Climate change, heat stress, and animal robustness: Future perspectives in pig production - Wendy Rauw

MINISTERIO
DE CIENCIA, INNOVACIÓN
Y UNIVERSIDADES

INIA
Instituto Nacional de Investigación
y Tecnología Agraria y Alimentaria

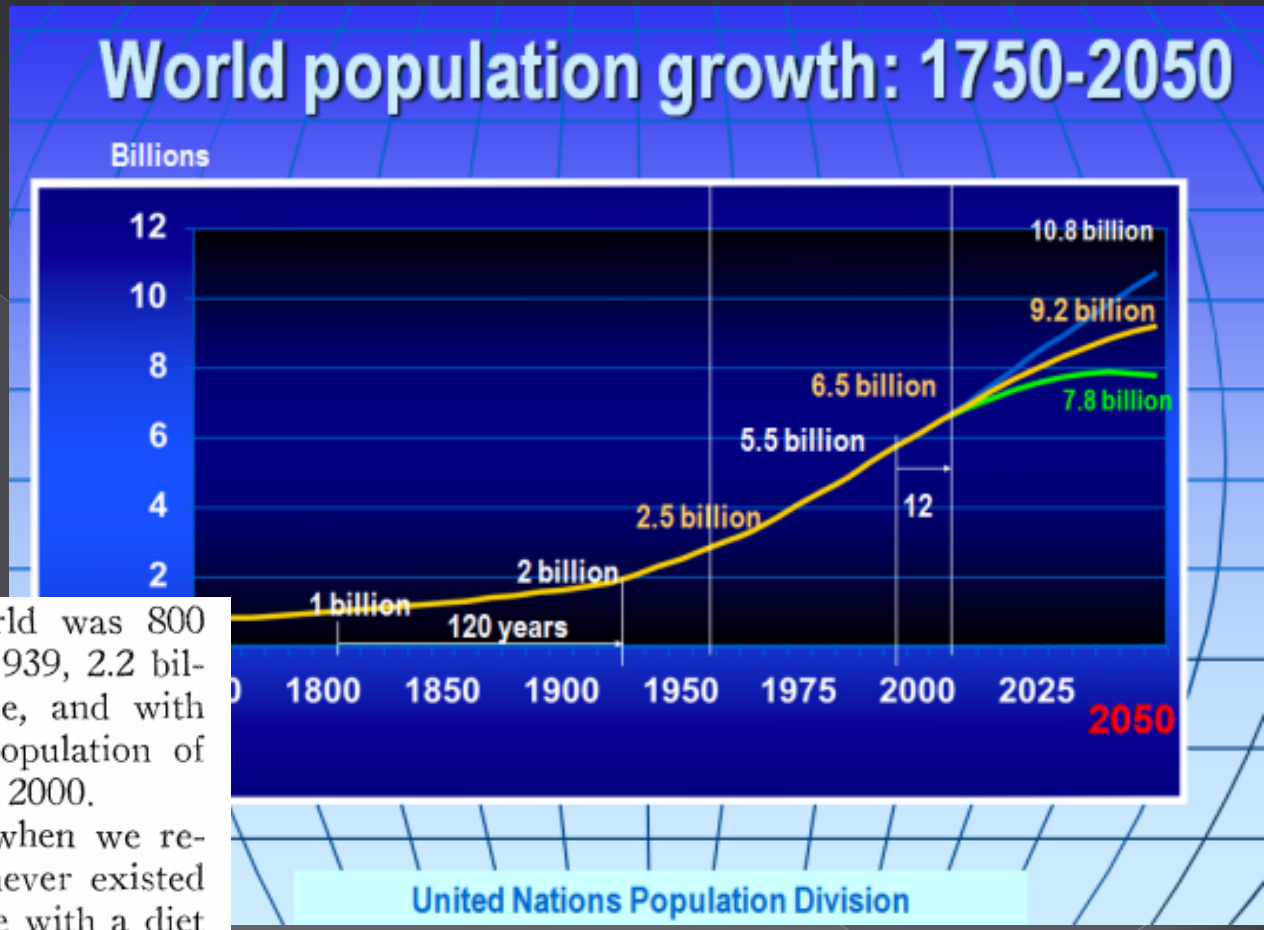
SUSTAINABILITY OF LIVESTOCK SYSTEMS

Current World Population

7,721,748,218

view all people on 1 page >

TODAY		THIS YEAR	
Births today	145,509	Births this year	82,270,284
Deaths today	61,051	Deaths this year	34,517,982
Population Growth today	84,458	Population Growth this year	47,752,302



In 1830, the population of the world was 800 million; in 1900, 1.6 billion; and in 1939, 2.2 billion. At the present rate of increase, and with the spread of medical science, the population of the world will be 4 billion by the year 2000.

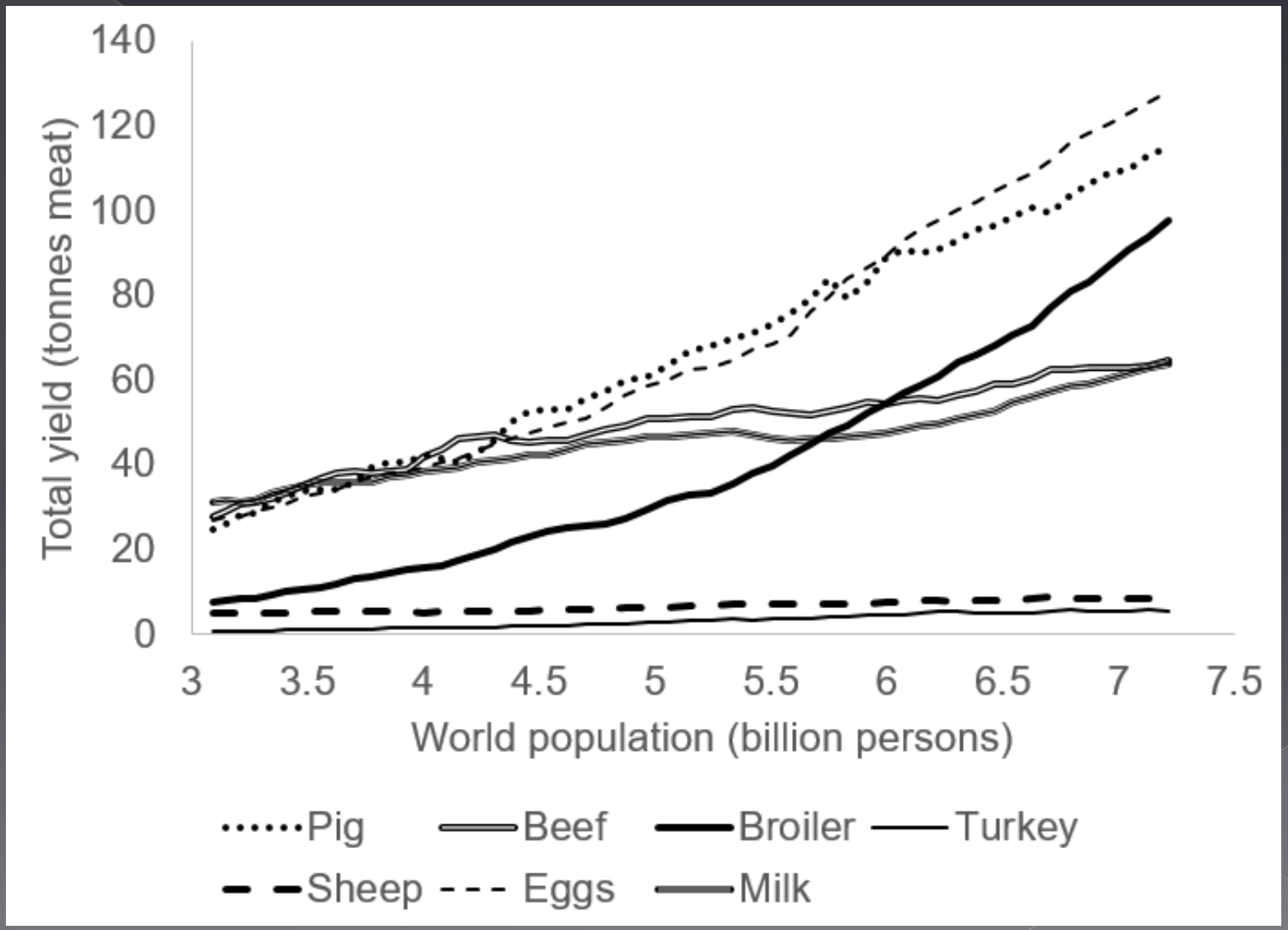
Is this a pleasant prospect? Not when we remember that a surplus of food has never existed in the world, that to provide everyone with a diet of 2,600 calories a day during the next twenty-five years the world's food production will have to be doubled. This does not seem possible when there are only 4 billion acres of land that can be used for food production by present methods, and when 2.5 acres of farm land are required to produce an adequate diet for one person. This serious situation

