How to solve the problem of scales to improve the efficiency in livestock production?

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The efficiency in livestock production

• Animals are not directly a limiting resource: they are secondary processors of primary biomass

• The efficiency of their conversion of biomass in animal products is essential:
  – To preserve resources
  – To increase competitiveness
  – To reduce the environmental impacts

• How to increase efficiency in livestock production to be sure to reduce competition of animal with edible food and to reduce environmental impacts?
The different scales of the problem

Territory, country

Farms

Animal...

knowledge
Biological or physical processes

Resources, Impacts

Decisions = possible actions!

At what scale do we have to study and to solve the problems?
A back-and-forth between emergence and reduction

"The macroscopic properties (of a system) differ radically from those of its constituents; yet they made thereunder, and it is the transition from one scale to the other, which gives rise to new behaviors."
Roger Ballian (HS Sciences et Avenir Juillet 2005)

1/ The risk to extrapolate conclusions from one scale to another: Example of greenhouse gas emissions (GHG) in cattle production

2/ A proposal of strategy to face the new efficiency challenge
The risk to extrapolate conclusions from one scale to another: Example of GHG in cattle production
High producing dairy cows are more efficient: they dilute the maintenance cost with more milk

Capper et al, 2009
Annual C balance of a dairy cows in a grass based system and in maize based system

C intake
- 2705 kg/y
- 3574 kg/y

C CO₂
- 1389 (51%)
- 1351 (38%)

C CH₄
- 106 (4%)
- 134 (4%)

C urine
- 37 (1%)
- 33 (1%)

C fecal
- 669 (25%)
- 1271 (36%)

C milk
- 505 (19%)
- 717 (20%)

Milk
- 7500 kg/y
- 10500 kg/y

0.210 g (grass) vs 0.187 g (maize) of C CH₄/ g C Milk
Conclusion at animal level

- Using high producing cows seems to improve the efficiency and to reduce the emissions
- Maize silage based diets well supplemented seems a good option
  - to increase the efficiency of C use/kg of milk
  - To reduce the decoupling of C in the effluent
- Global impact = reduction per cow * number of cows
- Do we have to promote dairy systems with high producing dairy cows fed corn as the best option?
At farm scale, no evidence of a benefit of higher milk production per cow on GHG

Source: Hacala et al, 2006
LCA: different trade-offs, but a good assesment of NZ grazing systems

Adapted from Basset-Mens et al. 2008
Conclusion at farm level

• Conclusion at farm scale does not support the conclusion at animal scale
  • GHG emissions are not really improved with higher milk production
  • Low producing animals fed with grass LCA seems better (case of NZ systems)
  • Methane emissions is the main but not the only one GHG
• Is it still true at larger scale?
Carbon footprint: the increase in milk yield reduces by more than 3 the GWP impact

\[ \text{CO}_2 \text{ equivalents, kg/cow} \]

\[ \text{CO}_2 \text{ per cow} \]

\[ \begin{array}{cc}
\text{1944} & 13.5 \\
\text{2007} & 27.8
\end{array} \]

\[ \text{CO}_2 \text{ per kg milk} \]

\[ \begin{array}{cc}
\text{1944} & 3.66 \\
\text{2007} & 1.35
\end{array} \]

Capper et al, 2009
Specialisation and intensification of cattle production without changing the global Meat / Milk ratio

Two cattle breeds more specialized and more productive

Carcass weight of Charolaises at culling

+ 60 kg in 30 years

Données Eurostat

Milk / cow / year

+ 103 kg milk/year

Agabriel, 2010
Methane emissions by French cattle

What’s wrong?

Where is there reduction by 3 expected?

Pflimlin et al. 2009

y = -0.1x + 853.2

y = -1.5x + 659.6

Methane Kg/T carcass

Methane kg/10T milk

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The system expansion explains the loss of expected benefit

Cederberg et al., 2003

Puillet et al., 2014
The specialization did not significantly affect the global meat production per cattle or per cow.

![Graph showing Meat Production (kg carcass/animal/year) from 1970 to 2010. The x-axis represents the year, and the y-axis represents the production per cow and per cattle. The graph indicates a steady increase in production per cow with minor fluctuations, while production per cattle remains relatively stable. Eurostats 2009 credits are visible.]
Conclusion on scales and GHG emissions

• Even if the impact is global for GHG, the findings across the animal are not conclusive at larger scales (see also Zehetmeier et al. 2012)
• Dairy specialization does not necessarily improve GHG emissions contrary to what is often written
• The improvement in meat production could be better than the improvement of the milk production
• Same type of demonstration can be done with N emission

• How to improve: Approach bottom-up or top-down?
A proposal of strategy to face the new efficiency challenge
The complexity of the challenge

- Take into account the limits of available resources and the problem of their allocation
- Take into account the diversity of objectives
- Take into account the direct and indirect interdependence of systems
- Take into account the dynamics
- Integrate social mechanisms
How to optimise the performance of the global feed (food) system?

Le système alimentaire mondial
(Jean-Louis Rastoin, Gérard Ghers, 2010, QUAE Ed.)

Efficiency
Efficacy
Pertinence
Performance
Resources
Results
Objectives

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Consequence on the strategy

1/ Pertinence: Determine the best allocation of resources to maximise their valorisation and satisfy the multiple goals of a region, according to its potentiality and resilience capacities.

→ From high level of organisation to low levels. How to decline global efficiency?

2/ Efficiency: According to this allocation of resources, increase the efficiency of each system in each context

→ Low levels of organisation. How to optimize systems?

3/ Efficacy: Verify the results obtained are consistent with the overall goals, develop pertinent indicators to assess it.

→ From low levels of organisation to high level to verify the global efficiency.
Optimal solution faced to a set of dilemmas

Reduce Land Use

Air quality

Anaerobic (N₂, but CH₄)

Specialisation (production)

More free time

Decrease pressure (N, pesticide) /ha

Water quality

Aerobic (CO₂, but N₂O)

Multiactivity (Services)

Increase profit

• No global answer

• The context is essential, a balance is required between systems
Why maximising the efficiency of each system before fixing the specific objectives is risky?

• The best resources gives generally the best performance to each system and often the best efficiency
• But the best resources are limited:
  • Area of arable land is limited, its increase will be associated to C de-sequestration
  • Increase in production per ha could be associated with negative side effect
• If each system maximises its efficiency do not guaranty to maximes the performance of the whole system
  • Competition between productions on the best resources
  • Specialisation of regions can imbalance the different dilemmas and generate some problems of sustainability (soil air and water quality, biodiversity, vulnerability)
• A maximisation of the regional objectives could give different answers than the addition of the best livestock or crop systems optimised independently
The specialisation of a region is visible and could affect its sustainability
And it can totally change the landscape of a region
Conclusions, open to discussion

• This is not because a solution is true at a level of organization, it will be at a higher level (systemic):
  Beware of simplistic upscaling approaches

• If you think this is the case, check it!

• Before to promote a solution to improve a system, consider all the consequences induced

• Science is “upscaling oriented” and aggregates knowledge. Also think global to decline for local

• Triangle of performance: a promising way to structure new projects

• How to balance regional priorities and industries priorities?
Thank you for your attention

When I eat beef that itself has eaten only grass and grain

I am a vegetarian by proxy

Philippe Gelück