Effects of high temperatures on the reproductive physiology the sow

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Concern about impact of **High Temperatures** on pig production-reproduction

Heat exposure is severe in many areas were pig production is important or **region**:
- Mediterranean, Continental
- Tropical: High T° + High Relative Humidity

Heat Stress + Seasonal infertility: frequent even in mild climates and modern pig housings ...
Sow housing prevents variations

Average Temperatures (°C)

IFIP - Experimental Pig Farm (Rennes)
High T° for Lactating sows!

% Daily exposure >25°C

Breeding - Gestation

% Daily exposure >25°C

Farrowing-Lactation

IFIP - Experimental Pig Farm (Rennes)
Large variations between farms and years!

Heat stress and farm management exacerbate the effect of photoperiod variations

Auvigne et al 2010
Temperature >> Photoperiod

From Prunier et al 1994

Winter (20-25°C)

Summer (25-35°C)

High T° = Limiting factor
No improvement with short photoperiod

From Prunier et al 1994
Effects of Heat Stress?

General

Reproduction
Thermo-regulation mechanisms

Thermo-neutrality

- Comfort Zone
- Adaptation
- Panting Periph blood
  - Intake
  - Prod.

38.5°C

Hypo-thermia

38°C

Prod. Health

Death

LCT

> 18°C

20-22°C

UCT

< 25°C

41°C

Death

Hyper-thermia

Prod. Health

Ambiant T°
Upper Critical Temperature varies with:

- Environment (Humidity...)
- Animal factors (breed, age, weight, physiology...)

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<thead>
<tr>
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<th>UCT</th>
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<tbody>
<tr>
<td>Gestation</td>
<td>20-23 °C</td>
</tr>
<tr>
<td>Lactation</td>
<td>18°C</td>
</tr>
</tbody>
</table>

Lactating sows = more susceptible!
Hansen (2009). Effects of heat stress on mammalian reproduction


Krisher (2013). In Vivo and In Vitro environmental effects on mammalian oocyte quality.


Bertoldo et al (2012). Seasonal variation in the ovarian function of sows
Temperature and reproduction

- **Boar libido**
- **Semen quality**
- **Embryo**
- **Fœtus**
- **Sow**

**Direct Effects**
- Embryo-fetal death
- Late returns
- Abortion
- Sow death

**Indirect Effects**
- Boar libido
- Semen quality

**Hormonal status**
- GnRH
- LH
- Oestrogens
- Progesterone
- Cortisol

**Intake**
- Body stores

**Nutritional imbalance**

**Immunity Health**

**Embryo-fetal death**
- Cycled returns
- Small litters

**Embryo**

**Fœtus**

**Sow**

**Anestrus**
- Silent oestrus
- Low ovulation rate
- Late ovulation
- Infertility
- Poor embryos
Heat Stress and low feed intake

Multiparous sows 21 d lactation

Energy deficit
BW loss

ME intake (MJ/day)
milk production (kg/day)

From Quiniou and Noblet (1999)
Variable BW loss in lactation

Gourdine (2006, review)

Variable effects on reproduction

Low BW L: Few effects

Medium BWL: ➤ WEI
> 5% BW loss (Primiparous)
> 10% BW Loss (Multiparous)

High BWL: Fertility, Embryo...
Lactational Negative Energy balance

- Low feed intake
- Excessive mobilisation of body reserves
  - LH pulsatility
  - Recruitment Follicules
- Follicular growth
  - Quality Follicules

Late estrus
- Ovulation rate
- Embryo development
- Embryo survival

Poor pregnancy recognition or Later pregnancy disruption

Infertility
Small /heterogenous litters

64th EAAP Nantes 2013
Summer: Pre-ovulatory follicles have low P4.

Refractoriness of the ovary to Gonadotrophins?

Subsequent poor oogenesis / maturation?

Bertoldo et al 2011
Embryo development is compromised

Summer / Oocyte from both small and large follicles have depressed developmental competence

Bertoldo et al 2010
Molecular effects on ovaries

- Pre-pubertal gilts (35d)
- HS (35° C) vs TN (20° C), 1 month
- Ovary: Alterations of mRNA expression of estrogen synthesis pathway members

- Malproduction of ovarian hormones?
- Poor Follicular recruitment?
- Low Oocyte viability?

