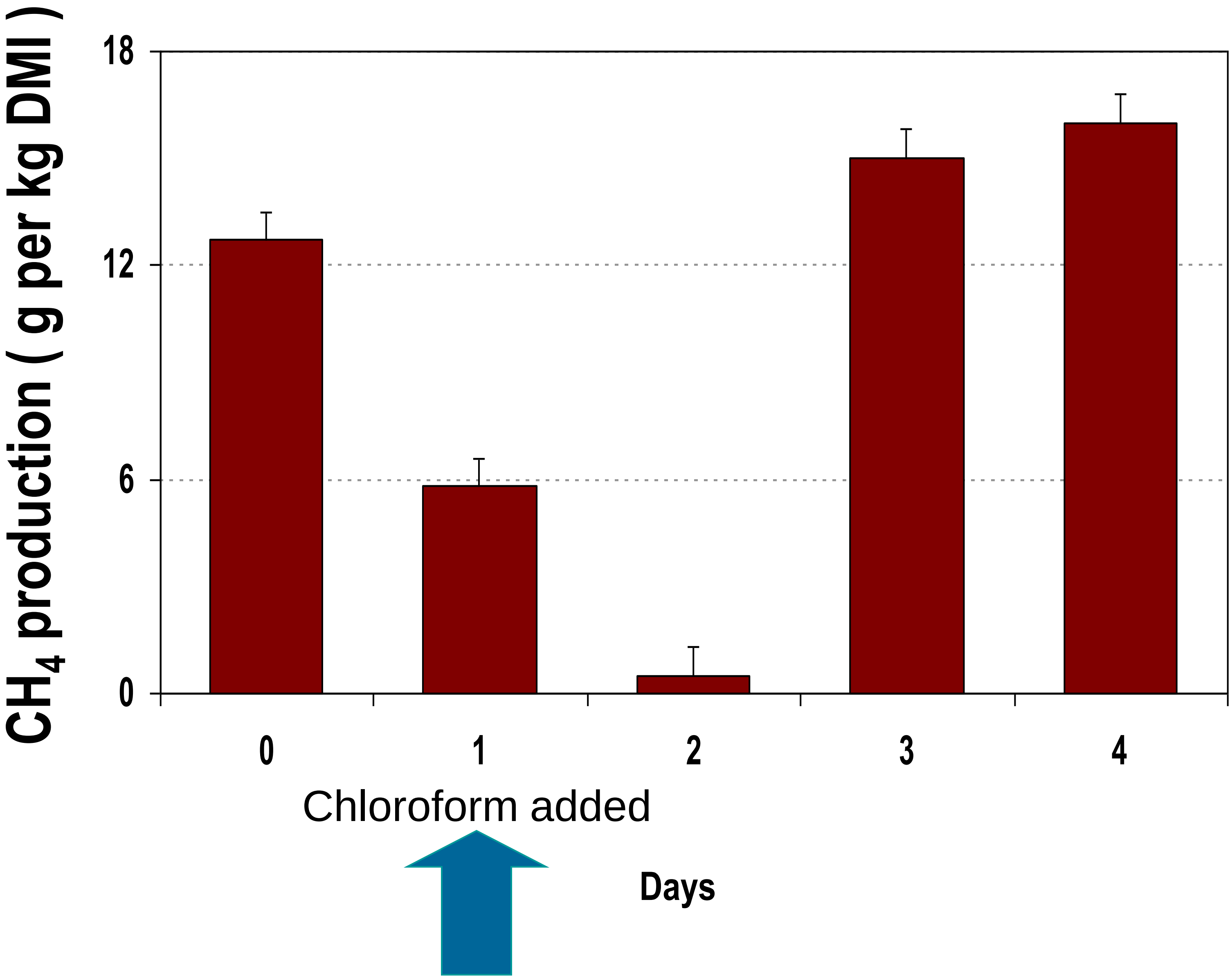
Acetogensis

- 2 CO_2+ 4 H_2 -------> CH_3-COOH + 2 H_2O

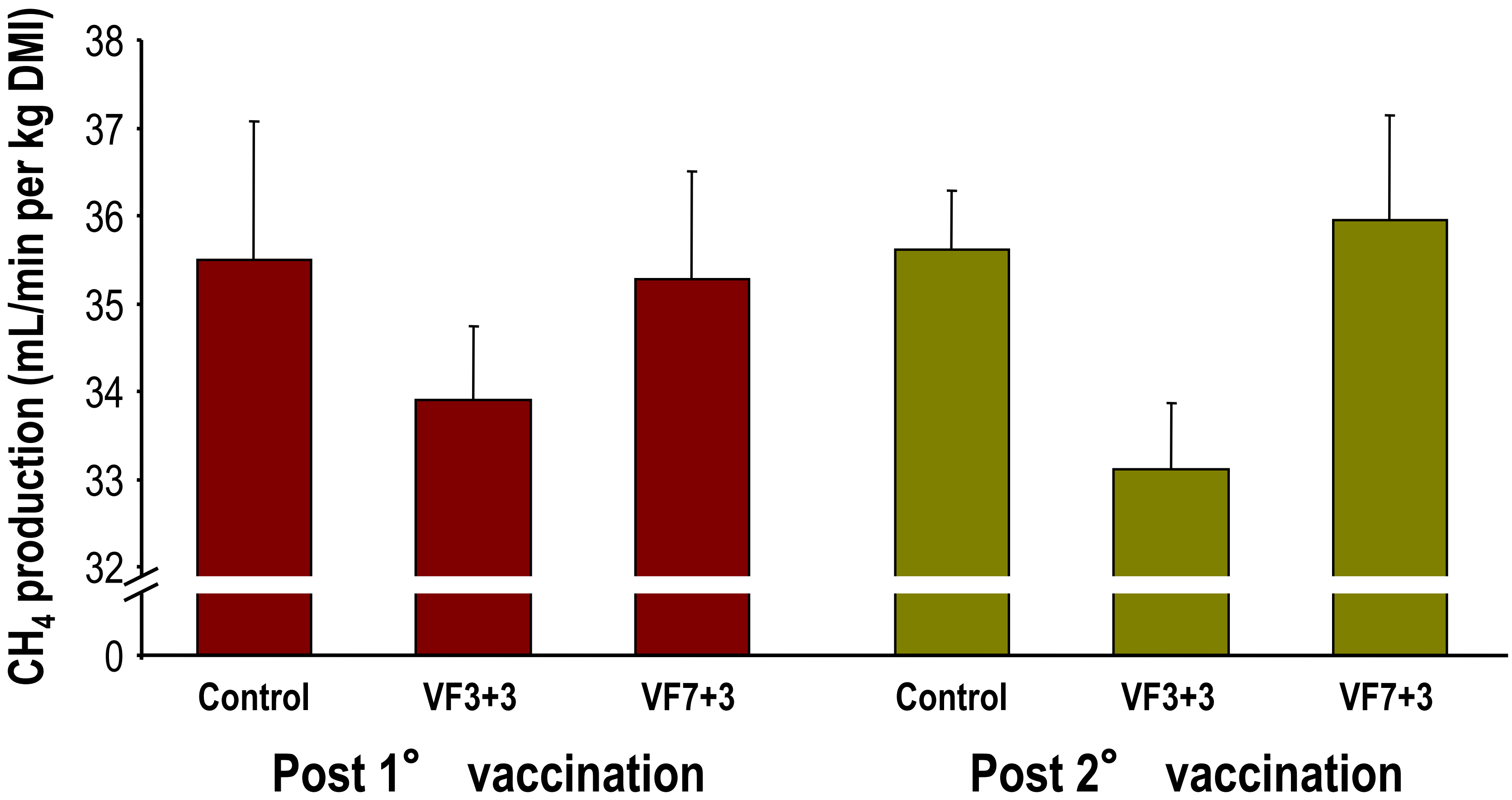
Direct inhibition
of methanogenesis
with the need
to redirect H^+
into alternative products

