

Sustainability challenges in animal breeding

or:

20 minutes for a six-hour talk

Pieter Knap

Sustainability: the three Ps

1. Profit

2. People

3. Planet

**Sustainable production
leaves these three
undamaged**



1. Profit

2. People

3. Planet

4. Pigs & Poultry

**Sustainable animal production
leaves these four undamaged**

How does animal breeding influence...

1. Profit
2. People
3. Planet
4. Pigs & Poultry

?

How does animal breeding influence Profit ?

- **Selection index theory maximizes the economic value of the selection response.**
- **Since 1943 (Hazel).**

How does animal breeding influence People ?

- **Social justice:**
 - **Biopiracy**

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Monsanto battles biopiracy claims

The Andhra Pradesh Biodiversity Board is seeking royalty payments from Monsanto India Ltd for genetic information it alleges was 'stolen' from Bt bacteria found in the soils of Mahanandi village in Kurnool district

Lison Joseph and C.R. Sukumar

Hyderabad: India is asking the local arm of multinational Monsanto Co. to pay a royalty for genetic information that forms the basis of a genetically modified seed sold by the firm here because it believes this information is that of a bacteria found in Andhra Pradesh.

The Andhra Pradesh Biodiversity Board, a statutory body set up by the Union government under the Biological Diversity Act, 2002, is seeking royalty payments from Monsanto India Ltd for genetic information it alleges was "stolen" from *Bacillus thuringiensis* (Bt) bacteria found in the soils of Mahanandi village in Kurnool district.

This bacteria strain, claims the board, was then used in developing Monsanto's genetically modified, bollworm-resistant Bt cotton seeds sold in India.

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Case study

- Introgression of Taihu breeds into western pig genotypes



Knap & Neeteson (2005)

Le type génétique hybride « Naïma »

Descriptif

Plan de croisement

Effectifs

Répartition géographique

Retour au tableau

Descriptif

Nom	: Naïma
Registre Zootechnique	: PEN AR LAN
Destination	: Truie parentale
Code de type génétique	: PENA3
Statut pour le gène Halothane	: Génotype NN

lignée composite
sino-européenne à
l'étage grand-parental

Jiaxing x Meishan

Laconie

♂ ou ♀
Tia-Meslan
(PETT0)

♀ ou ♂
Caréli
(PECC0)

♂ ou ♀
Gallia
(PEGG0)

♀ ou ♂
Redone
(PERE1)

Naïma
(PENA3)



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Qui sommes-nous ?
Génétique porcine en France

Organisations de sélection
Centre d'IA
Races pures
Hybrides

Tables récapitulatives
Tests et résultats
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Plan(s) de croi:

Aktuell	BHZP-Sau db.CLASSIC
Wir über uns	BHZP-Sau db.NAİMA
db-Züchtung	BHZP-Eber db.77
db-Besamung	BHZP-Eber db.65
db-Software	Was ist ein Hybridschwein?
Produktbegleitung	Zuchtmethode
Service	Leistungsprüfung
Kontakt	Zuchtwertschätzung
AGB Züchtungsz.	Lineare Beurteilung
Impressum	Forschung / Versuche
	Tiergesundheit

BHWP-Sau db.NAİMA

Das BHWP erzeugt eine neue Hybridsau, die ab Februar 2005 unter dem Namen db.NAİMA vermarktet wird. Dazu wird ein hyperfruchtbarer synthetischer Eber des französischen Zuchtunternehmens PEN AR LAN in der BHWP-Sauenvermehrung eingesetzt.



Die db.NAİMA ist eine Kombination aus sehr fruchtbaren sino-europäischen Ebern namens *Redone* und BHWP-Vermehrungssauen. PEN AR LAN züchtet *Redone* seit 1983 und hat in dieser Linie die Stärken von Schweinen chinesischen und europäischen Ursprungs kombiniert. Dabei handelt es sich um eine synthetische Linie, die über 20 Jahre hinweg aus fruchtbarsten Genpools gezüchtet worden ist. Die *Redone* zeichnen sich durch sehr gute Fruchtbarkeits- und

Aufzuchtleistungen aus und sind äußerst robust.

Die db.NAİMA werden ausschließlich in deutschen Vermehrungsbetrieben, die von der Veterinärsgesellschaft betreut und mit umfassendem Gesundheitsmonitoring überwacht werden, erzeugt.

Um marktkonforme Schlachtschweine zu erzeugen, wird empfohlen, die db.NAİMA mit fleischbetonten und gut bemuskelten db-Ebern 77 zu belegen.

Das BHWP bietet mit der stressstabilen db.NAİMA eine neue Perspektive, um die Wirtschaftlichkeit weiter zu verbessern.



Meidam GP Dam Dam Line [▶ click for more information ◀](#)

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Breeding Stock

AC1 Hybrid Parent Gilt - a new generation hybrid pig

The AC1 is the outcome of 40 years of breeding expertise and scientific development. A pig to revolutionise production, this versatile animal offers a range of desirable characteristics with the ability to operate to the highest efficiency in any environment, both in and outdoors.

The ACMC breeding and performance testing programme has developed the AC1. Leading edge genetic technology is used to select the best performing Meidam and Volante dam lines.

From these ACMC has produced the AC1 female with fourteen functioning teats, longevity in production and a docile temperament. "A world leader in applied pig genetic development providing the ultimate in product value."

AC1 - a proven performing female

Scientifically controlled development has created a pig with all the best qualities of the hardy, hyper-prolific breeds. Rigorous testing means no compromise on efficient growth or carcass quality.

Genetic selection has delivered a high quality female. It can be mated with a variety of boars to produce progeny suitable for many markets and capable of meeting stringent contract requirements. ACMC call this the Breeding Hub System.