The Scientific Monthly, Vol. 68, No. 2 (Feb., 1949), pp. 118-121

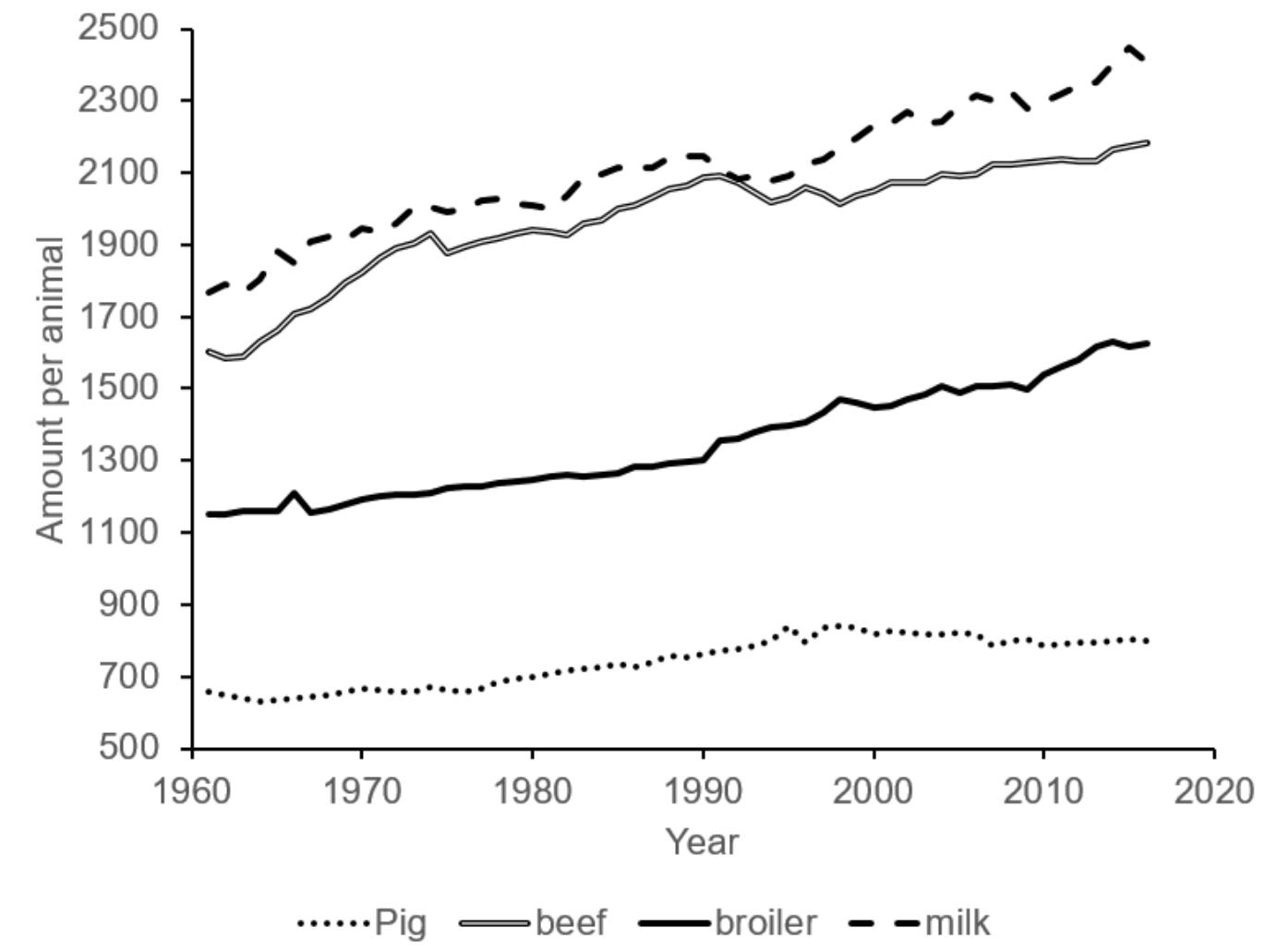
MEDICAL RESEARCH: OPERATION HUMANITY

ANDREW C. IVY

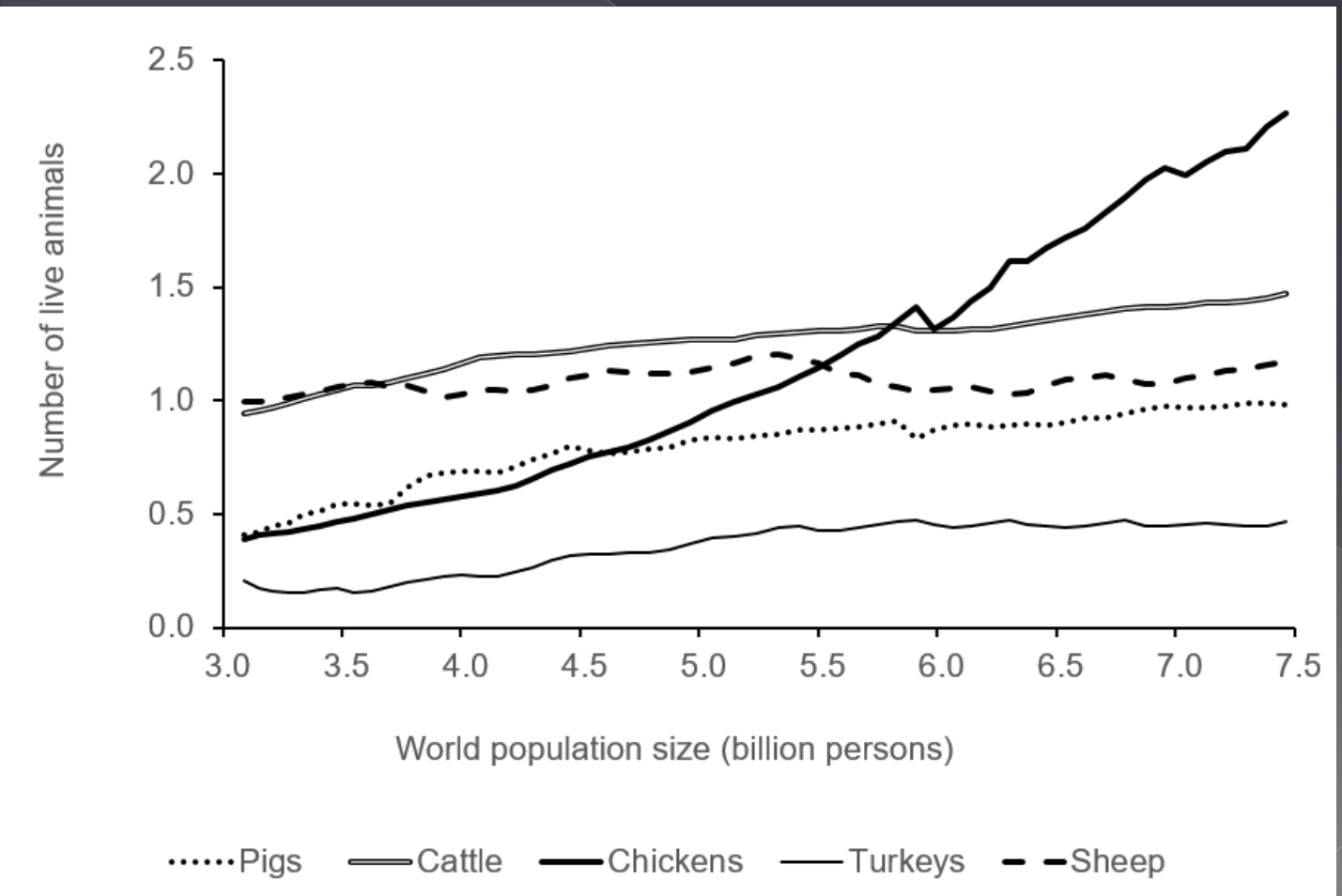
SUSTAINABILITY OF LIVESTOCK SYSTEMS



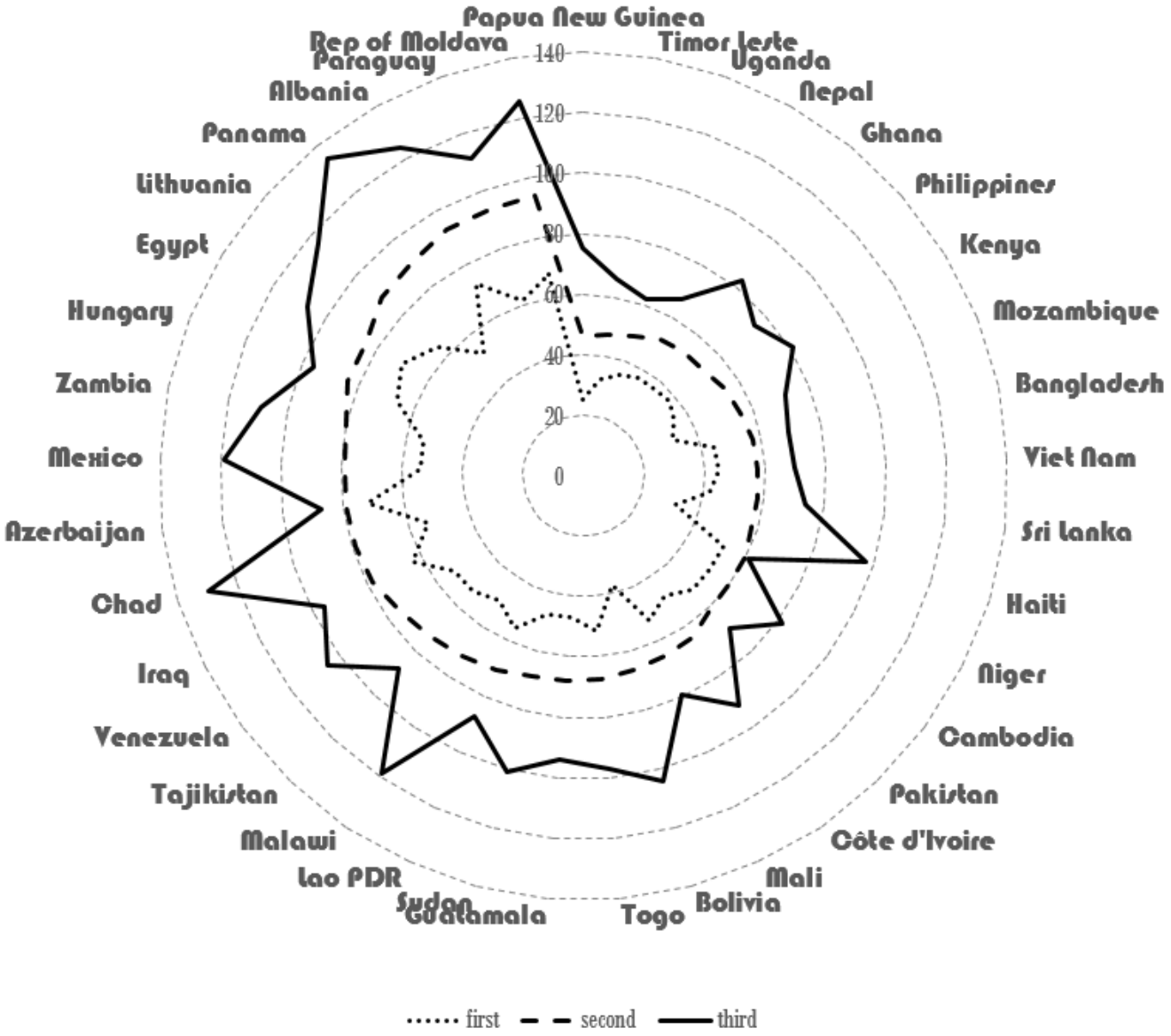
SUSTAINABILITY OF LIVESTOCK SYSTEMS



SUSTAINABILITY OF LIVESTOCK SYSTEMS



SUSTAINABILITY OF LIVESTOCK SYSTEMS



SUSTAINABILITY OF LIVESTOCK SYSTEMS

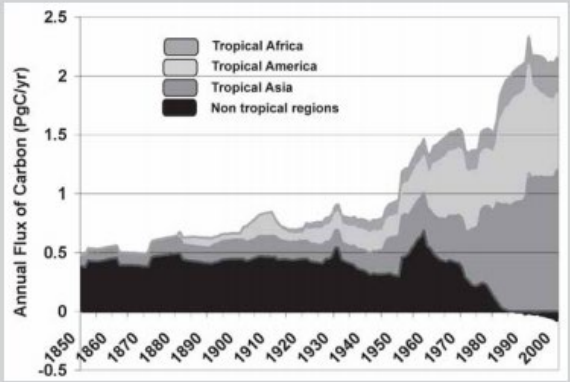
Demand ⇧ = land use ⇧

Currently: ~ 30% total land surface
~ 70% agricultural land (+ feed crops)

Clearing land = release of carbon held in trees

☞ (Brazil, India, Indonesia)

FIGURE 1. Annual emissions of carbon from changes in land use over the period 1850 to 2000. Essentially all of the emissions were from tropical countries in the 1990s, nearly half from tropical Asia.