Methods of methane mitigation: → ***Direct inhibition of methanogenesis***

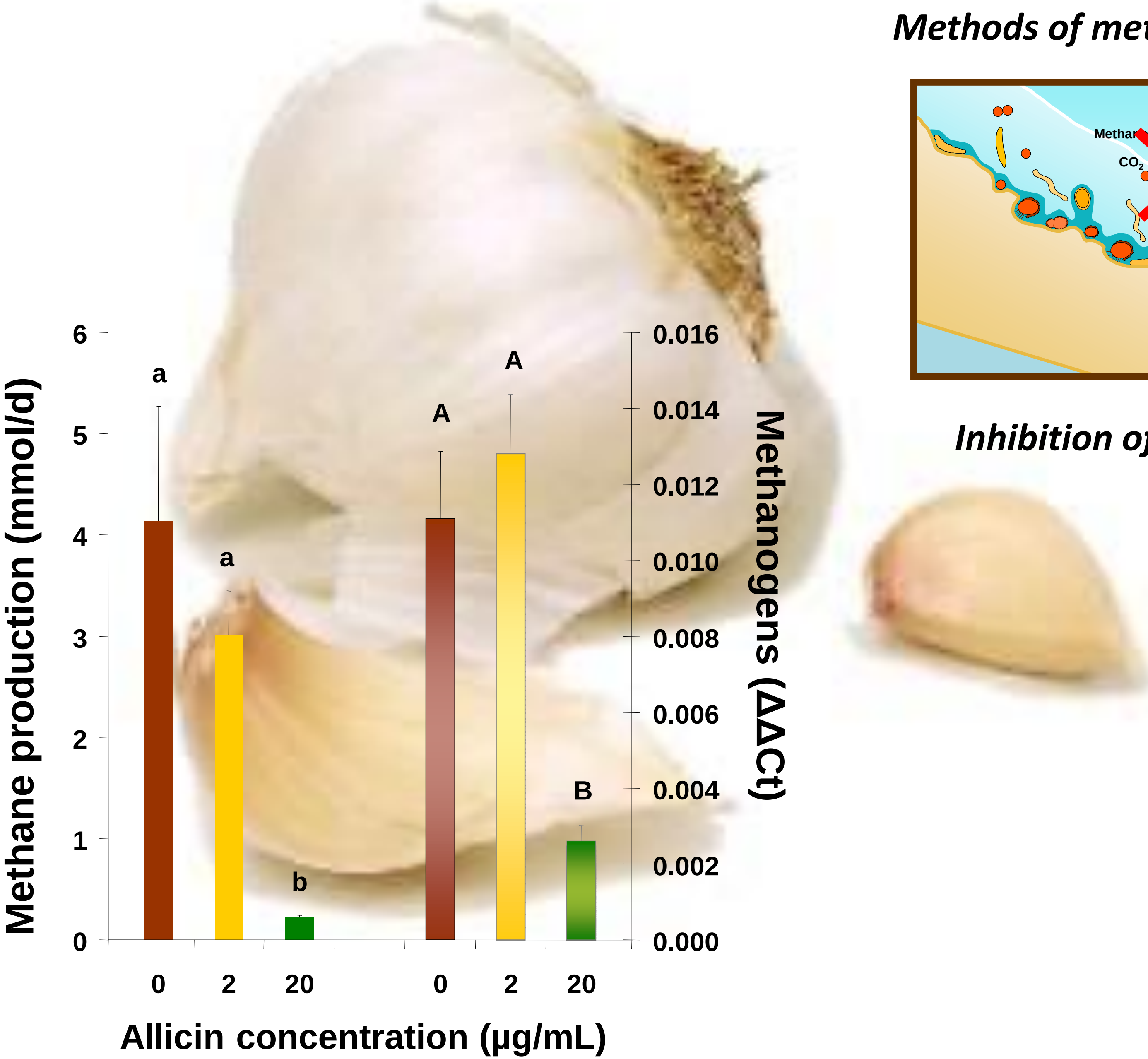




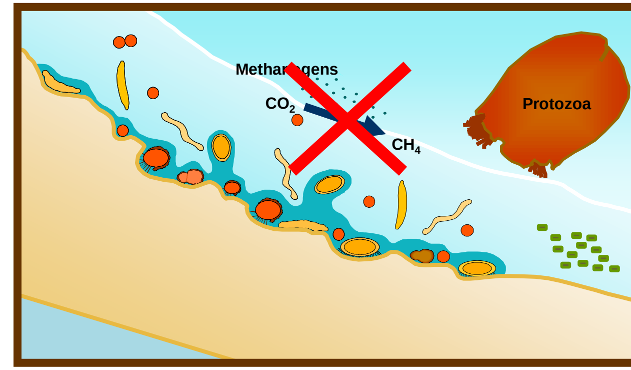
CH$_4$ production (g per kg DMI)
18
12
6
0
0
1
2
3
4
Chloroform added
Days



From Wright et al. (2004)