AC1 - high value, high quality, competitively priced

- Versatile - performs well in all environments in or outdoors
- Prolific - consistently higher numbers born and reared
- Easily managed - docile temperament with superb mothering qualities
- Progeny - can be tailor made using the ACMC Breeding Hub System
- Conformation - fourteen functioning teats, sound and robust
- Longevity - for fuller productive life
- Stress free

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"Indoors or Outdoors"
Parent Gilt

[Indoor photos](#)

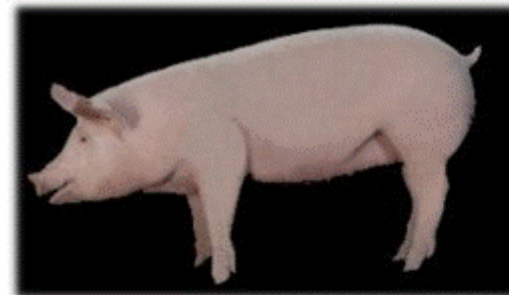
[Outdoor photos](#)

[Click here to view ACMC's
Breeding Hub System](#)

Genex Meishan

The new generation female

(Click image for a larger version)



- ▶ can produce 30+ pigs per sow year
- ▶ produces large litters of healthy, viable piglets
- ▶ combines the best qualities of the Chinese Meishan (prolificacy, mothering ability, docility, teat numbers, early sexual maturity and fertility) with the proven leanness and efficiency of our White Breeds
- ▶ hybrid vigour gives increased longevity



Genex Hybrid

A true F1 female

(Click image for a larger version)

- ▶ this Large White/Landrace cross leads the industry in performance and longevity
- ▶ excellent milking and mothering ability
- ▶ derived from individually tested parents, this has become the standard by which
- ▶ produces fast-growing, feed efficient market hogs with the consistent carass qualities the packing industry demands



ntrogr
n pig

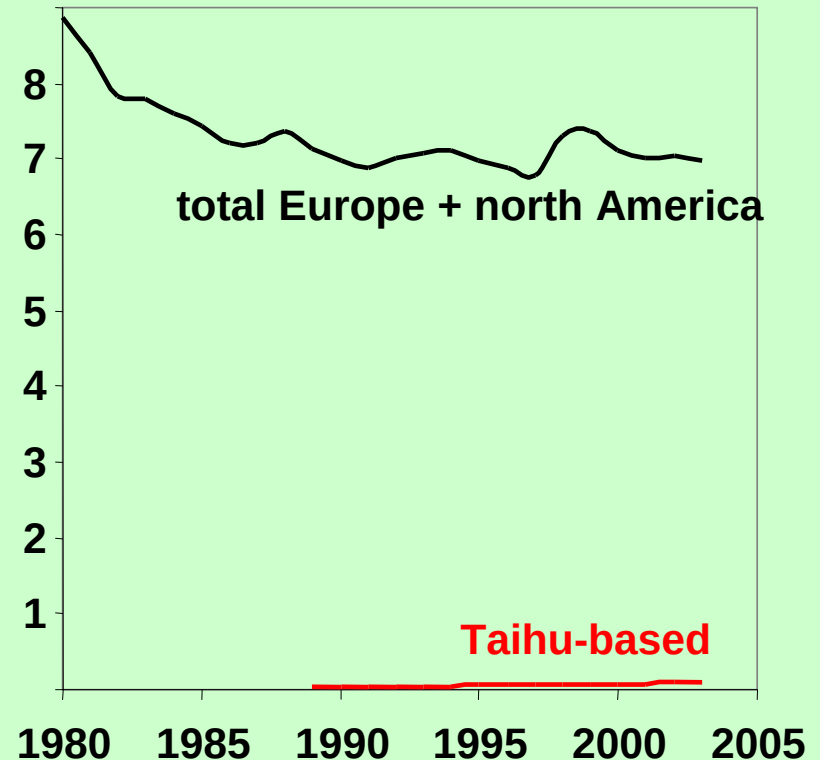
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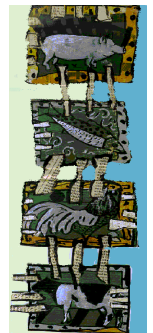
can survive

- 100.000 is less than 1.5 % of the total market volume
- **the winner**: the genotype, not the industry

replacement gilts
(mio per year)



Knap & Neeteson (2005)



How does animal breeding influence People ?

- Social justice:
 - Biopiracy
- Food safety
 - Contamination
 - Composition

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Press Info item. 27/10/2006

Breeding of salmonella-resistant chickens



More than half of all outbreaks of collective foodborne infections (CFI) in France are caused by salmonella: they very frequently result from the consumption of poultry products. Eradication of this micro-organism

to ensure food safety is thus a priority for the poultry industry, notably in laying hens. To facilitate these efforts, researchers in the INRA centres in Tours and Toulouse have, in partnership with the AFSSA, developed several approaches to the breeding of hens which are genetically resistant to salmonella carriage. Current studies aim to demonstrate the feasibility of this genetic breeding technique.

In poultry farms, the detection of chickens infected with salmonella is both costly and difficult. Although some animals may die in the event of severe infection, others are qualified as "healthy carriers", i.e. they harbour salmonella for several weeks without presenting any symptoms of the disease.

The idea of increasing the resistance of animals to salmonella dates from the 1940s: more recently, several resistance genes have been identified. But the breeding of animals based on this trait alone may increase the frequency of healthy carriers and thus the risks of CFI. INRA researchers, working in collaboration with the AFSSA¹, have developed a programme aimed at improving resistance to carriage by strengthening the genetic mechanisms for salmonella elimination.

Salmonella resistance is genetically programmed

To demonstrate the role of genetics, the researchers first of all studied resistance to carriage in several chicken lines. The major differences observed strongly suggested a role for genetics, this hypothesis being reinforced by the heritability value of resistance parameters.

Breeding experiments were then initiated, their aim being three-fold: firstly to demonstrate the feasibility of a genetic improvement in resistance, then to obtain novel genetic material which could be used for research and finally to accumulate the material necessary to test future genetic markers. The results obtained demonstrated that breeding for