SUSTAINABILITY OF LIVESTOCK SYSTEMS

Demand ⇧ = water use ⇧

Table 2. Estimated amount of water required to produce crops and livestock.

Crop or livestock	Water required (liters per kilogram)
Crop	
Soybeans	2000
Rice	1600
Sorghum	1300
Alfalfa	1100
Wheat	900
Corn	650
Potatoes (dry)	630
Millet	272
Livestock	
Broiler chicken	3500
Pig	6000
Beef cattle	43,000
Sheep	51,000

Source: Pimentel and colleagues (2004).

SUSTAINABILITY OF LIVESTOCK SYSTEMS

Demand ⇧ = energy use ⇧

Pimentel et al. (2004): kcal fossil energy/kcal animal protein

Table 13. Grain and forage inputs per kilogram of animal product produced, and fossil energy inputs (kcals) required to produce 1 kcal of animal protein.

Livestock	Grain (kg)	Forage (kg)	kcal input / kcal protein
Lamb	21	30	57:1
Beef cattle	13	30	40:1
Eggs	11	--	39:1
Grass-fed beef cattle	--	200	20:1
Swine	5.9	--	14:1
Dairy (milk)	0.7	1	14:1
Turkeys	3.8	--	10:1
Broilers	2.3	--	4:1

From: Pimentel, D. 2004. Livestock production and energy use. In, *Encyclopedia of Energy*, Matsumura, R. (ed.), Elsevier, San Diego, CA. pages 671-676.

SUSTAINABILITY OF LIVESTOCK SYSTEMS

Demand ⇧ = emissions and waste ⇧

Gerber et al. (2013):

44% methane (ruminants)
53% nitrous oxide (manure)
5% carbon dioxide

☞ Global warming, acidification and eutrophication of ecosystems

SUSTAINABILITY OF LIVESTOCK SYSTEMS

WorldWatch Institute (2004): "The human appetite for animal flesh is a driving force behind virtually every major category of environmental damage now threatening the human future: deforestation, erosion, fresh water scarcity, air and water pollution, climate change, biodiversity loss, social injustice, the destabilization of communities and the spread of disease"

SUSTAINABILITY OF LIVESTOCK SYSTEMS

Solutions:

1. More plant-based, less meat-based diets
2. Livestock intensification (optimal farming)
3. Improved animal robustness (suboptimal farming)

This presentation:

1. Sustainability of livestock systems
2. Livestock intensification (optimal farming)
3. Improved animal robustness (suboptimal farming)
4. Prospects for sustainable livestock production

This presentation:

1. Sustainability of livestock systems
2. Livestock intensification (optimal farming)
3. Improved animal robustness (suboptimal farming)
4. Prospects for sustainable livestock production

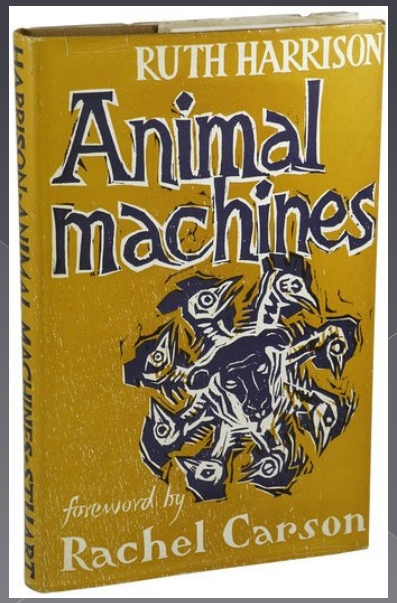
Livestock intensification

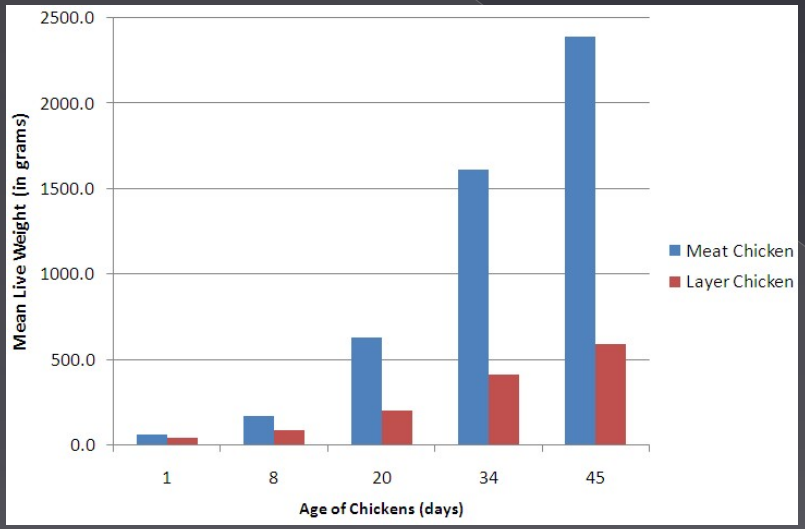
Closing the "yield gap" = realized – attainable production

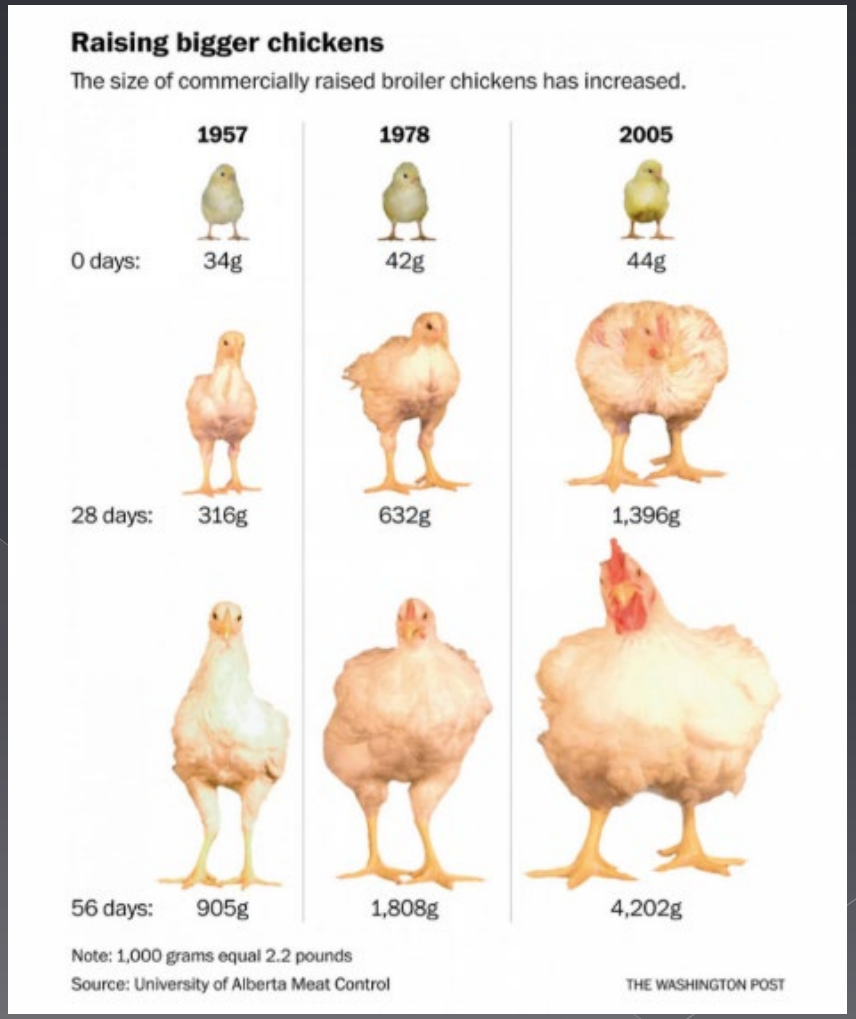
Attainable = technology, water, nutrients, land, biodiversity, labor

Not realized = accessibility, market influence, knowledge

Livestock intensification
("Animal Machines" 1964)
Large production units + best genetics




2500.0
2000.0
1500.0
1000.0
500.0
0.0
Mean Live Weight (in grams)
1
8
20
34
45
Age of Chickens (days)
Meat Chicken
Layer Chicken


Raising bigger chickens
The size of commercially raised broiler chickens has increased.
1957
1978
2005
0 days:
34g
42g
44g
28 days:
316g
632g
1,396g
56 days:
905g
1,808g
4,202g
Note: 1,000 grams equal 2.2 pounds
Source: University of Alberta Meat Control
THE WASHINGTON POST

Livestock intensification

Resource allocation: output ☜ inputs

Resources (R) allocated to processes add to give the total amount of resources consumed

R (Total) = R (Maintenance) + R (Production) + R (Reproduction) + R (Rest)

Rest = Activity + Other + 'Buffer' (reacting to stress & pathogens)

Closing the yield gap ☜ Increased quantity/-lity inputs?

Livestock intensification

Precision livestock farming (2004)

Real-time monitoring and control systems
- Production, reproduction, health
- Blood parameters, sweat, saliva, body T, behavior, stress, sound, analytes, viruses + pathogens

☞ Individualistic approach

☞ Sustainable intensification ↑

LIVESTOCK INTENSIFICATION

Increased quality:

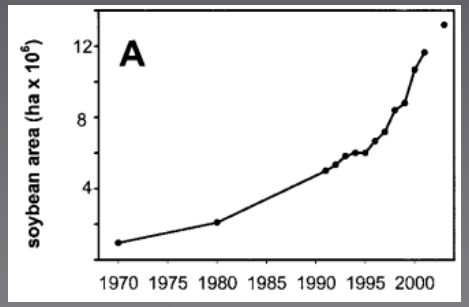
☞ Highly productive crops = potential human-edible food

Worldwide: 33% cereal, 74% maize, 83% soybean

☞ Sourcing from international markets

Soybean: EU mayor importer (>95%)
Market share: 31% USA, 31% Brazil, 19% Argentina

☞ Sustainability ↓



1. Sustainability of livestock systems
2. Livestock intensification (optimal farming)
3. Improved animal robustness (suboptimal farming)
4. Prospects for sustainable livestock production

Improved robustness

Reaction Norm (Woltereck, 1909)

