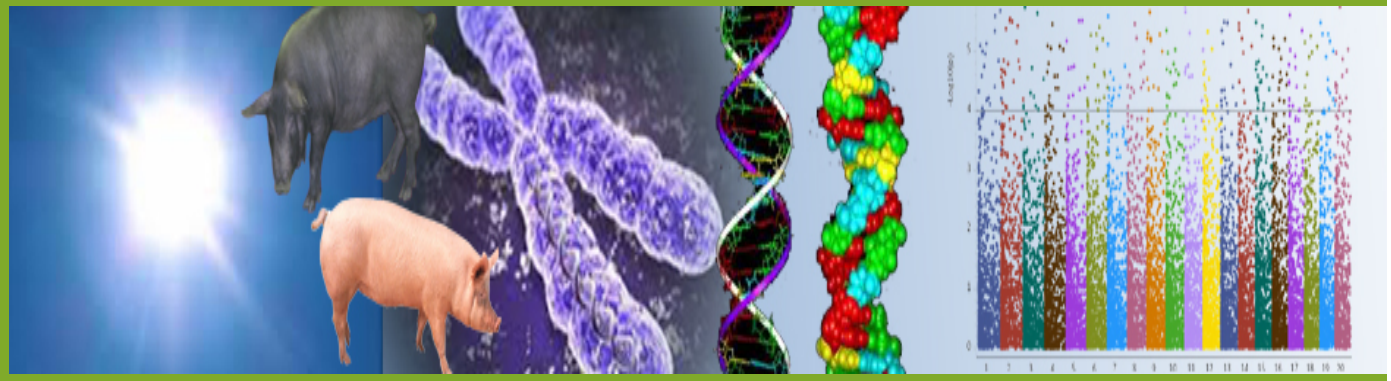

Breeding pigs for heat tolerance: challenges to face

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Breeding pigs for heat tolerance: challenges to face

1. Why considering heat tolerance in breeding pigs?
2. What could be the breeding objectives?
3. How achieving the goal?: traits of interest
4. How achieving the goal?: breeding schemes
5. Conclusion

1/1 Why considering heat tolerance in breeding pigs?

Definitions

Heat resistance: ability to survive to heat stress

Heat tolerance: ability to maintain his production level under thermal stress

Heat stress: we can find three types of heat stress in farming systems

"Long-term": as it occurs in warm climates

"Short-term":

a. during 2-3 summer months in temperate areas

b. during heat waves

1/2 Why considering heat tolerance in breeding pigs?

- **Global pig market:** Pig breeding is an international business

- **Increased pig production in warm climates:** More than 50 % of pig production occurs in warm climates, with predicted faster growth than in temperate areas (FAO, 2006)

- **Increased sensitivity to heat stress of mainstream pig breeds** (see meta-analysis of Renaudeau et *a*l., 2011):
  e.g. USA pig production :economic losses from heat stress : around 300 millions dollars/year (St-Pierre et *al*., 2003)

- **Genetic component of heat tolerance exists:** Between or within breeds or lines (Gourdine et *al*., 2006; Zumbach et *al.,* 2008; Bloemhof et *al*., 2008; Lewis and Bunter, 2011; Bergsma and Hermesch, 2012)

- **Climate change:** the general average temperature is expected to increase with the frequency and the amplitude of heat waves and thus heat stress should be accentuated

(IPCC, 2007; Hoffmann, 2010)

Breeding pigs for heat tolerance: challenges to face

1 Why considering heat tolerance in breeding pigs?

2 What could be the breeding objectives?

2/1 What could be the breeding objectives?