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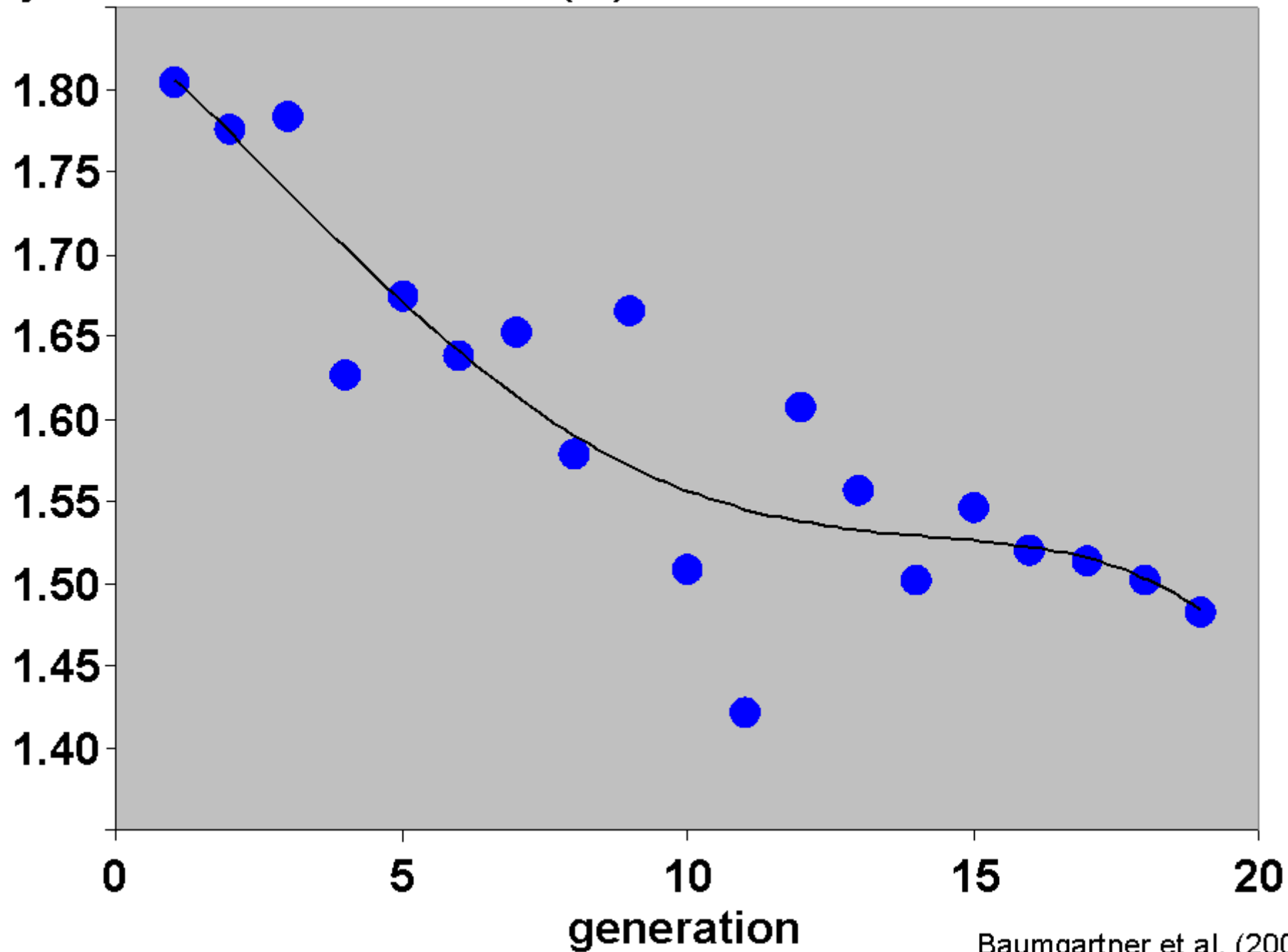


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Changes in egg quality traits associated with long-term selection for lower yolk cholesterol content in Japanese quail

J. BAUMGARTNER¹, Z. KONČEKOVÁ¹, J. BENKOVÁ¹, D. PEŠKOVIČOVÁ¹,
J. SIMENOVOVÁ², J. CSUKA¹

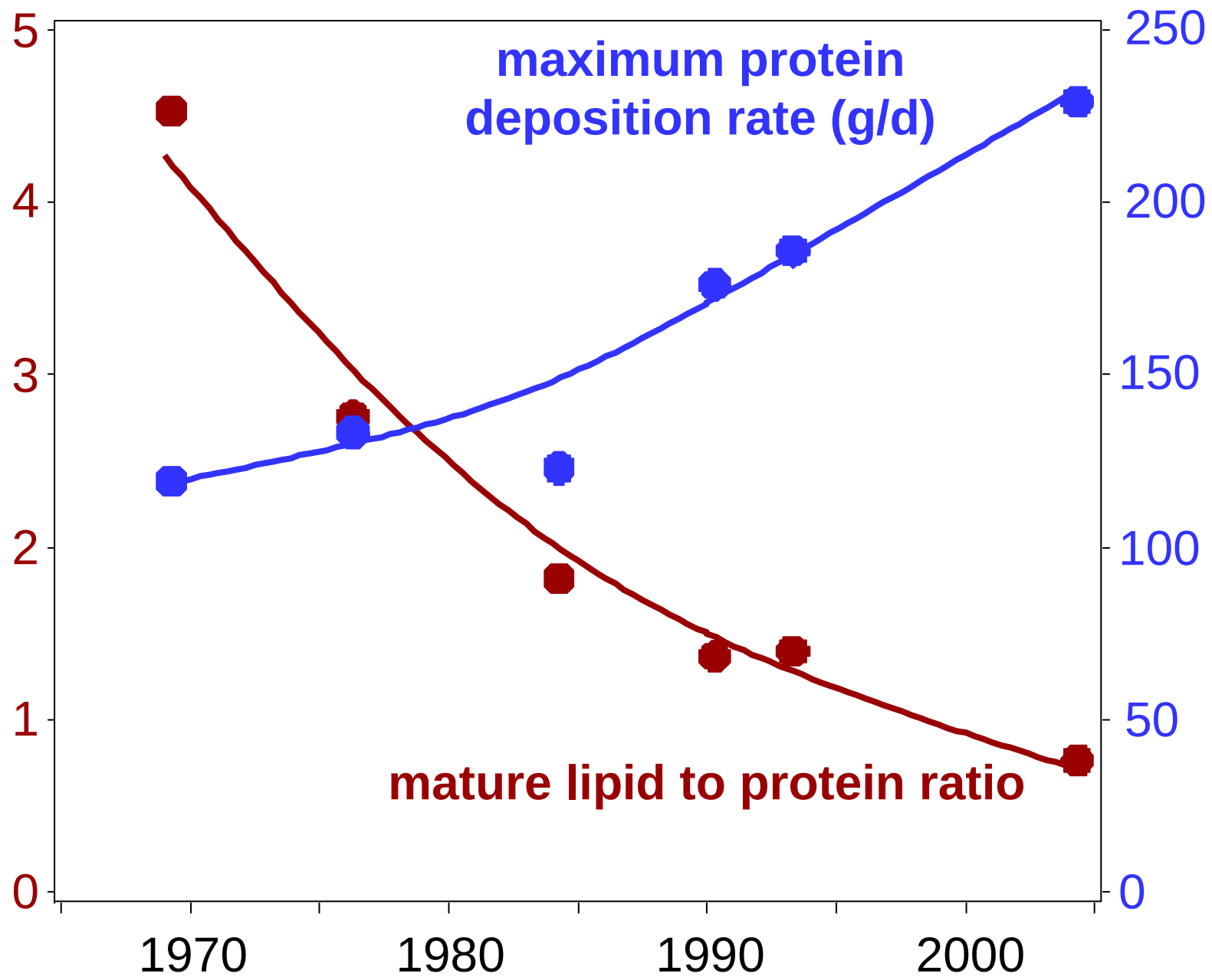
yolk cholesterol content (%)



Baumgartner et al. (2008)

How does animal breeding influence the Planet ?