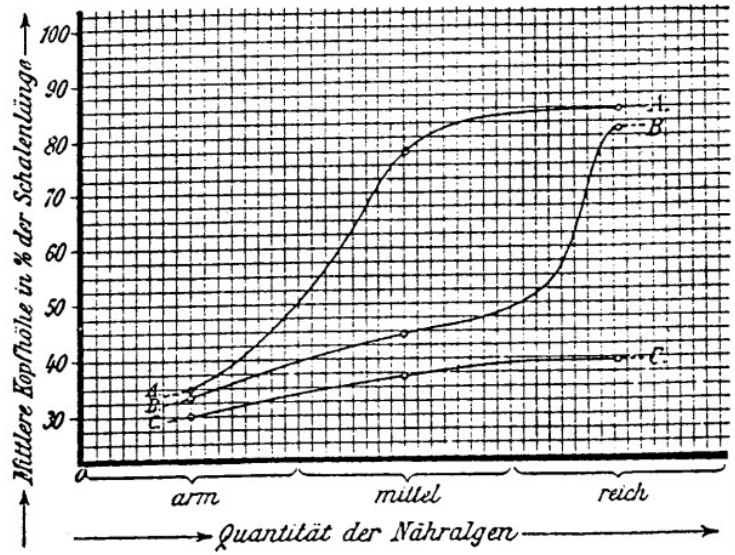
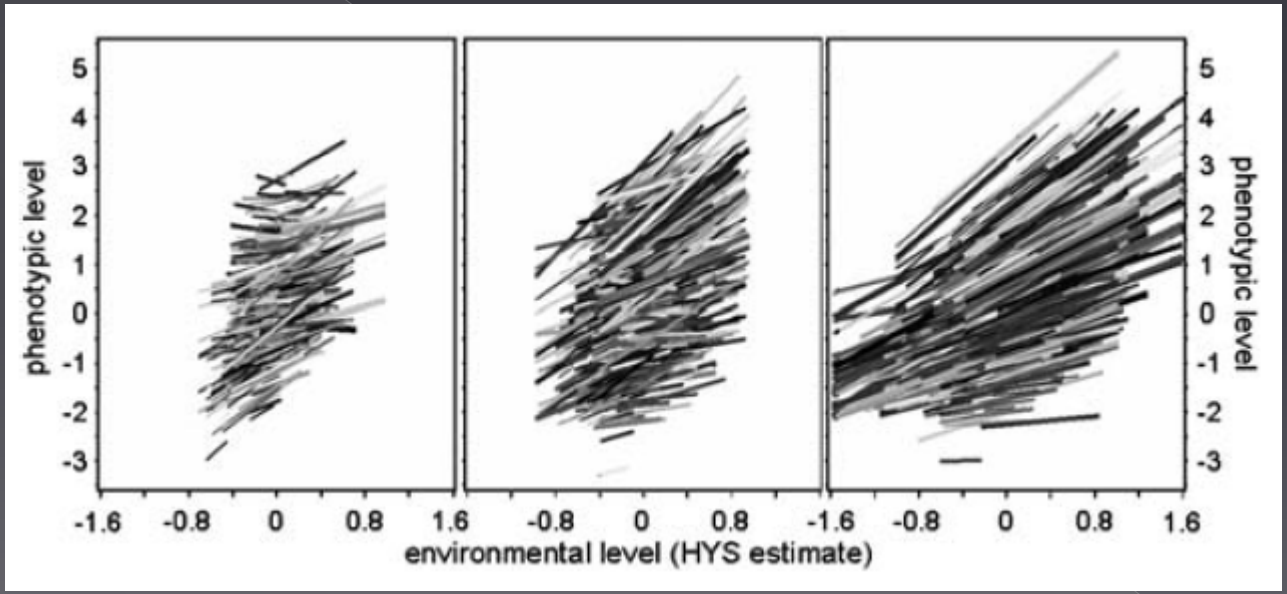


Figure 2. Phenotype curves for females of three pure lines of *Hyalodaphnia cucullata*. This is Figure 12 from Woltereck (1909: p. 139). *Abscissa*: nutrient level; *ordinate*: relative head height. A: strain from Moritzburg; B: from Brosdorf; C: from Kospuden. All strains were grown at a constant intermediate temperature and were from a "middle generation" of parthenogenesis. The curves show non-uniform variation between pure lines.

IMPROVED ROBUSTNESS

Reaction norms (progeny tested across a wide environmental range)



Improved robustness

Knap (2005): "the ability to combine a high production potential with resilience to stressors, allowing for unproblematic expression of a high production potential in a wide variety of environmental conditions"

"Sustainable breeding goals combine robustness traits with production traits, balancing production potential with environmental sensitivity"

☞ Animals are required to produce in wide variety of environmental conditions ☞ temperature, nutrients

Improved robustness: heat stress

Periods: TN1, HS1, TN2, HS2, TN3, HS3, TN4

frontiers in Genetics

ORIGINAL RESEARCH
published: 26 October 2017
doi: 10.3389/fgene.2017.00155

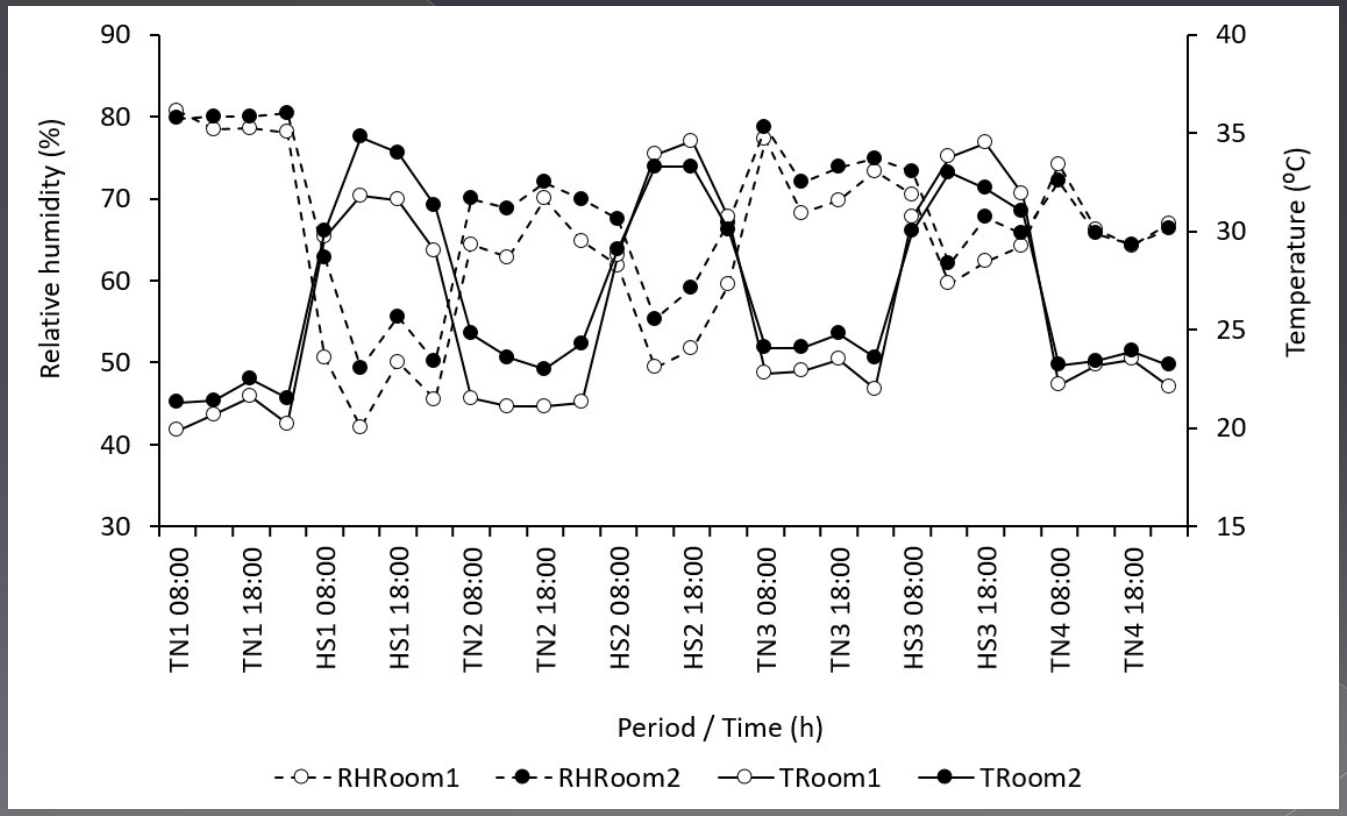
Effects of Diet and Genetics on Growth Performance of Pigs in Response to Repeated Exposure to Heat Stress

Wendy M. Rauw[1,2*], E. Johana Mayorga[2], Soi Meng Lei[2], Jack C. M. Dekkers[2], John F. Patience[2], Nicholas K. Gabler[2], Steven M. Lonergan[2] and Lance H. Baumgard[2]

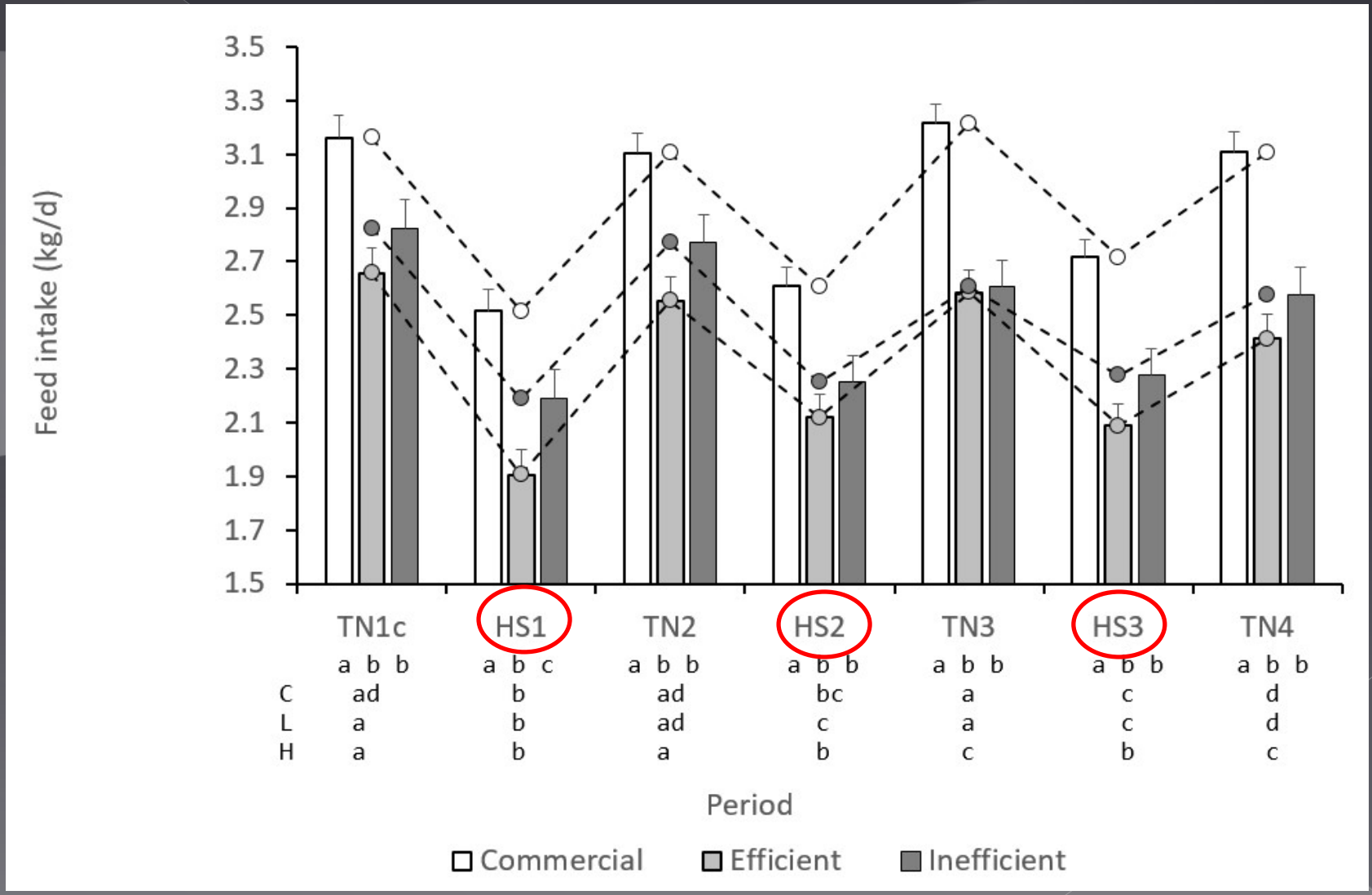
[1] Departamento de Mejora Genética Animal, Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria, Madrid, Spain, [2] Department of Animal Science, Iowa State University, Ames, IA, United States