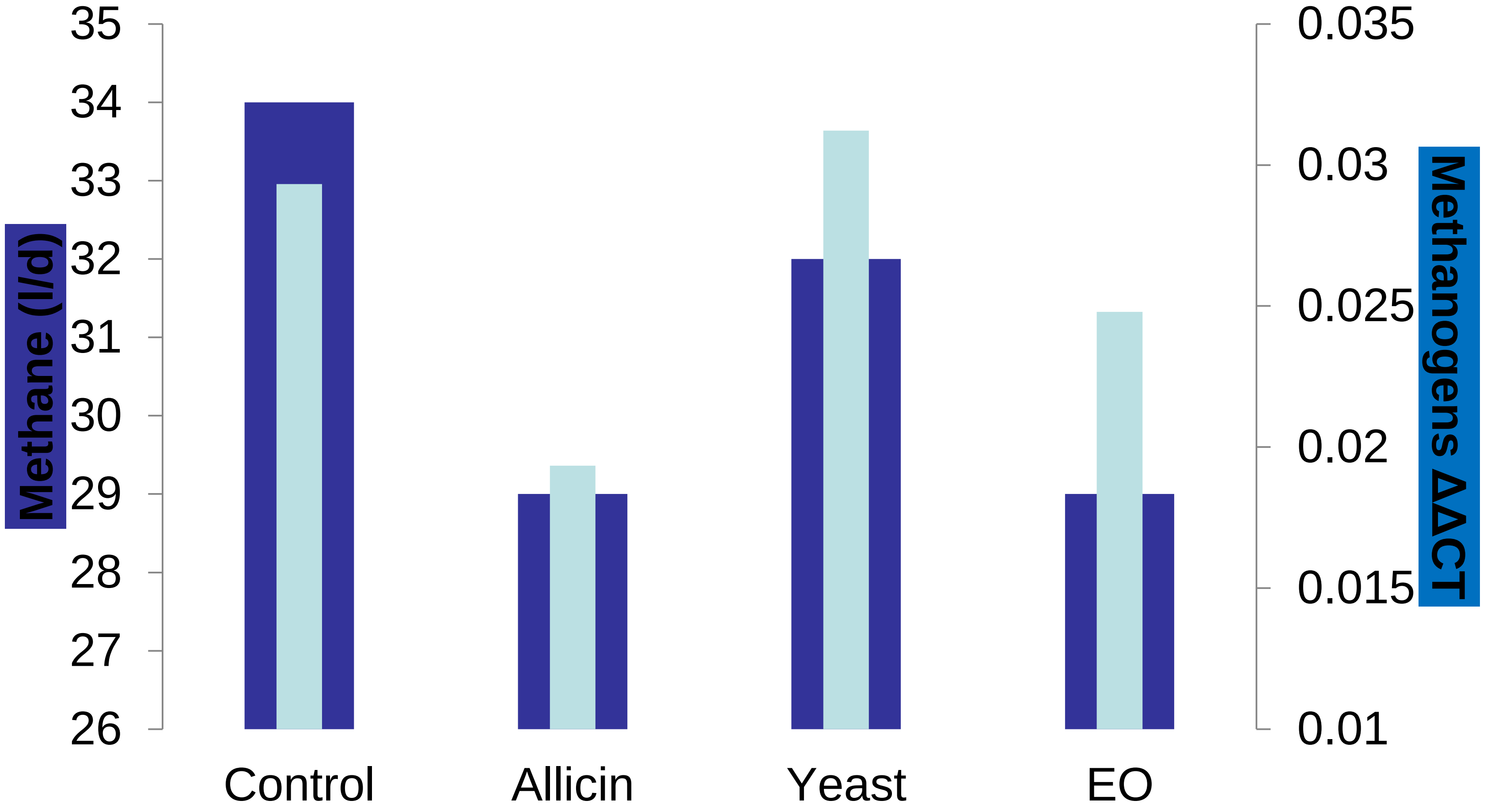


Methods of methane mitigation

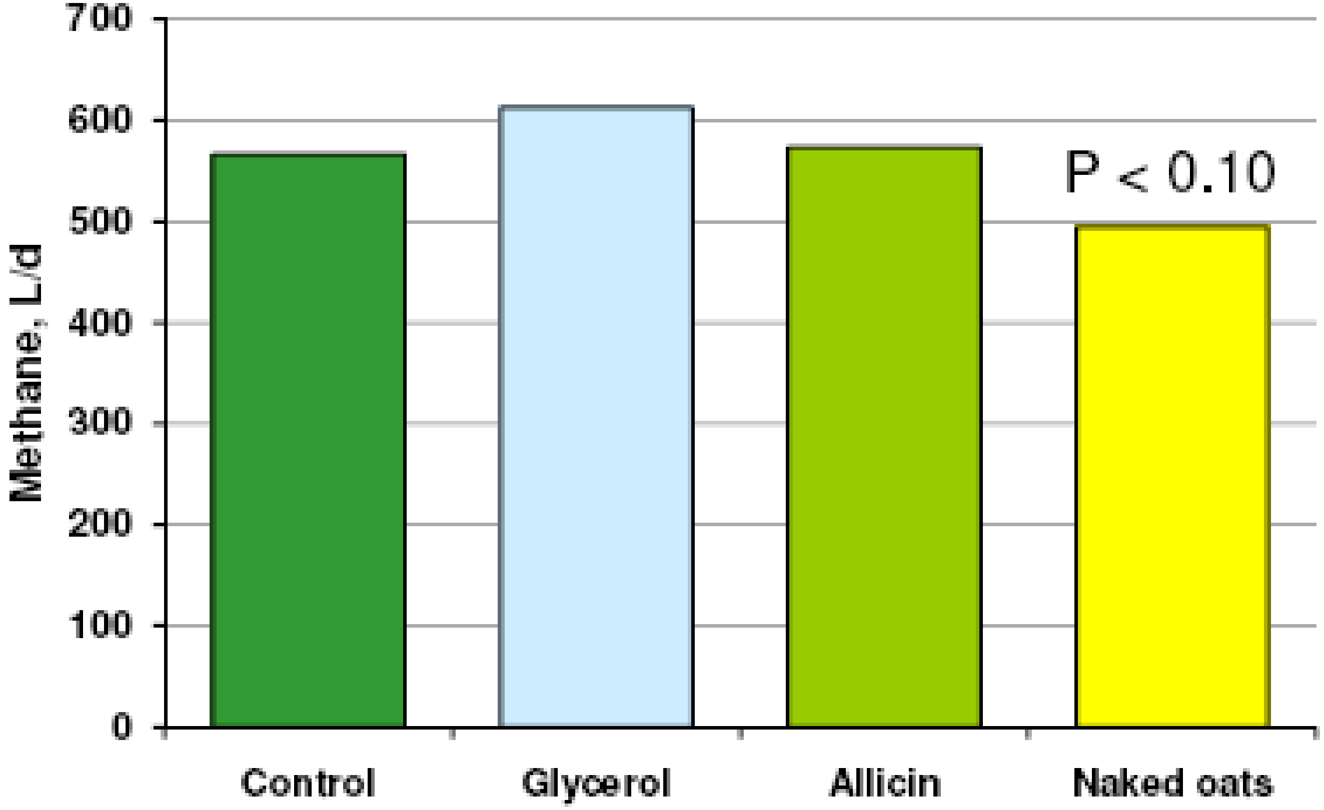


Inhibition of methanogens

The effect of a yeast based probiotic, Allicin an extract from garlic and the essential oil analogue on methane production by and methanogen numbers in the rumen of store lambs