- **Pollution**
- **Biodiversity**

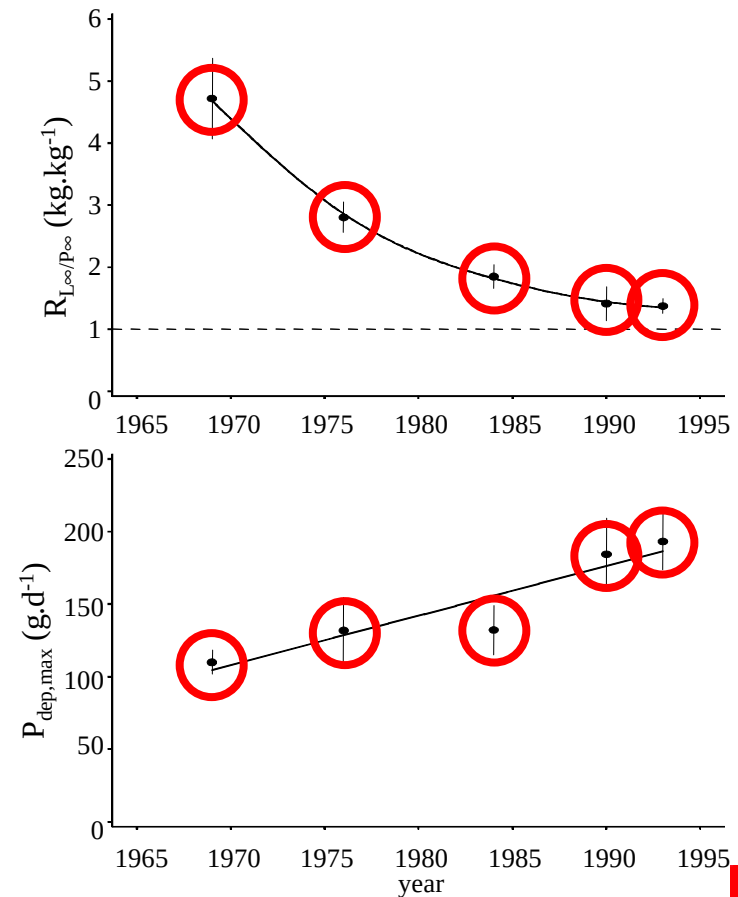


Simulation: cumulative nitrogen excretion

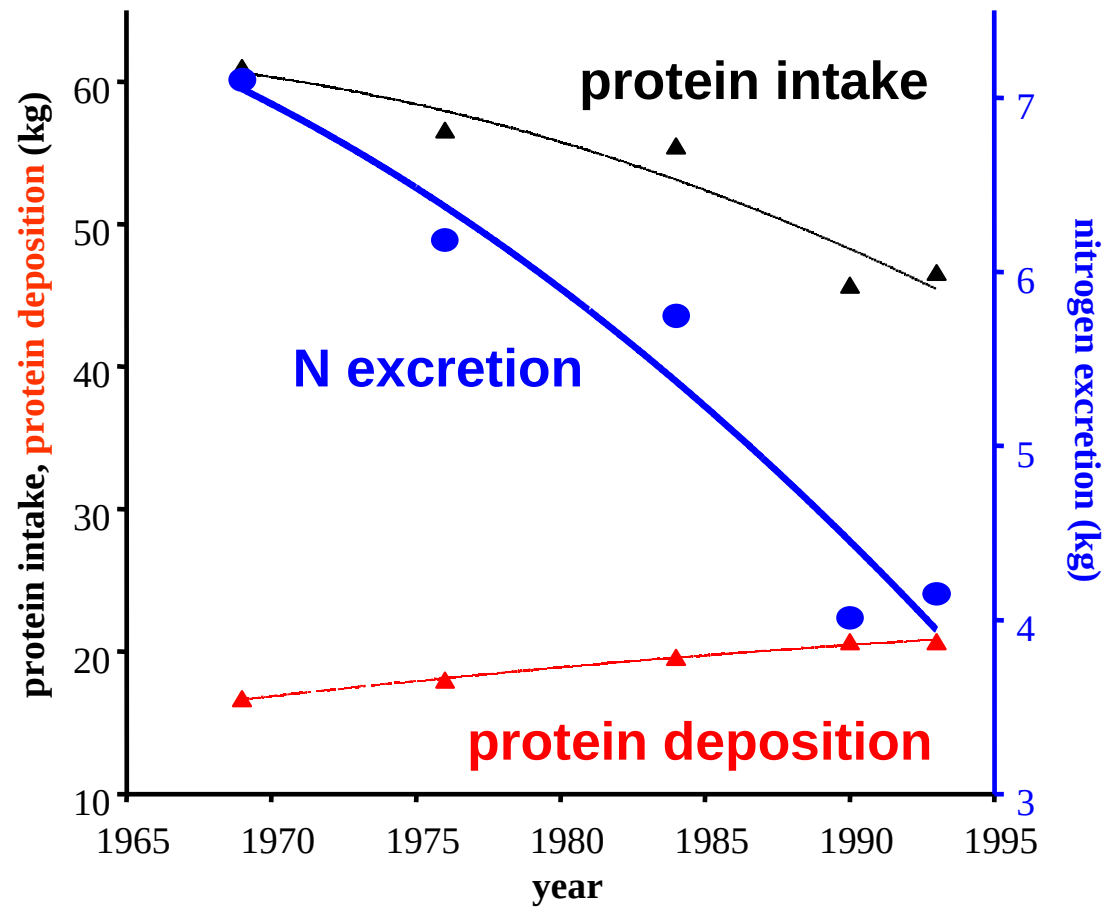
growing pig
20 - 120 kg BW

13.3 MJ DE/kg
17.8 - 19.8 % CP

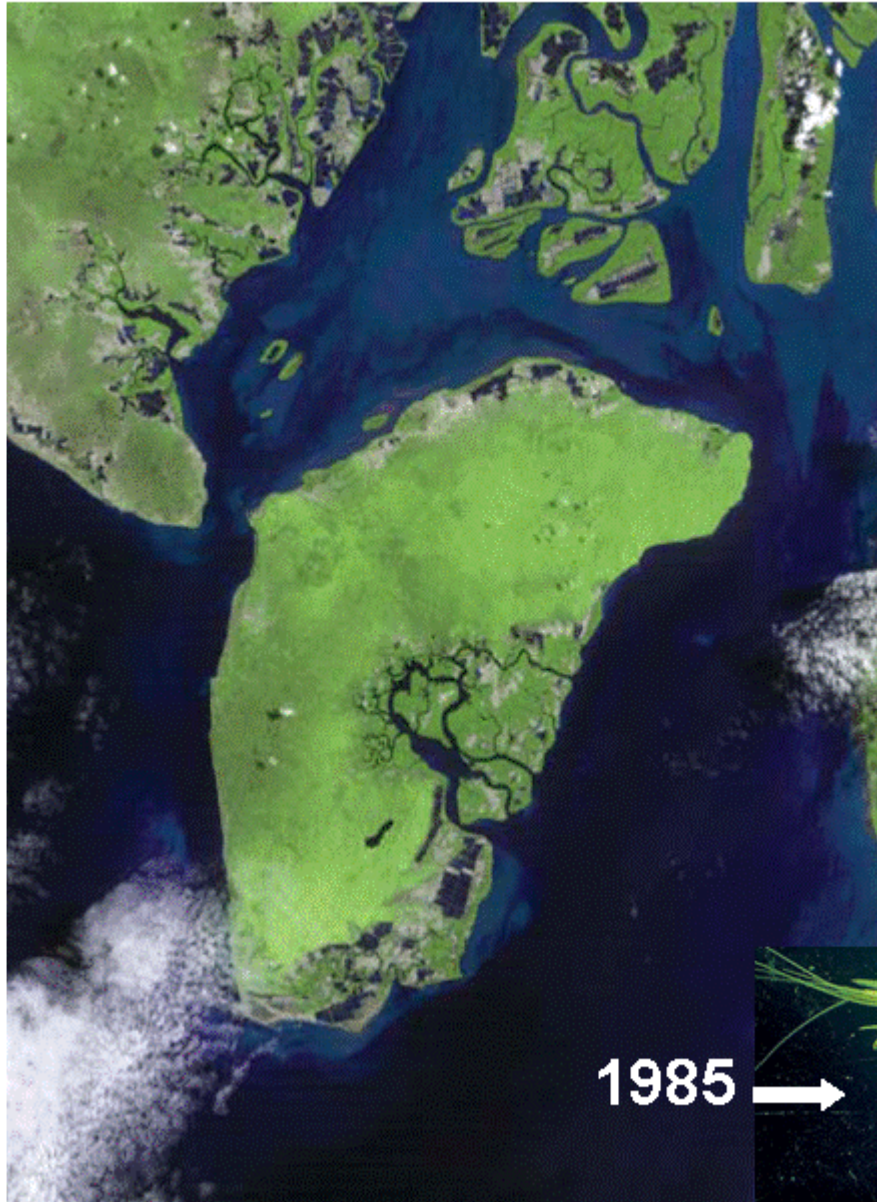
5 scenarios (1969-1993)
for genetic
growth potential



Knap et al. (2003)



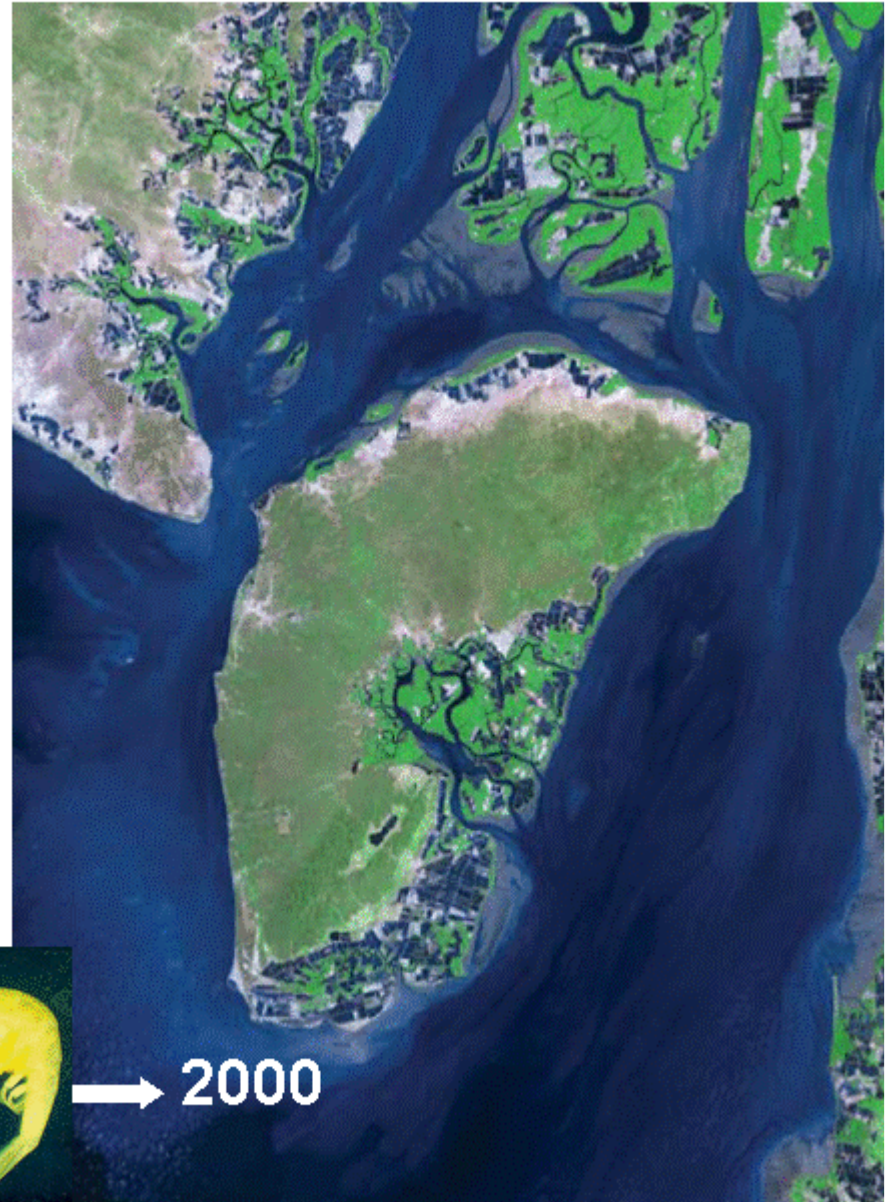
- **Genetic improvement of growth rate and body composition leads to reduction of N excretion**
 - **Genetic improvement of feed efficiency adds to that**
 - **But the main focus must be on cleaner production systems**
- **How do we design genotypes for these ?**



1985



2000







Departments/Areas

- ▶ Homepage
- ▶ Fisheries and Environmental Science
- ▶ Shrimp Department
- ▶ Aquatic Feeds and Nutrition Department
- ▶ Finfish Department
- ▶ Center for Tropical and Subtropical Aquaculture (CTSA)
- ▶ Aquaculture Interchange Program (AIP)
- ▶ Shrimp Consortium
- ▶ Publications

Related Links

- ▶ U.S. Marine Shrimp Farming Program
- ▶ ATP Research
- ▶ NRI Research

National Institute of Standards and Technology Advanced Technology Program (NIST-ATP)

U.S. consumers represent the largest shrimp market in the world, and consumer demand continues to grow significantly each year. From 1998 to 2002, shrimp consumption in the U.S. grew an estimated 25 percent, and per capita consumption reached a record 3.7 pounds in 2002, up from 3.4 pounds in 2001. Despite this incredible demand, domestic production of shrimp is low, resulting in a \$3 billion federal trade deficit in shrimp products. Increasing the domestic supply of wild-caught shrimp is an unlikely solution, due to high cost and over fishing.