Improved robustness: heat stress

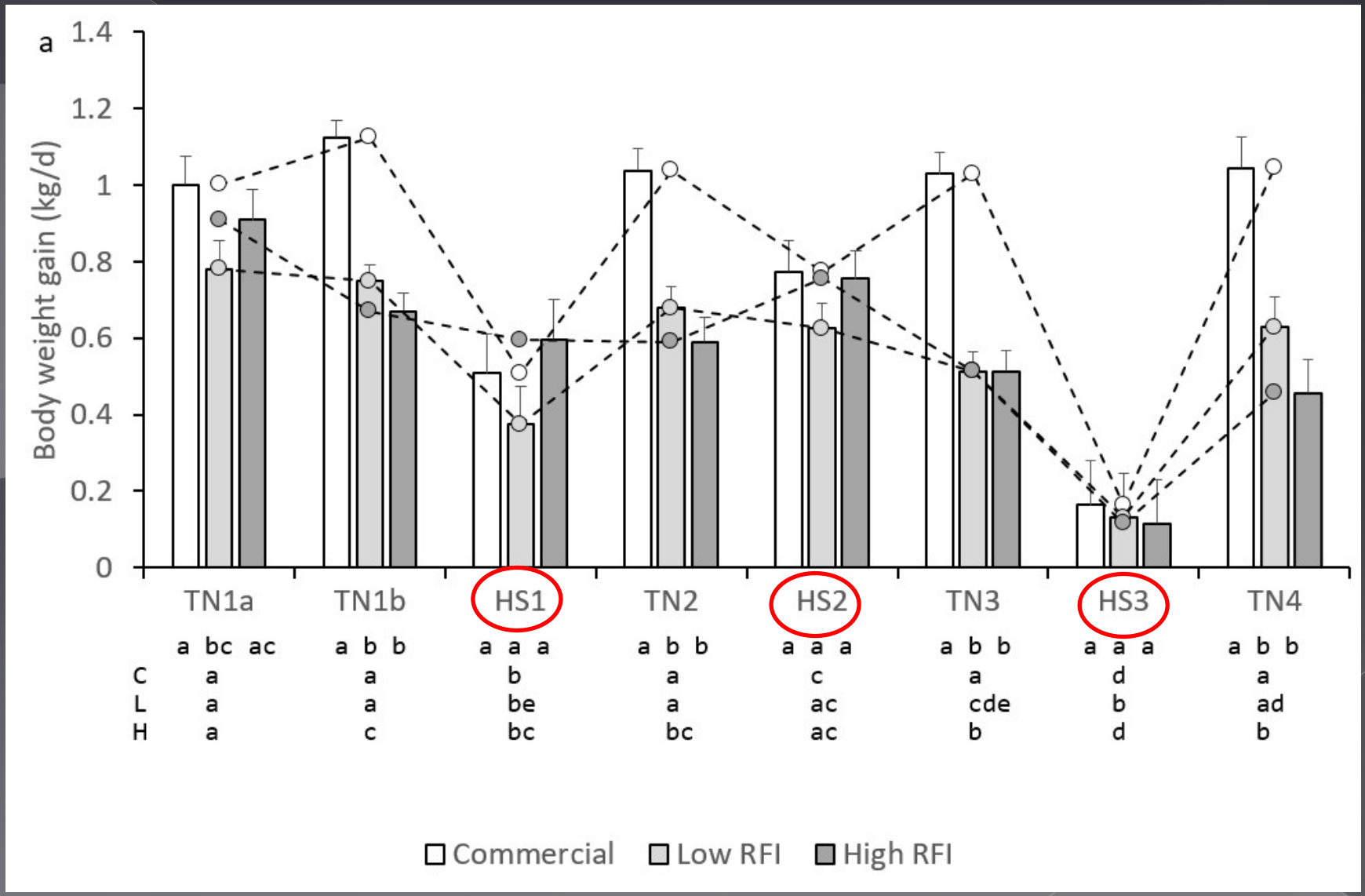
Periods: TN1, HS1, TN2, HS2, TN3, HS3, TN4



Improved robustness: heat stress



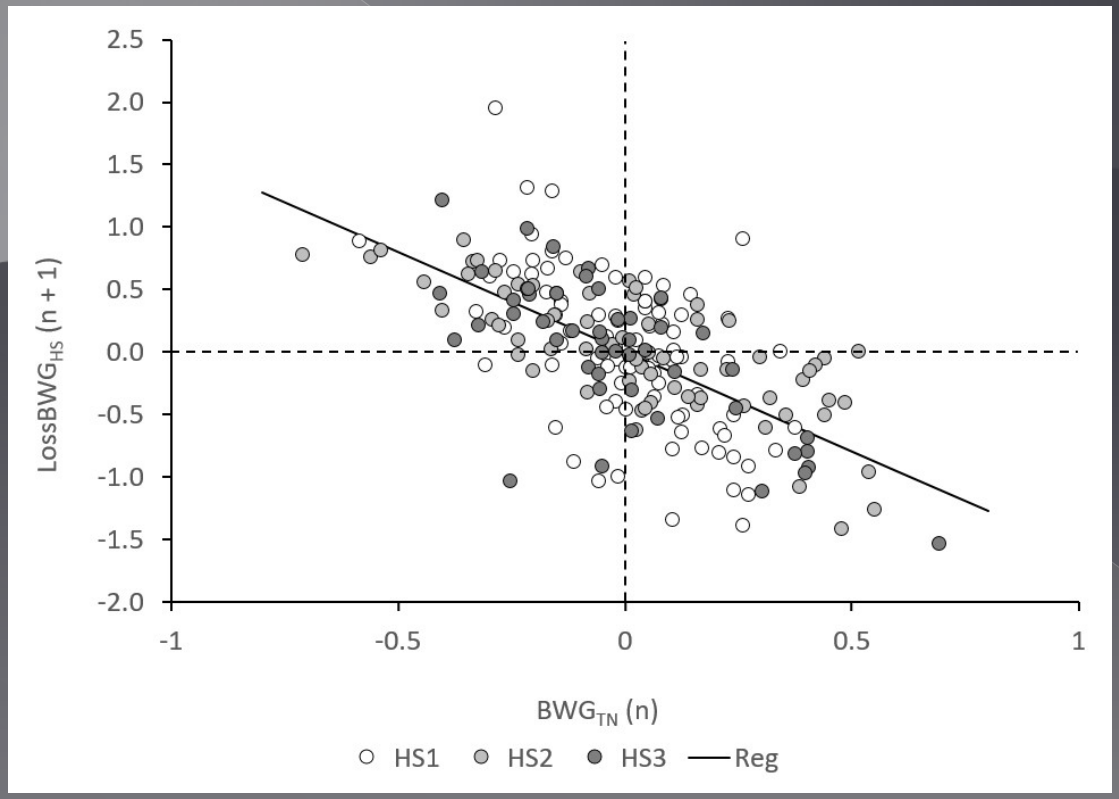
Improved robustness: heat stress



Improved robustness: heat stress

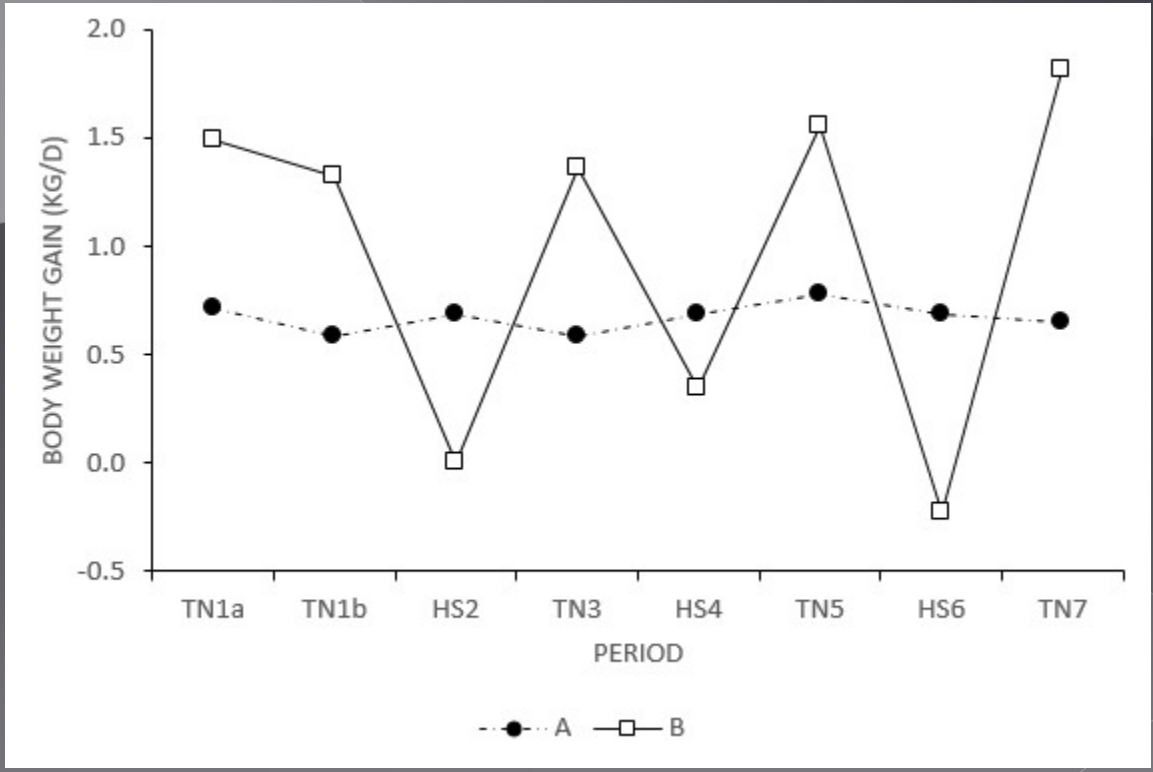
Higher BWG in period n = larger loss in n + 1

r = -0.65 (P < 0.0001)