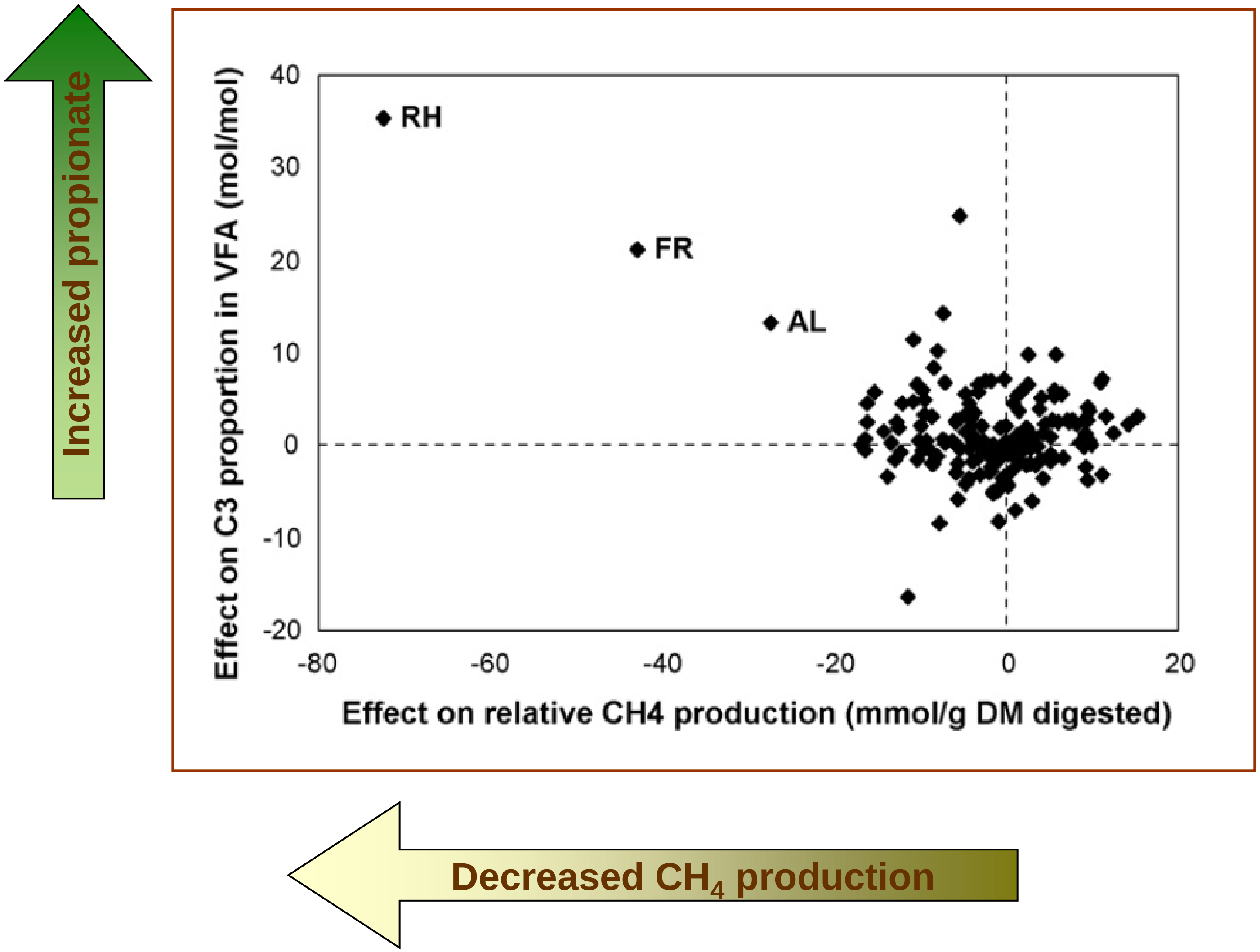


Effect of Supplements on Methane Production by Lactating Dairy Cows



DEFRA Project AC0209

Plant additives



RH: *Rheum officinale* (rhizomes)

FR: *Frangula alnus* (bark)