Although U.S. production of shrimp from aquaculture increased from an estimated 10 million pounds in 2001 to 12 million pounds in 2002, this represents a meager amount relative to the U.S. demand for shrimp products and total world production of cultured shrimp.

If a significant increase in domestic shrimp production from aquaculture does not occur, the U.S. shrimp supply will remain under foreign control, with an ever increasing trade imbalance and inferior products for the American consumer. In light of the significant demand for shrimp products in the U.S. and a limited domestic supply, a tremendous opportunity exists for the expansion of a U.S. shrimp aquaculture industry. For this to occur, critical research is needed to develop new and viable alternatives to traditional shrimp farming.

With funding from the U.S. Department of Commerce, the National Institute of Standards and Technology's Advanced Technology Program (NIST-ATP) awarded funds to a joint-venture team to develop technologies that will benefit the U.S. shrimp farming industry.

The joint-venture team consists of researchers from the OI, as well as [Zeigler Brothers, Inc. \(ZBI\)](#), and the [Kahuku Shrimp Company \(KSC\)](#).

The goal of the project is to develop an economically viable, environmentally sustainable system for shrimp production that would prevent the introduction of pathogens into the culture environment, and simultaneously mitigate negative environmental effects typically associated with traditional shrimp farming.

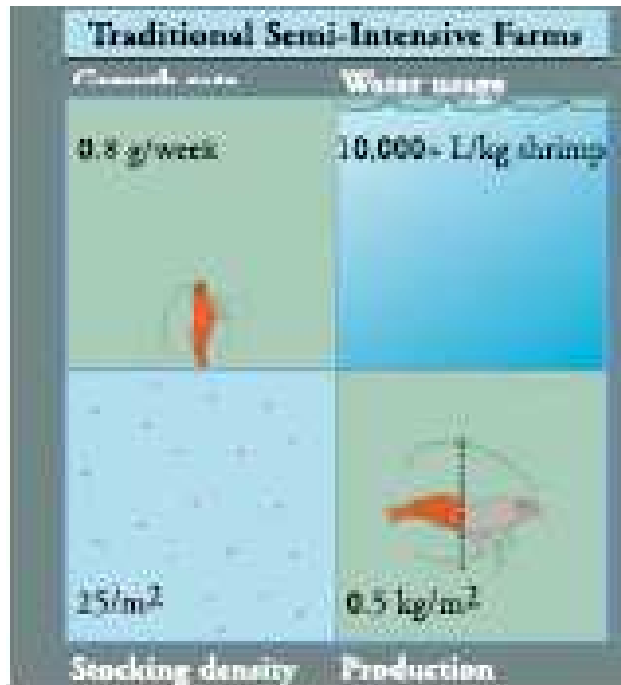
The system would require no water exchange and would allow shrimp production to be moved inland, away from sensitive coastal areas. This gBiosecure Zero-Exchange Shrimp Technology (BioZEST) system will pave the way for the expansion of a domestic shrimp aquaculture industry by providing an alternative approach to grow high-quality, disease-free shrimp in an environmentally safe and profitable manner.

Research on the BioZEST system focuses on four interrelated areas, including:

- Specific pathogen free (SPF), genetically improved shrimp
- A consortium of microorganisms that supports rapid shrimp growth, maintains acceptable water quality.

An aerial photograph of the Oceanic Institute facility. The facility is situated on a steep, arid hillside overlooking a coastline. It includes several large, rectangular swimming pools, numerous smaller pools, and several large, circular black water storage tanks. A paved road runs along the edge of the property, separating it from the ocean. In the background, a small pier extends into the turquoise water. The text "2001 ANNUAL REPORT Oceanic Institute" is overlaid in white on the right side of the image.

2001 ANNUAL REPORT
Oceanic Institute



BioZEST: Biosecure Zero-Exchange Shrimp Technology



Biosecure Zero Exchange System



- **High stocking density**
- **Inland locations →
low water salinity**

GxE interactions

Environmental sensitivity

Aquaculture America 2006 - Meeting Abstract

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THE CONTRIBUTION OF GENETICS TO BioZEST DEVELOPMENT

Hein van der Steen*, John Rocha, Donghuo Jiang, Daniel Ciobanu, Shaun Moss

SyAqua, P.O. Box 348, 3033 Nashville Road, Franklin, KY 42135, USA

Breeding shrimp for BioZEST involves the application of principles of genetics and the use of relevant information from carefully designed experiments. Currently, most focus in shrimp breeding is on improving traits such as growth and survival rates. BioZEST is based on the concept that diseases such as TSV can be excluded through the use of SPF stock and the implementation of adequate biosecurity protocols. A high health state-of-the-art GN is now under construction in bio-secure, land-locked Kentucky, and is expected to be completed and in operation next year.

Figure-1 illustrates the genetic progress that has been accomplished for shrimp biomass harvested in three shrimp lines that are bred by **SyAqua** in the context of the ATP BioZEST project. Biomass harvested is the real trait of interest for farmers, since it combines harvest weight and survival, and it is expressed here as grams of shrimp harvested/shrimp stocked.

In the future, other traits will also be subject to routine genetic improvement: traits of interest to other components of the shrimp production chain (processors, retailers and consumers), namely final product yield and quality, shrimp tail %, raw and cooked shrimp meat %, and some shrimp meat quality parameters that may be of interest to consumers, such as % of poly-unsaturated fatty acids (omega-3 and -6), fat content, raw and cooked shrimp color. Feed conversion efficiency will be another trait of interest in the future, as well as more focus on aggression and feed intake behavior. Quantitative genetics research has enabled us to precisely quantify levels of GxE interaction that are present for the different shrimp production traits. Environmental factors such as stocking density, salinity, temperature, diet, water quality, and stress levels have been studied. With this detailed knowledge an effective breeding system can be implemented for continued BioZEST line development. In the future molecular-based approaches relying on the utilization of genetic markers will complement and enhance classical quantitative genetic approaches, and it is expected that rates of genetic improvement per generation will further increase.