IMPROVED ROBUSTNESS: HEAT STRESS

- Higher production = lower robustness to HS



IMPROVED ROBUSTNESS: LOCAL FEEDS

Heavy dependency of soybean imports

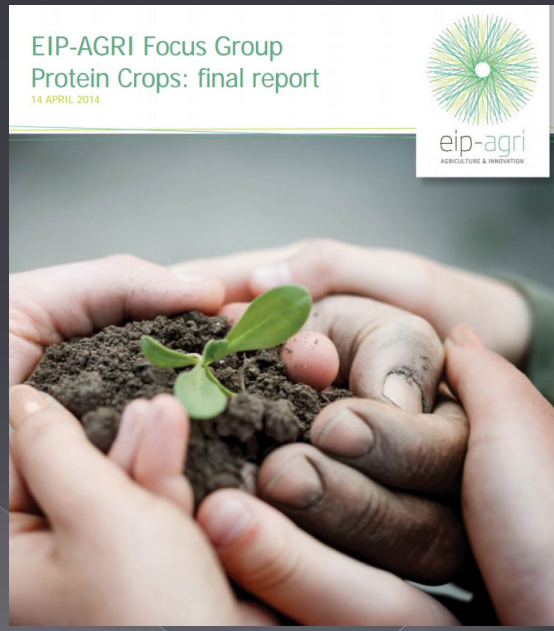
☞ Motion for a European parliament resolution (2011)

EXPLANATORY STATEMENT

The EU protein crop deficit

A recent study published by the European Commission* on the protein crop sector reveals a remarkable decrease in protein crop production in the European Union in the past ten years. The main dried pulses excluding soybeans decreased by 30%, and soybean production by 12%. This trend increases an already existing alarming dependence of the Union on the imports of protein crops, which are mainly used for animal feed and carries major risks especially for the EU livestock sector, as price volatility on international markets has substantially increased. *(LMC international report).

Overall EU protein crop production currently only occupies 3% of the Union's arable land (excluding fruit and vegetables). In spite of public support for the sector since 1978, production of dried pulses, which temporarily increased during the 1980s, has again decreased to roughly one million ha in 2008. More than 40 million tonnes of crop proteins, mainly soy beans and corn gluten feed are imported annually, representing 80% of the EU's crop protein consumption. In terms of land use abroad for crop protein imports into the EU, this represents ten per cent of the EU's arable land, or 20 million ha.



Focus Group on Protein Crops (2013):

"Have a long way to go before being competitive"

→ innovation agronomy and breeding

Improved robustness: local feeds

Resource allocation: output ☜ inputs

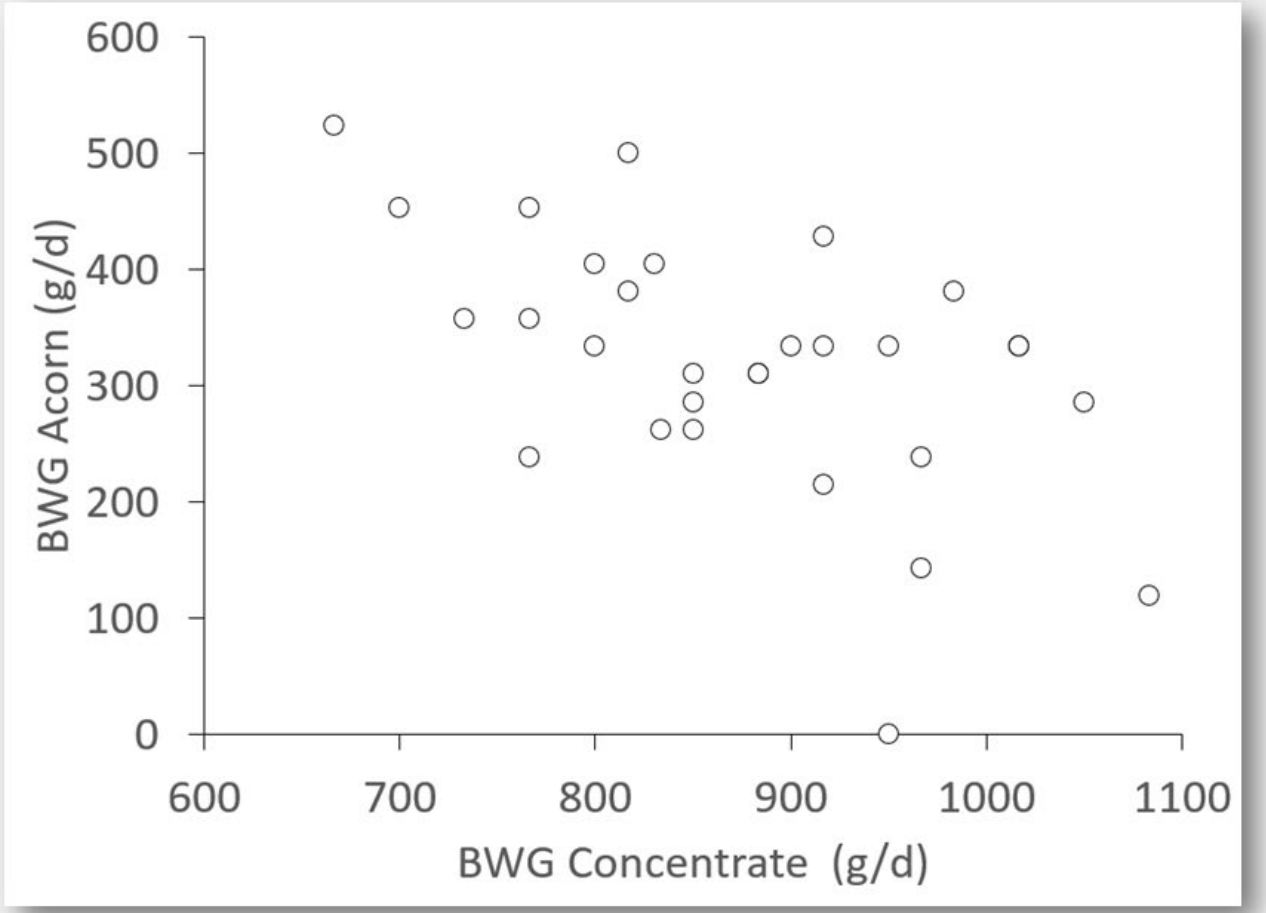
R (Total) = R (Maintenance) + R (Production) +
R (Reproduction) + R (Rest)

Local feeds & feedstuff co-products = *suboptimal* quality

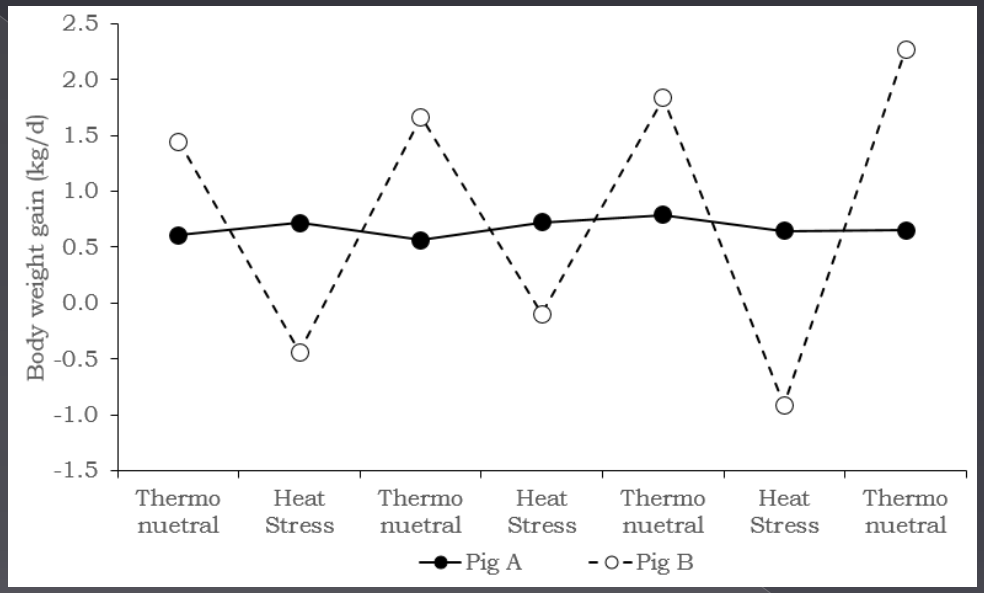
☜ Feed efficiency cannot be sustained on high fiber

Improved robustness: local feeds

Improved robustness: local feeds



Improved robustness: local feeds



Literature: production ⇧ = environmental sensitivity ⇩

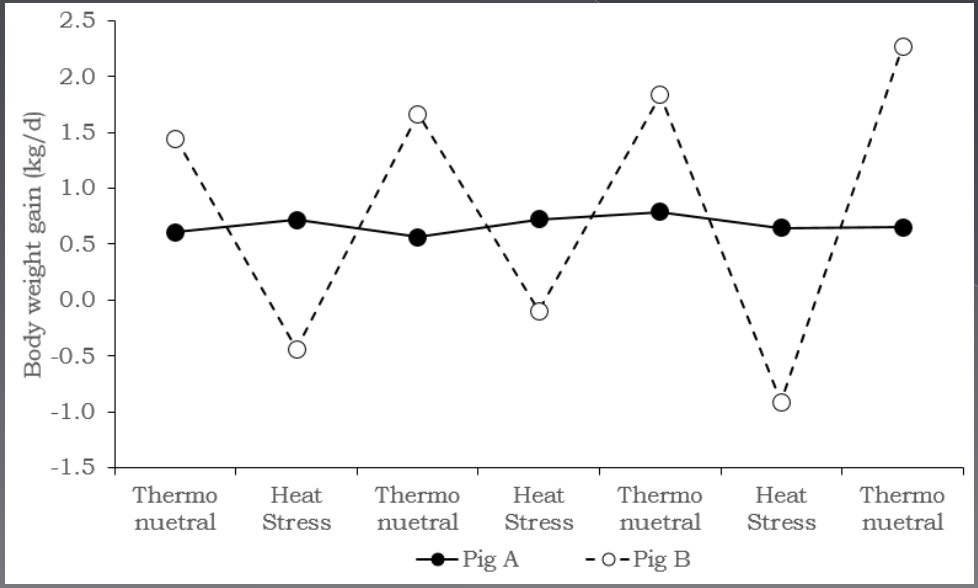
☞ May require a different type of animal than in high-input high-output production systems