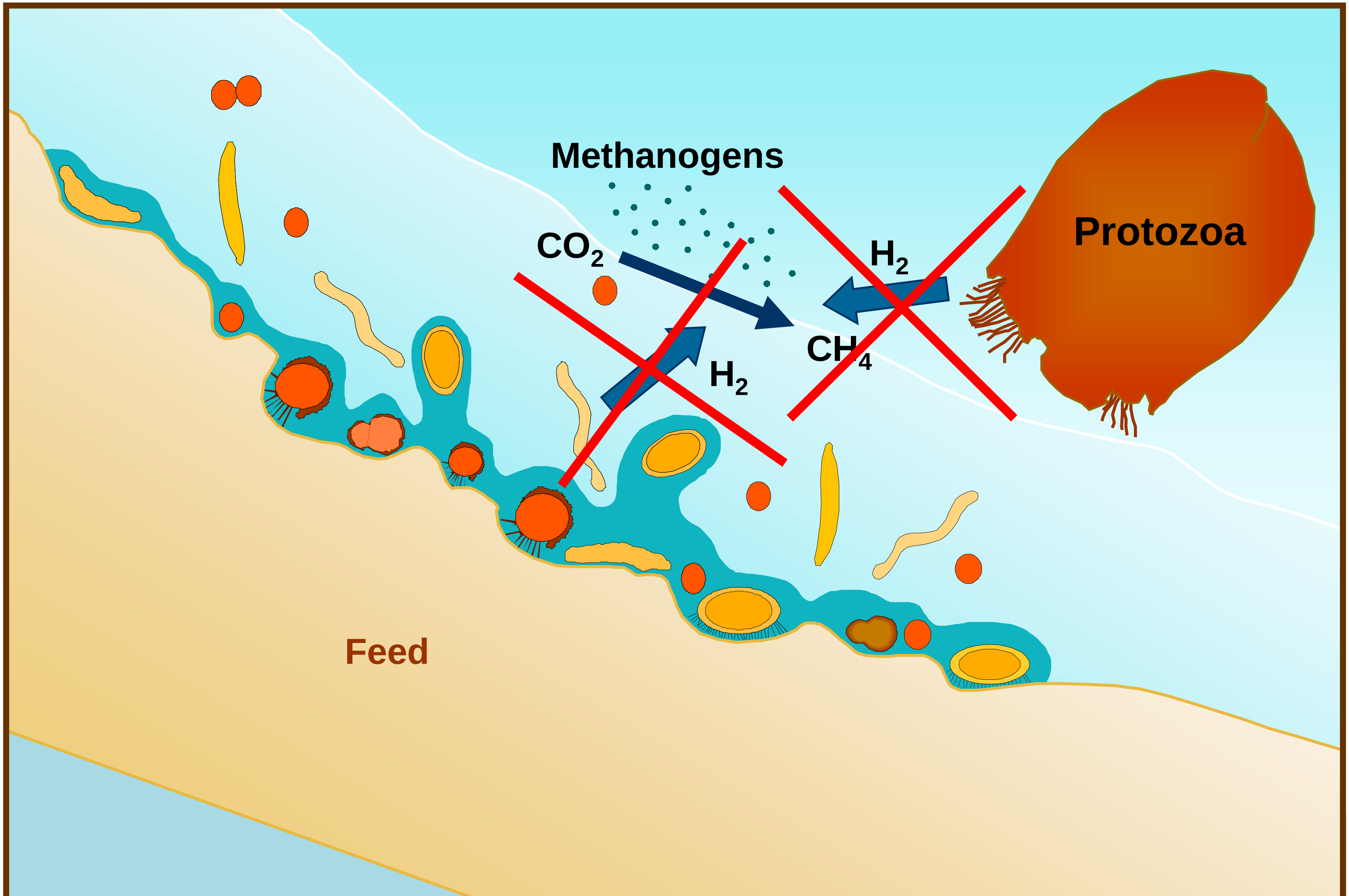
AL: *Allium sativum* (bulbs)

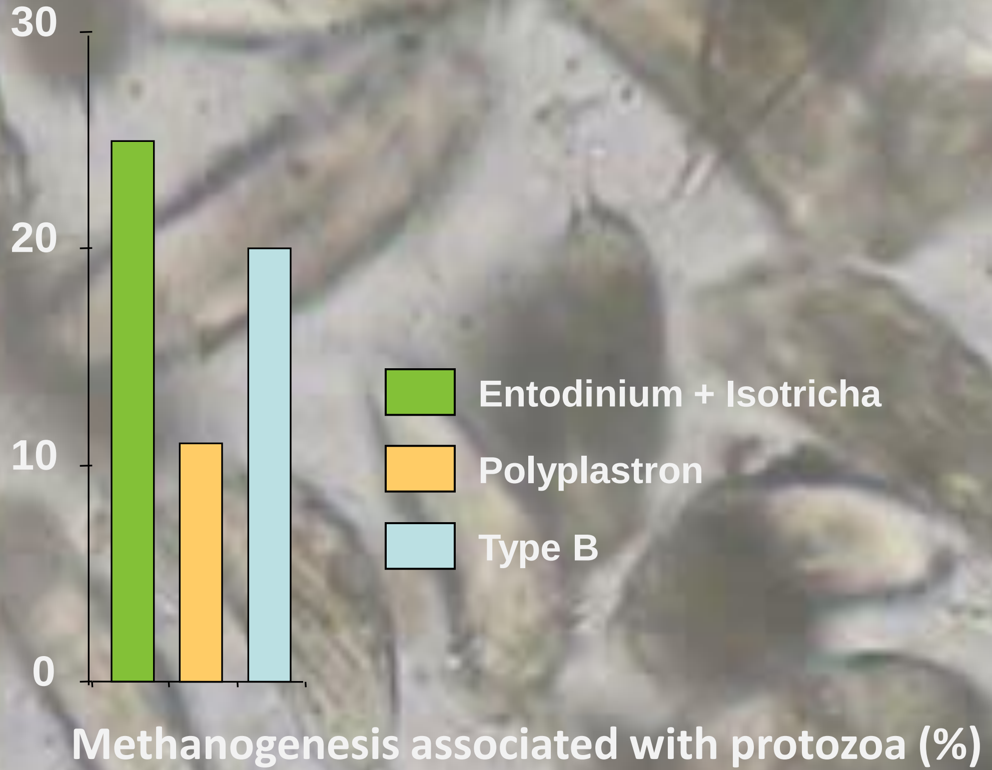
◆ = Individual agent tested. Changes are expressed as % of corresponding control values.

From Garcia-Gonzalez et al. (2007)

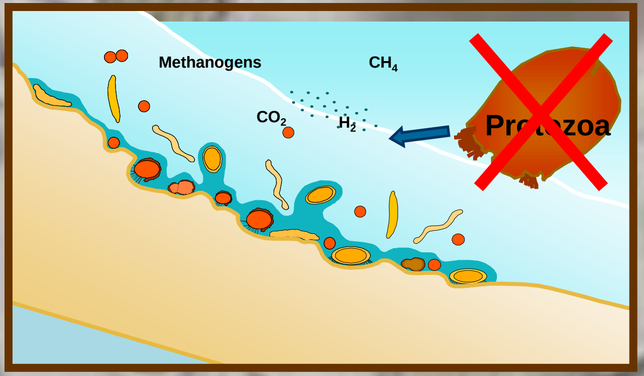
Decreasing the production of H+ in the rumen

Methods of methane mitigation: ➡ *Decrease H_2 production*





Methods of methane mitigation:



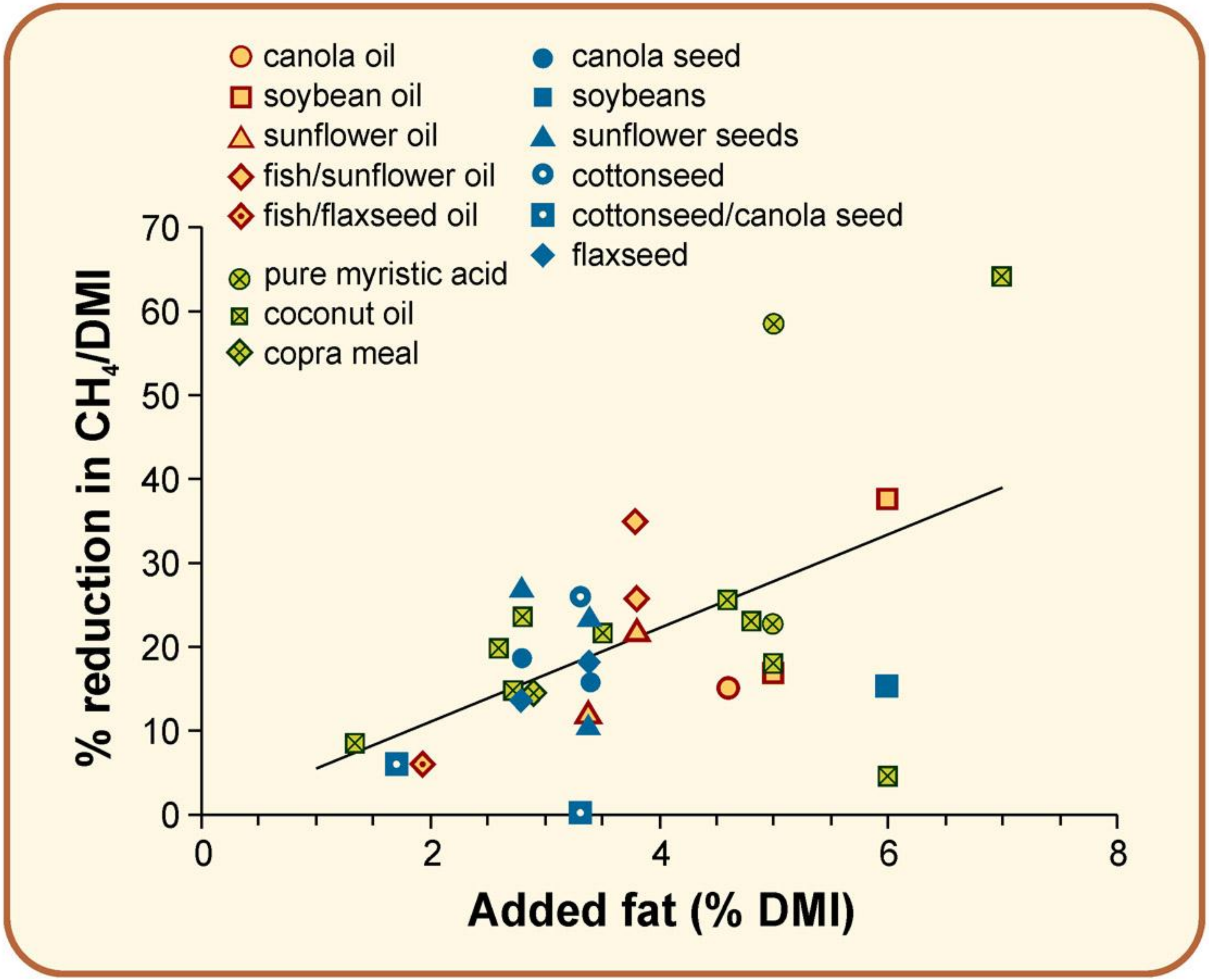
Decrease H_2 production

CH_4 production	PF	F	s.e.m.	*P*
L per day	26.0	35.2	2.82	0.049
L per kg LW	0.52	0.71	0.044	0.024
L per kg DMI	21.6	29.0	1.41	0.006

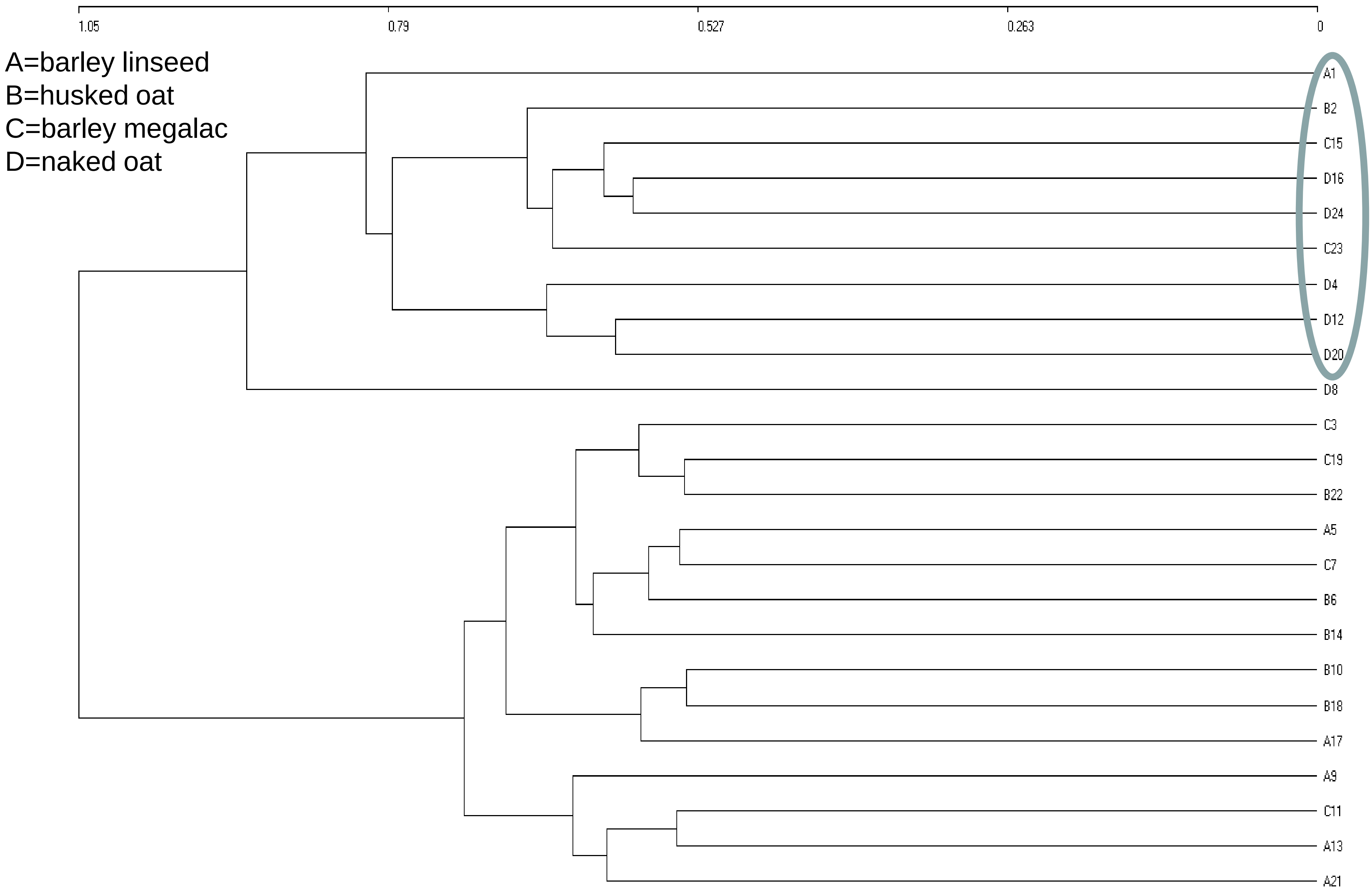
PF: protozoa-free lambs; F: faunated lambs.
LW: liveweight; DMI: dry matter intake