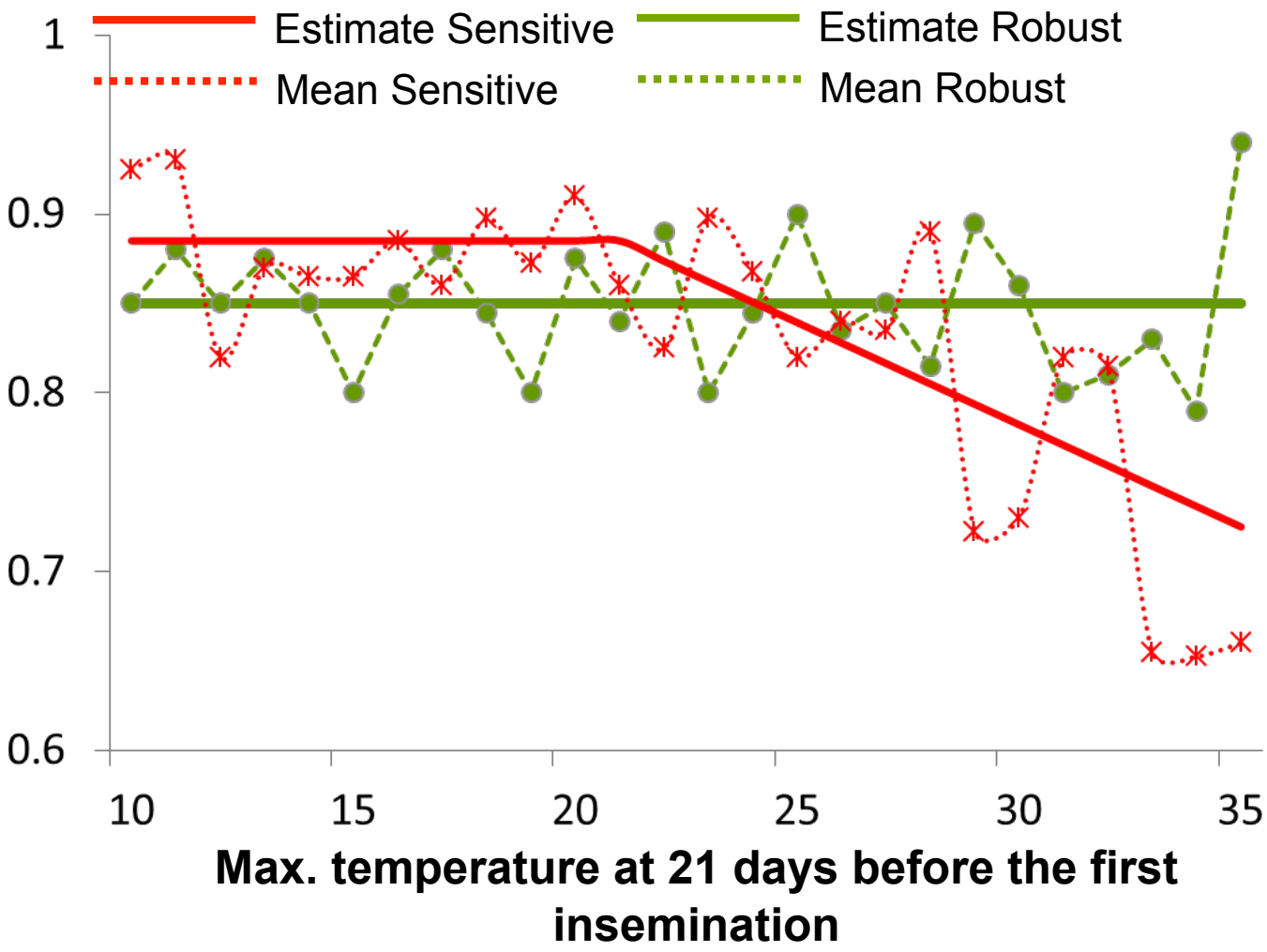
- **Specific genotypes according to the environment of production**

  e.g. Large White and Landrace dam lines selected from tropical data are relatively robust to high temperatures (Lewis and Bunter, 2011; Bloemhoff et *al*., 2012)

- **Robust pigs:** able to perform in most conditions of production (Knap 2005)

2/2 What could be the breeding objectives?

Farrowing rate



Source: adapted from Bloemhof et *al*. (2013)

2/3 What could be the breeding objectives?