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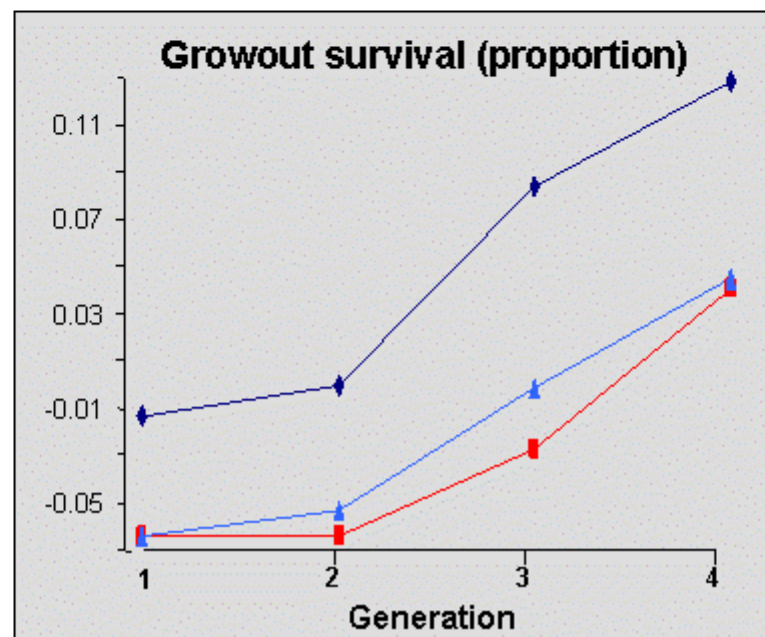
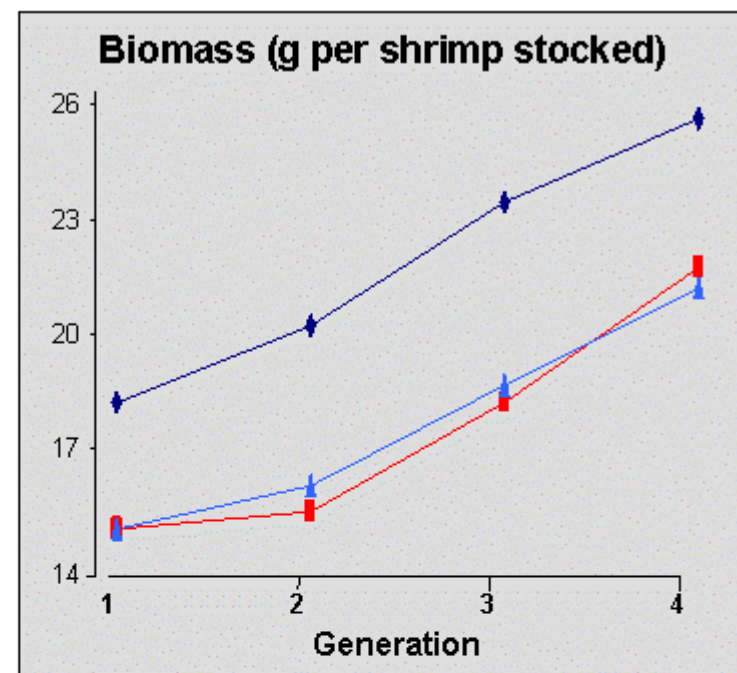
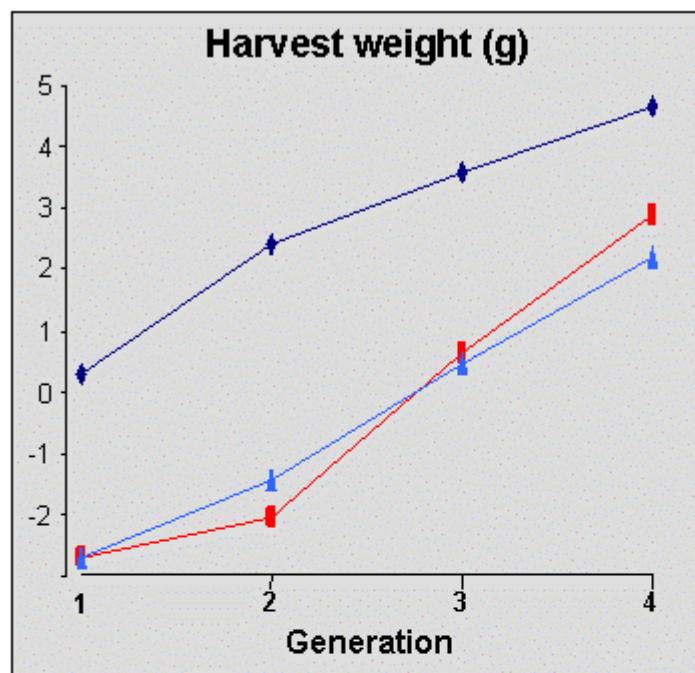
Genotype x Environment Interactions

ADG		ppt		
		2	18	34
ppt	2	0.32	0.71	0.72
	18		0.30	0.96
	34			0.31

SURV		ppt		
		2	18	34
ppt	2	0.09	0.33	-0.08
	18		0.08	0.35
	34			0.04

ADG		shrimp / m ²	
		200	400
shrimp / m ²	200	0.42	0.92
	400		0.48

SURV		shrimp / m ²	
		200	400
shrimp / m ²	200	0.05	0.23
	400		0.09



- **Genetic improvement of growth rate and body composition leads to reduction of N excretion**
 - **Genetic improvement of feed efficiency adds to that**
 - **But the main focus must be on cleaner production systems**
- **We can design genotypes for these**

SEFABAR : Sustainable European Farm Animal Breeding And Reproduction

QLG7-CT-2000-01368

Breeding and genetics : status, challenges, outlook and sustainability issues

Pierrick HAFFRAY⁽¹⁾ and Anne Marie NEETESON ⁽²⁾

(1) SYSAAF, Syndicat des Sélectionneurs Avicoles et Aquacoles Français,
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(2) EFFAB, European Forum for Farm Animal Breeding
www.faip.info



Main conclusions



- The sustainable genetic and reproduction will be Hi-Tech
- There are already ready to apply options
- Need of R&D : methods, new traits, genomic, perception of citizens / sterilisation
- Need to go toward the society → Project of Code of Good Practices supported by EU (FOOD-CT-2003-506506 ; www.sefabar.info/code-efabar/)

How does animal breeding influence Pigs & Poultry ?