Literature summary of added fat vs CH_4 production

$Y = 5.562\ (SE = 0.590) \times$ % added fat; $r^2 = 0.67$; $P = 0.004$

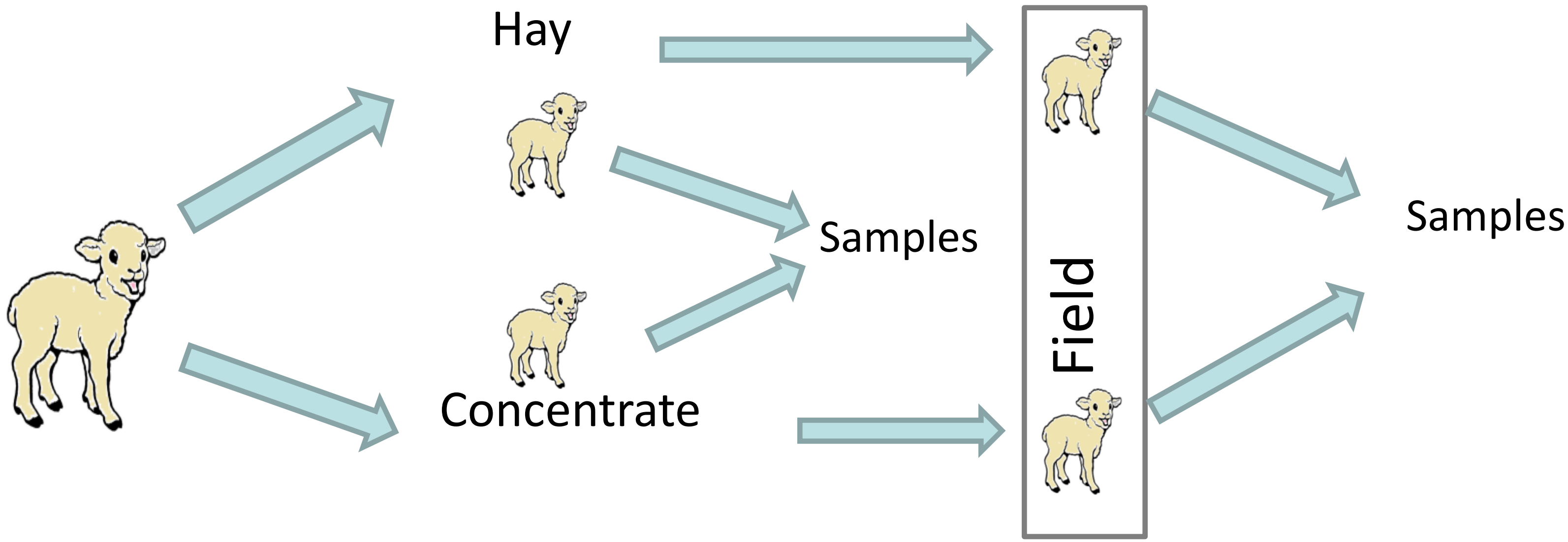


	Barley megalac	Barley linseed	Naked oats	Husked oats	SED
Methane (l/d)	36	28	24	36	4.7*
Methane (l/ kg intake)	31	24	21	31	3.4*
LWG (g/d)	106	105	107	119	19.3
Wool growth (g)	8	7.5	8.4	7.8	0.827
Methane / Kg LWG	447	286	232	320	106



1.05
0.79
0.527
0.263
0
A=barley linseed
B=husked oat
C=barley megalac
D=naked oat
A1
B2
C15
D16
D24
C23
D4
D12
D20
D8
C3
C19
B22
A5
C7
B6
B14
B10
B18
A17
A9
C11
A13
A21