Evaluating and taking into account GxE interactions is crucial => several prerequisites

- Accurate standardized phenotypes
- Good knowledge on genetic parameters and correlations between traits of interest according to the heat load
- Sufficient variation in environmental constraints and correct description of environments of production
- Good representation of progeny across environments

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3. How achieving the goal?: traits of interest

- **Using usual performance traits**
- **Using new « phenotypes »:**
  - Thermoregulatory indicators
  - New phenotypes from « omics » tools

3/1 How achieving the goal? traits of interest: usual performance traits

This is the case of most research studies

- Investigation of genetic component of economic important traits as a function of head load

- Use of reaction norm models => h^2 of traits may differ according to the head load: *e.g.*

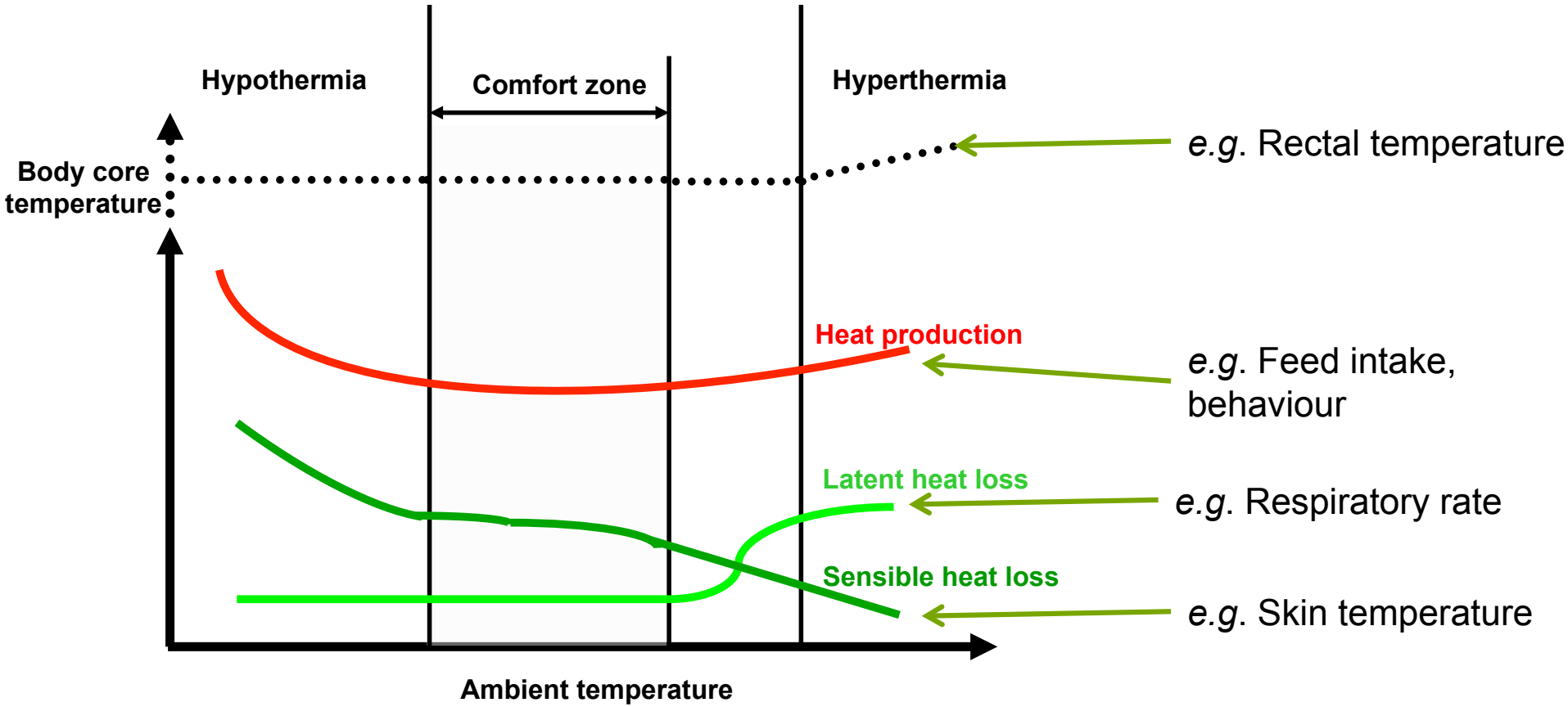
Carcass weight	**Cold**	**Hot**
Cold	$h^2 = 0.14 \pm 0.01$	$r_g = 0.42 \pm 0.13$
Hot		$h^2 = 0.28 \pm 0.01$

Source: adapted from Zumbach et *al*. (2008)

3/2 How achieving the goal? traits of interest: thermoregulatory indicators

The second strategy consists in selecting for heat resistance while keeping up the production efficiency.