1. Sustainability of livestock systems
2. Livestock intensification (optimal farming)
3. Improved animal robustness (suboptimal farming)
4. Prospects for sustainable livestock production

Prospects for sustainable livestock production

Two scenarios:

1. Livestock intensification (optimal farming)
2. Improved animal robustness (suboptimal farming)



Prospects for sustainable livestock production

Optimal farming ☞ efficiency ⇧, production ⇧, costs ⇩

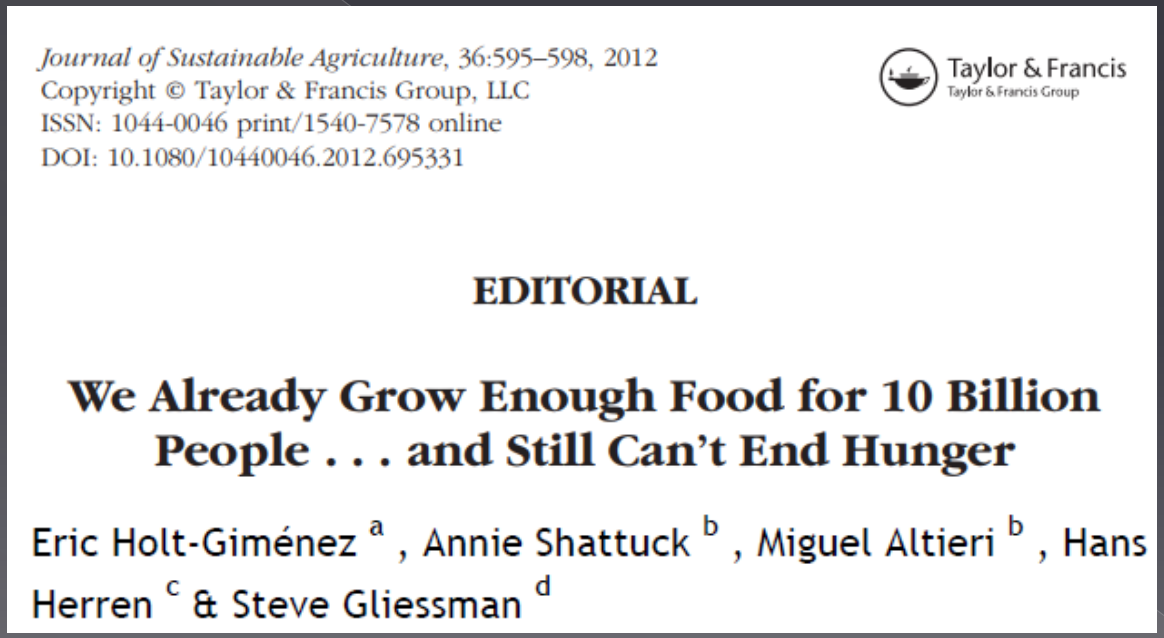
Suboptimal farming ☞ efficiency ⇩, production ⇩, costs ⇧

☞ Can suboptimal farming be viable?

PROSPECTS FOR SUSTAINABLE LIVESTOCK PRODUCTION

Optimal farming ☞ efficiency ⇧, production ⇧, costs ⇩

Suboptimal farming ☞ efficiency ⇩, production ⇩, costs ⇧



Journal of Sustainable Agriculture, 36:595–598, 2012

ISSN: 1044-0046 print/1540-7578 online
DOI: 10.1080/10440046.2012.695331

Taylor & Francis
Taylor & Francis Group

EDITORIAL

We Already Grow Enough Food for 10 Billion People . . . and Still Can't End Hunger

Eric Holt-Giménez [a], Annie Shattuck [b], Miguel Altieri [b], Hans Herren [c] & Steve Gliessman [d]

"Hunger is caused by poverty and inequality, not scarcity"

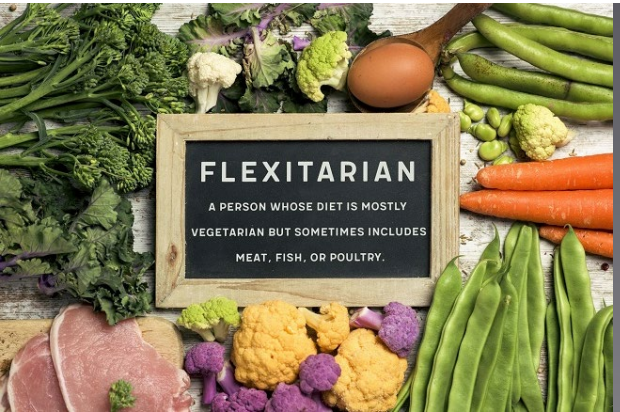
Prospects for sustainable livestock production

Suboptimal farming ☞ efficiency ⇩, production ⇩, costs ⇧

~ 50% of current supply, all vegetarian
☞ Reduction in nitrogen emissions, greenhouse gas emissions, use of cropland for food production, reduction in the use of soymeal

Flexitarian Diets and Health: A Review of the Evidence-Based Literature

*Emma J. Derbyshire**

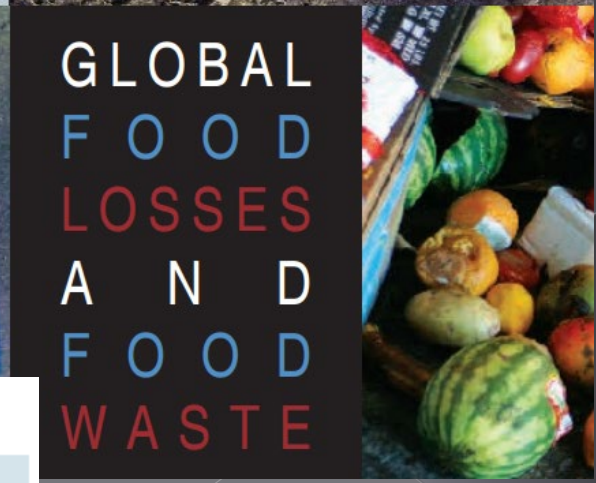


Prospects for sustainable livestock production

Suboptimal farming ☞ efficiency ⇩, production ⇩, costs ⇧

Food waste!

1/3 lost or wasted
- shape, color, size
- best before date
- Restaurants



Target 12.3

By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses.

PROSPECTS FOR SUSTAINABLE LIVESTOCK PRODUCTION

Optimal farming ☞ efficiency ⇧, production ⇧, costs ⇩

Suboptimal farming ☞ efficiency ⇩, production ⇩, costs ⇧

Willingness to pay:
Welfare
Locally produced

Consumer liking and willingness to pay for high welfare animal-based products

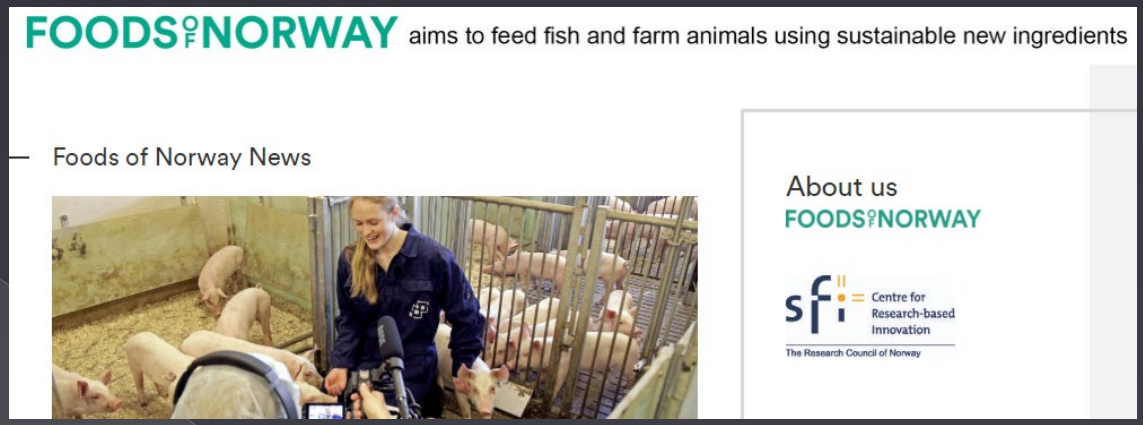
Fabio Napolitano*, Antonio Girolami and Ada Braghieri

Market Potential for Locally Produced Meat Products

Leigh J. Maynard, Kenneth H. Burdine, and A. Lee Meyer

Prospects for sustainable livestock production

Niche market?



spruce trees
algae (yeast, 50-60% P)
rapeseed

Reducing the land use of EU pork production: where there's swill, there's a way

Erasmus K.H.J. zu Ermgassen [a,*], Ben Phalan [a], Rhys E. Green [a,b], Andrew Balmford [a]

[a] Conservation Science Group, Department of Zoology, University of Cambridge, Downing Street, Cambridge CB2 3EJ, UK
[b] RSPB Centre for Conservation Science, Royal Society for the Protection of Birds, The Lodge, Sandy SG19 2DL, UK

Bug business: Cockroaches corralled by the millions in China to crunch waste

Thomas Suen, Ryan Woo

4 MIN READ

JINAN, China (Reuters) - In the near pitch-dark, you can hear them before you see them - millions of cockroaches scuttling and fluttering across stacks of wooden boards as they devour food scraps by the tonne in a novel form of urban waste disposal.