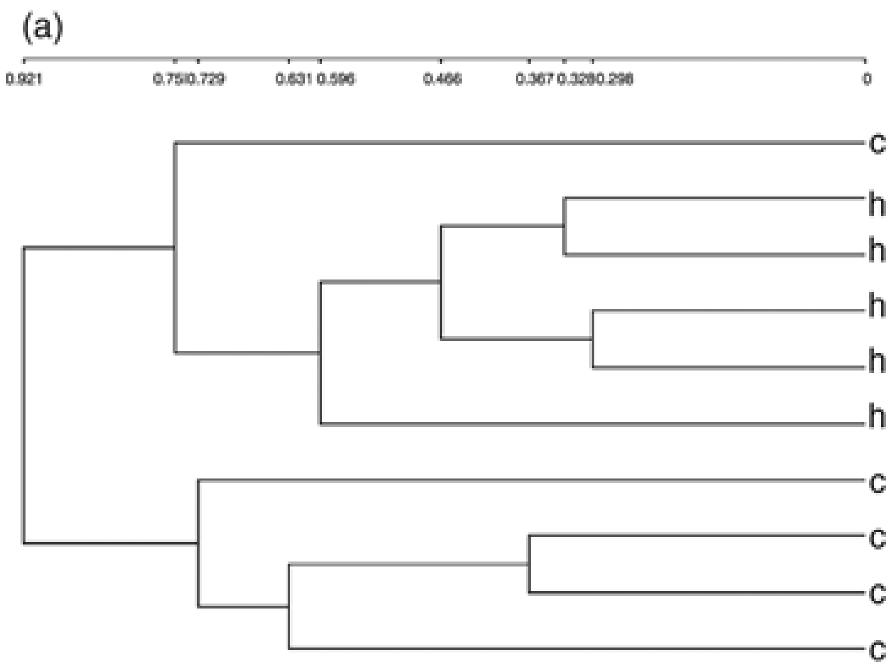
1. Weaning experiment



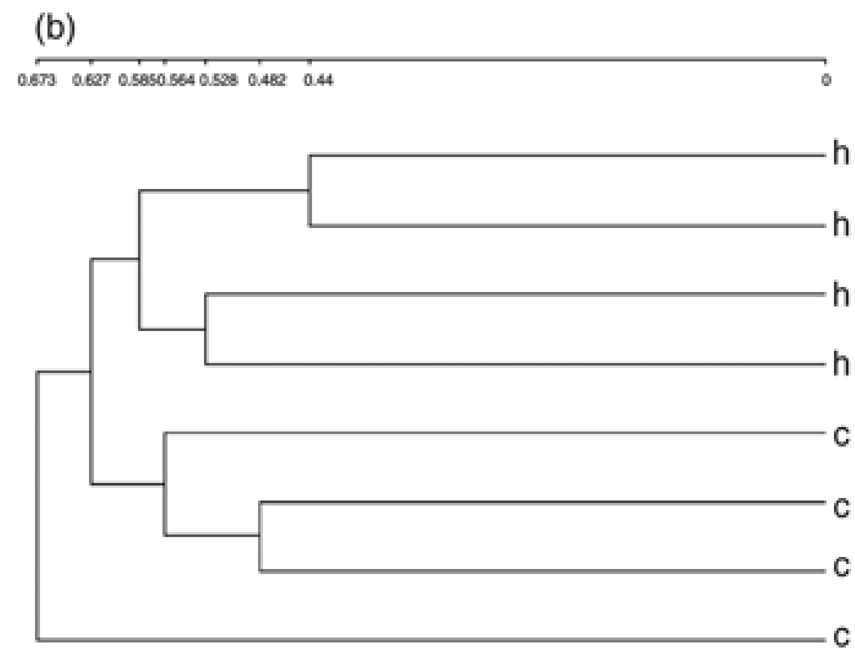
TRFLP Analysis

Results at Weaning

Results after Field

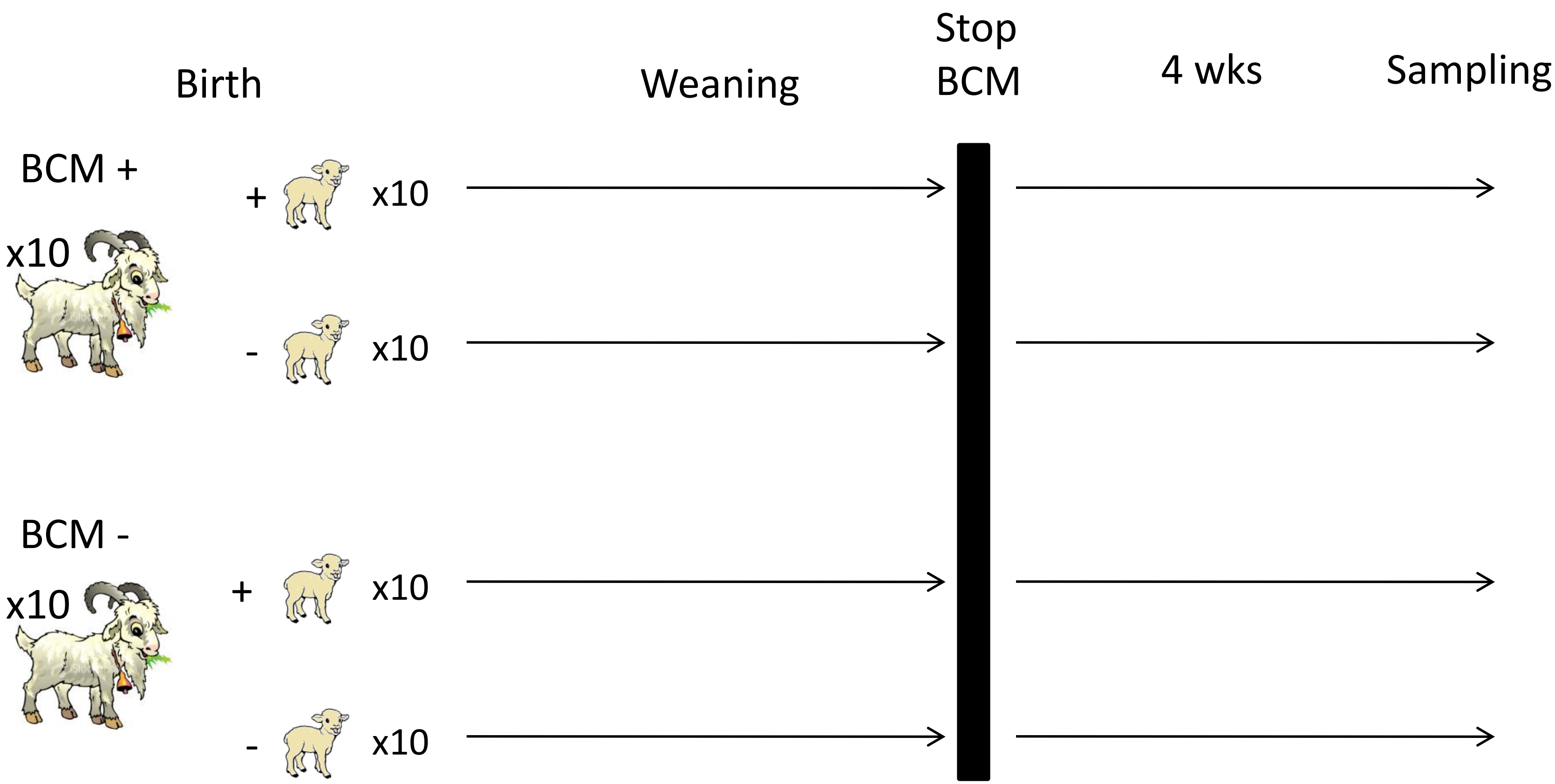


Phase I



Phase II

2. Bromochloromethane (BCM) rumen conditioning experiment



Effect of BCM addition on CH_4, milk yield and rumen archaeal numbers

Goats (week 8)	G+		G-		SEM	P value
CH_4 L/kg LW	0.349		0.564		0.059	0.008
Milk yield, g/day	1242		887		142	0.088
Kids	G+ k+	G+ k-	G- k+	G- k-		
CH_4 L/kg LW (week 12)	1.02	1.80	0.742	1.90	0.214	0.001
Methanogens (week 12)	7.31	7.96	6.72	7.81	0.289	0.222
CH_4 L/kg LW (week 16)	1.56	2.40	1.59	1.70	0.258	0.043
Methanogens (week 16)	7.74	7.64	7.52	7.51	0.125	0.232

$CH_{4\ as}$ g/kg DMI

Analysed as repeated measures

Fixed effects

- Origin
- Measurement group, measurement time
- Sire

Heritability = 0.16, repeatability = 0.29

Questions