- We can distinguish:



Source: adapted from Mount (1979) and Renaudeau et *al*. (2004)

3/3 How achieving the goal? traits of interest: thermoregulatory indicators

The inheritance of traits directly related with thermoregulatory responses is poorly described in pigs.

e.g. : genetic parameters from tropical Large White lactating sows (Gourdine et *al*., 2013).

	Rectal temperature	**Respiratory rate**	**ADFI**	**Litter growth rate**
RT	$h^2 = 0.39 \pm 0.10$		$r_g = -0.12 \pm 0.31$	$r_g = -0.05 \pm 0.20$
RR		$h^2 = 0.23 \pm 0.07$		
ADFI			$h^2 = 0.10 \pm 0.06$	$r_g = 0.55 \pm 0.22$
LGR				$h^2 = 0.28 \pm 0.05$

3/4 How achieving the goal? traits of interest: thermoregulatory indicators

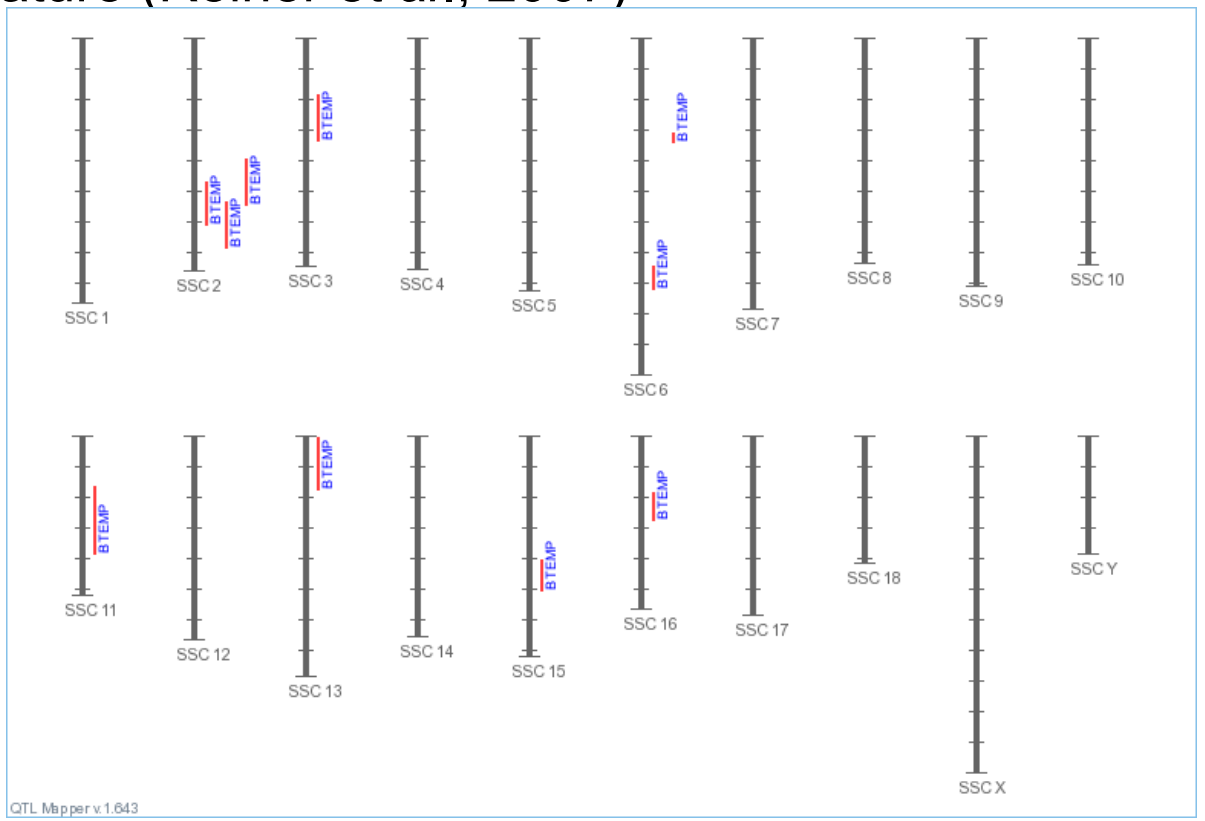
- There is no commercial genetic program with thermoregulation traits in the selection index. Why?:
    - Need to choose biologically relevant traits technically easy and low cost to record
    - Need to weight the trait in the breeding index:

      e.g. what is the economic cost of 0.1°C increase of the SD of body core temperature of lactating sows?

3/5 How achieving the goal? traits of interest: new phenotypes from genomic tools

- To our knowledge, only few QTLs related to heat resistance have been identified in pig:

  e.g. In infection disease experiments, 10 QTLs were found for body temperature (Reiner et *al*., 2007)



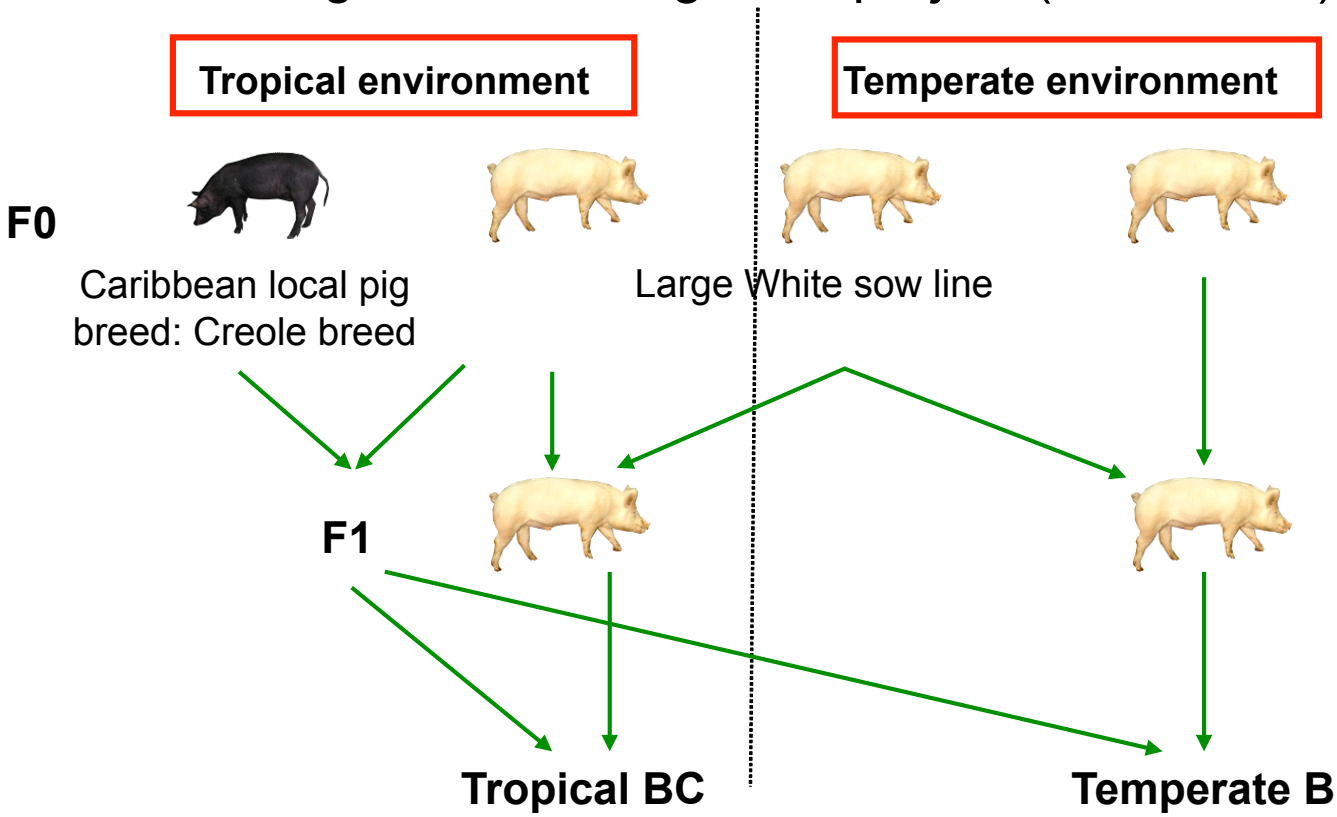
Source: http://www.animalgenome.org/

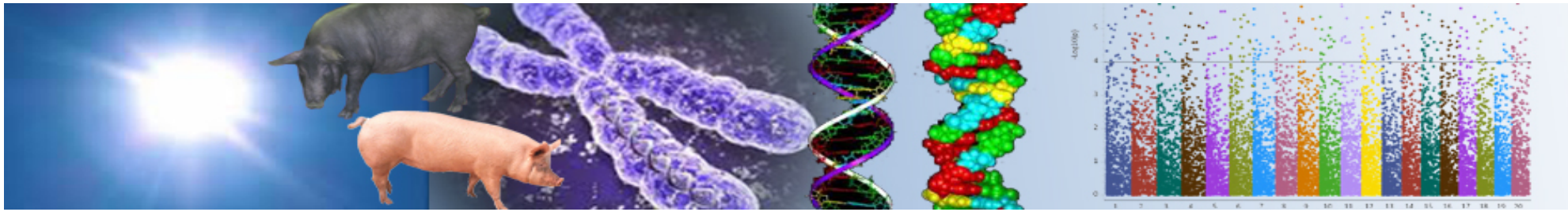
3/6 How achieving the goal? traits of interest: new phenotypes from genomic tools

- An alternative strategy to select heat tolerant pig could be :
  - Identifying SNP panels dedicated to production traits under heat stress
  - Using the SNP panel as a selection tool for estimating genomic breeding values
- The implementation requires :
  - a reference population and candidates close enough for the accuracy of genomic breeding values
  - low cost SNP panels for the economic efficiency of the scheme

How achieving the goal? traits of interest: new phenotypes from genomic tools

- New phenotypes from structural and functional genomic studies: *e.g.* the INRA PigHeaT project (2012-2016) (ANR-12-ADAP-0015)





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4. How achieving the goal?: breeding schemes

4 How achieving the goal?: breeding schemes

- Genetic improvement program for heat tolerance can be addressed either through genetic selection or crossbreeding or both:
  - Crossbreeding from mainstream commercial pig breeds is the norm
  - But, the heat tolerance of local tropical breeds could be utilized by crossbreeding or by introgressing “heat adaptation” genes into a mainstream commercial breed (or line)
- To our knowledge, little has been published on this topic in pigs:
  - Many local pig breeds are from tropical areas, but many of them are not well characterized.
  - It is necessary to implement breeding programmes for conservation and improvement of locally heat-adapted breeds. (FAO, 2007; Hoffmann, 2010)

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5/1 Conclusion

- Breeding for heat tolerance traits in pigs is a complex issue.

- But we can expect that selecting animals with high-production level under hot environment can be achieved with success and in different ways.

- For that, additional researches are still required to better know:
  - The level of GxE interactions of economically important traits
  - The genetic basis of variation of heat tolerance / resistance
  - The physiological mechanisms underlying heat tolerance

5/2 Conclusion

- Other aspects could interact with breeding for heat tolerance such as:
  - disease resistance,
  - digestive efficiency with diverse resources
  - purebreds-crossbred interactions
  - and …
- Genetics is not the only solution to mitigate the effects of heat stress, but it should contribute.