Insect producers must conform with the same general rules that apply to operators in other sectors

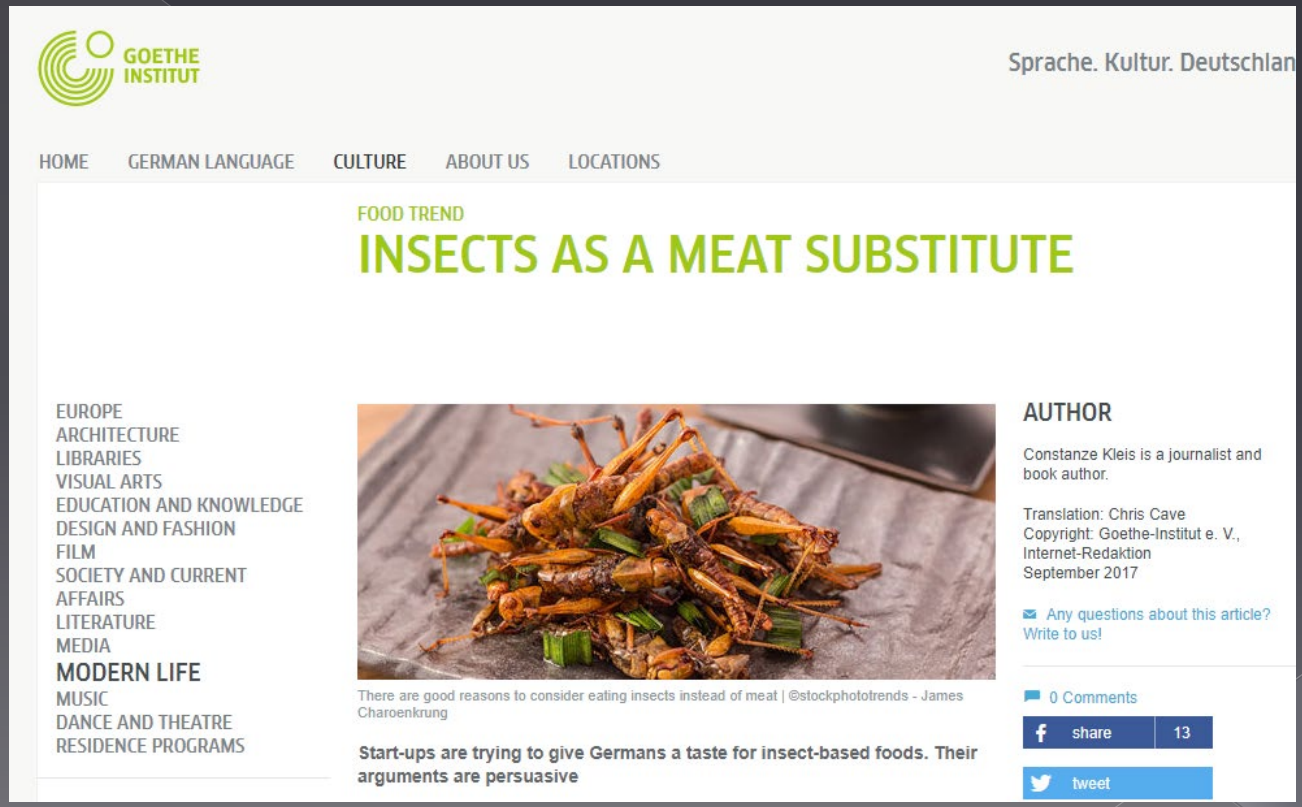
Animal by-products for feed: characteristics, European regulatory framework, and potential impacts on human and animal health and the environment

D. Jędrejek[1,4], J. Levic[2], J. Wallace[3] and W. Oleszek[1]

Slaughtered animal	Edible = human consumption, %	Inedible = by-product, %
Chicken	68	32
Pig	62	38
Cattle	54	46
Sheep/Goat	52	48

Prospects for sustainable livestock production

Meat alternatives: lower requirements for land & water, lower greenhouse gas emissions (plant-based, lab-grown, insects)

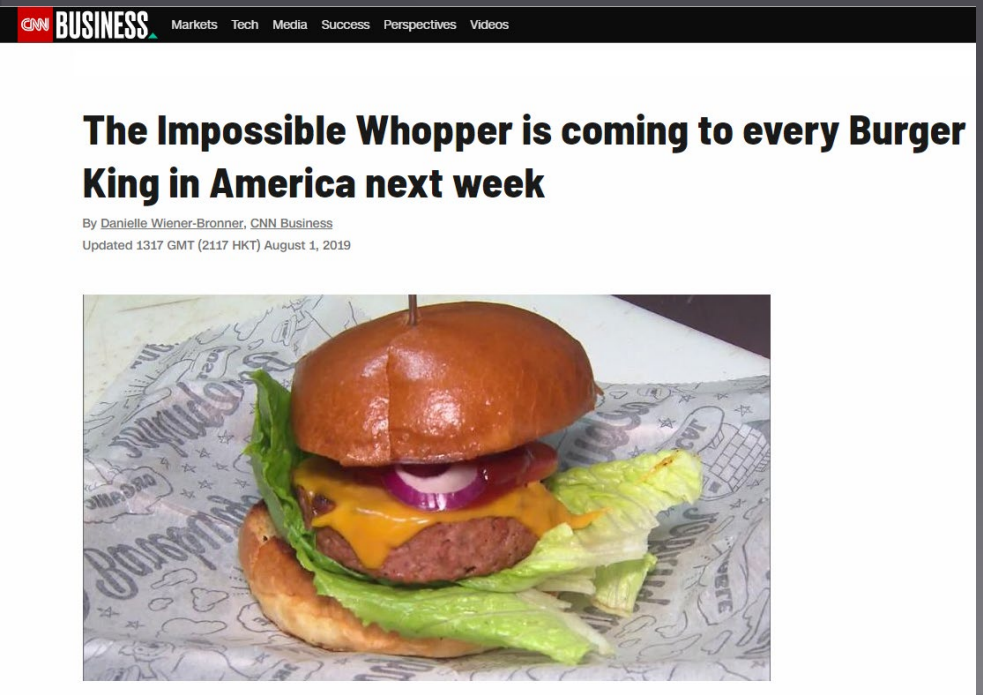


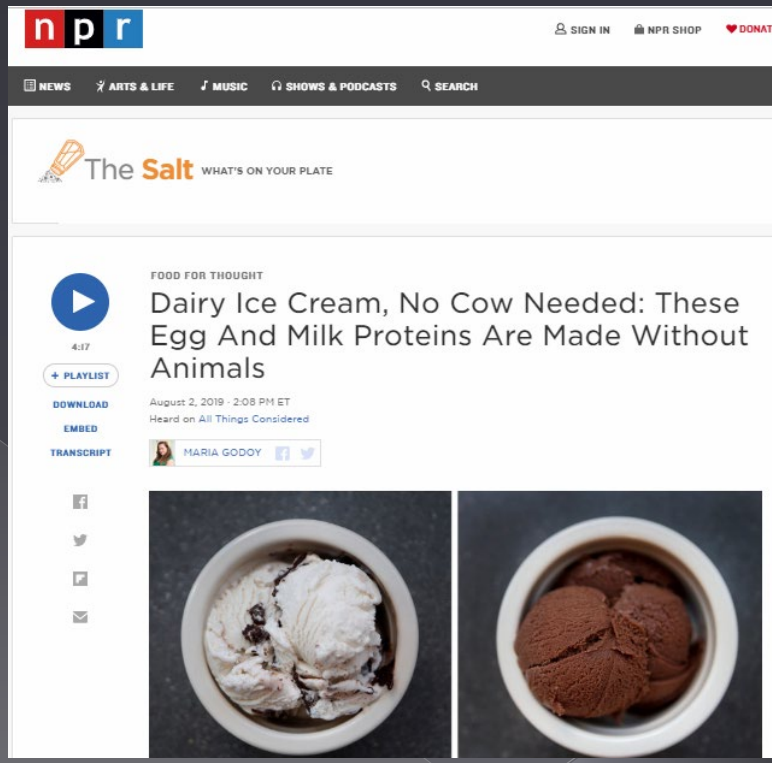
Prospects for sustainable livestock production

Fast food industry = major catalyst for cheap meat products

⇩

Alternatives

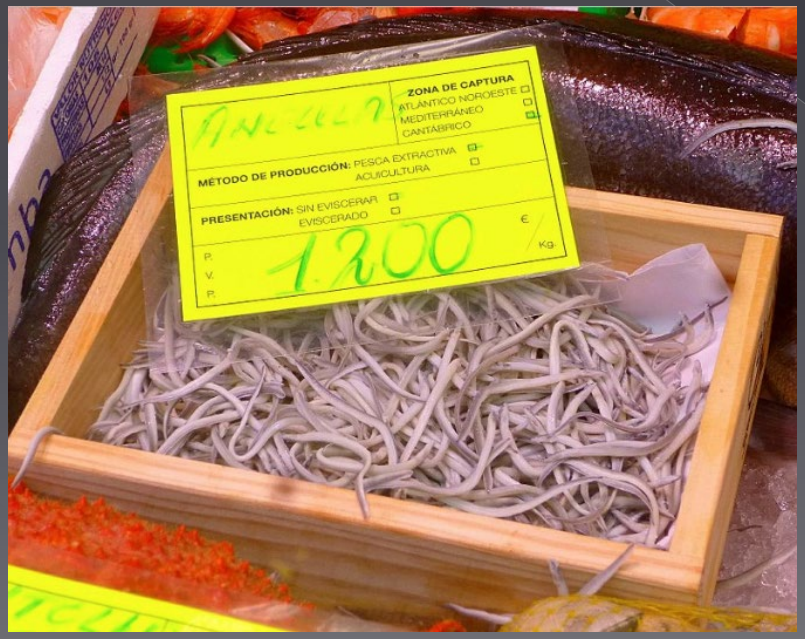




PROSPECTS FOR SUSTAINABLE LIVESTOCK PRODUCTION

☞ Added premium price for livestock animal proteins

= cover cost for welfare and suboptimal production systems



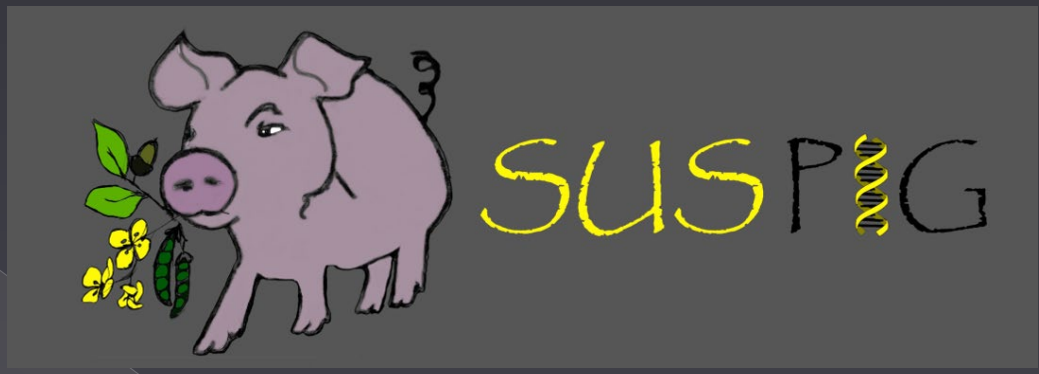
≠

Acknowledgements

ERA-NET SUSAN
EUROPEAN RESEARCH AREA ON SUSTAINABLE ANIMAL PRODUCTION

Project goals of ERA-NET SusPig

- Evaluate if improved **feed efficiency (FE)** can be sustained with **climate change** and with more reliance on **local feed resources** and feedstuff co-products.
- Evaluate **environmental, social and economic impacts** of this strategy.
- Design **new pig production systems** with regard to environmental and social aspects and their tradeoffs.



Scan me

WWW.SUSPIG-ERA.NET

Project Partners

Wendy Rauw, INIA, Spain
Lotta Rydhmer, SLU, Sweden
Ilias Kyriazakis, Newcastle University, UK
Margareth Øverland, NMBU, Norway
Hélène Gilbert, INRA, France
Jack Dekkers, Iowa State University, USA
Susanne Hermesch, University of New England, Australia
Alban Bouquet, IFIP, France
Emilio Gómez Izquierdo, ITACYL, Spain

Thanks!

rauw.wendy@inia.es