- A lot, of course.
- From the point of view of animal welfare:
 - Behavioural patterns
 - Environmental sensitivity

Environmental sensitivity

Robustness

Important for the animal

Important for the farmer

High economic value

Controlling aggression without debeaking

From the previous section, three main points follow:

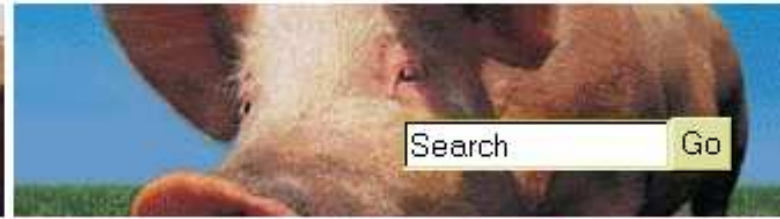
1. It is important to select a strain of bird that is less aggressive, and to continue to breed birds that are more docile. Research has shown that breeding for low aggression can have a marked effect in only 4 or 5 generations (20-21). Dr Mike Gentle, a well-known researcher in this area, has concluded (22): *"In the long term, beak trimming should be phased out and undesirable behaviour controlled by environmental means and by increased effort being devoted to the genetic selection of commercial stocks which do not engage in damaging pecking, either in cages or when floor-housed in large flocks."*
2. Hens must be kept in groups small enough to be able to recognise each other. If they are to be kept in large sheds, the area could be subdivided into several smaller areas by even low partitions to separate one large flock into several smaller sub-groups.
3. Hens must be able to express their natural behaviour, including the strong urge to peck. They must have material in which to forage and dustbathe.

Good husbandry is a major factor in reducing aggression, especially preventing conditions that cause frustration or fearfulness in hens. Thus, in addition to the above, they must also have an adequate and well-balanced diet, easy access to food and water, enough space, and minimum disturbance.

Farmers need to make a much greater effort to control aggression without debeaking. It is completely unacceptable to "solve" a behavioural problem by cutting off part of an animal's body.

References

1. Farm Animal Welfare Council (1991), **Report on the Welfare of Hens in Colony Systems**, Surrey UK
2. Glatz P (1987), "Effects of beak trimming and restraint on heart rate, food intake, body weight and egg production in hens", **British Poultry Science**, vol 28 (601-611)
3. Gentle M, Hughes B & Hubrecht R, (1982) "The effect of beak trimming on food intake, feeding behaviour and body weight in adult hens", **Applied**



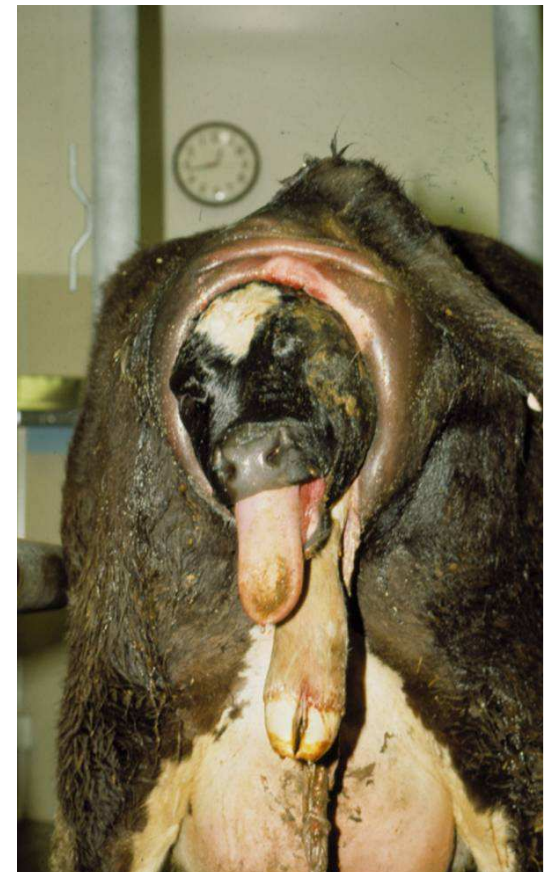
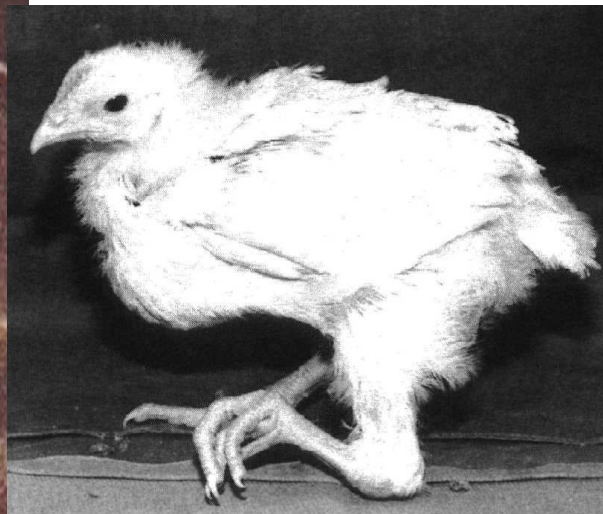
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Educational resources

CIWF holds international conference on animal sentience

"Breeding that predisposes animals to suffering is an abuse of welfare"

John Webster (2005)



"... **to decrease stressability** ... can be regarded as a measure to adapt the animals to ... conditions which otherwise would cause stress ... and therefore **must be seen as detrimental to their welfare**

... the only acceptable way to reduce stress is to provide conditions that will not result in stress"

" [when animal] welfare ... is taken seriously, it is not possible to continue selection that has its focus on more productivity"



GERMAN
ANIMAL WELFARE
FEDERATION

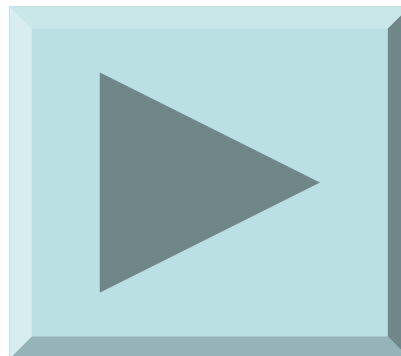


http://www.sefabar.info/member_area/sefabar.asp

Environmental sensitivity

Genetic antagonisms

Production traits versus robustness traits



Environmental sensitivity

Genetic antagonisms

**Production traits versus
robustness traits**

**Antagonisms can be
neutralized by
dedicated selection**

**Antagonisms can be
neutralized by
dedicated selection**

**The main challenge for
professional animal
breeding in the 2010s**

Animal breeding influences...

- 1. Profit**
- 2. People**
- 3. Planet**
- 4. Pigs & Poultry**

**...and there are good
options to do so
in positive ways**

What do we need to make that work?

Data

...as always

Sustainability challenges in animal breeding

or:

20 minutes for a six-hour talk

Pieter Knap