Nteeba et al 2013. Effects of Chronic Heat Stress on Ovarian Steroidogenesis Pathway Members in Gilts. (Iowa State University report)
Heat Shock Proteins, Oxidation

- **HS Proteins expressed** by somatic cells in response to thermal stress. Is synthesis altered in HS ovaries or embryos?
  - Pennarosa et al 2012
  - Sirotkin et Bauer 2011 ...

- **Oxidative process** associated with Heat Stress
  - Protective anti-oxydants? (Van Wettere et al, 2012)
In other species HS may impact:

- Oviduct
- Uterine environment
- Placenta
- Fœtal development (thermal imprinting)

Few specific studies on pigs ....
Death rate $\times 4$ (Canada, $T^\circ > 30^\circ C$, D’Allaire et al. 1996)
- Hyperthermia
- Heart failure

Health, Welfare?
- Stress: Activation of adeno-corticotrope axis (Cortisol)
- Immune function altered (Canaday et al. 2013)
Critical stages for Heat stress?
Critical stages: Gilts
Omtvedt et al 1971

Gilts in controlled environment

% Pregnant

0-8 days 8-16 days 53-51 days 102-110 days

0-8 days 8-16 days 53-51 days 102-110 days

Time of Heat Stress (days post breeding)

Maintenance of pregnancy: 0-8d post-b Breeding

Hot 32-38°C
Ctrl 23°C

Session 23a
**Critical stages: Gilts**

Omtvedt et al 1971

- Viable embryos
- Live piglets
- Still born

**Time of Heat Stress (days post breeding)**

- Embryos = **8-16d** Pregnancy recognition + Attachment
- Foetus: late gestation
A controlled trial
Mature gilts (160 d)

Follicular phase + 30 d Pregnancy
(Canaday et al 2013)

- Light intensity (40 days)
  Dim 11Lx
  Bright 433 Lx

- Temperature (40 days)
  Cold: 15°C
  Neutral: 21°C
  Hot: 30°C

Pregnancy rate (83.2%)
Litter size (14.3 ± 0.5)
Follicle development
Expression of estrus
Ovulation rate
Progesterone 14d
Fetal development at 30d

No Light x Temperature effect
No effect of Hot T°
Cold T°: Stress, Growth, Immunity
Heat Stress at successive stages
Williams et al 2013

<table>
<thead>
<tr>
<th>Primiparous - Controlled chambers</th>
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<tr>
<td>Late Gestation (90-111d)</td>
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<td>Farrowing-Lactation (25 d)</td>
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<td>Breeding (13 d)</td>
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<table>
<thead>
<tr>
<th>18-20° C</th>
<th>24-30° C</th>
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<tr>
<td>TN</td>
<td>HS</td>
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- No effect on reproduction!
- Short exposures
- Low BW losses
- Individual resistance?
A controlled trial
Mature gilts (160 d)

Follicular phase + 30 d Pregnancy
(Canaday et al 2013)

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altrenogest

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Cold T°: Stress, Growth, Immunity
Critical stages: Field trial
(Bloemhof et al. 2013)

- A large field trial in Spain and Portugal
- 16 farms, > 22,000 sow records (Farrowing Rate, Litter size)
- Outside $T^\circ$: Average, Max, Heat Load (Max – UCT)

Farrowing rate %
Critical stages: Field trial

Correlation Farrowing Rate – Daily maximum T°

Weaned Sows

-21 to -14 d before AI

Lactation period

From Bloemhof et al 2013
Critical stages: Field trial

Correlation Farrowing Rate – Daily maximum $T^\circ$

From Bloemhof et al 2013

-21 to -14 d before AI
+38 to 55d after AI

Previous cycle
Early feto-placental devt?

From Bloemhof et al 2013
Critical stages: Field trial

Correlation Litter Size - Daily maximum $T^\circ$

-7 d before to +12 d after AI

Weaned Sows

Day of reproduction cycle

Estrous and Early pregnancy

( Bloemhof et al 2013)
Critical stages: summary

- Gilts: More susceptible
  - Growth (puberty, in utero?)
  - Previous cycles

- Weaned sows
  - Previous lactation (FR, Oocyte, embryo quality, litter size)

- All females:
  - 0-14 days post breeding
  - 1st month pregnancy
  - Late pregnancy (mummies, stillborn)
Conflicting results! Conclusions depend on:

- Severity of Heat Stress: level (25-30°C), fluctuations
- Duration: Single vs Multiple expositions
- Physiological status, age, parity
- Photoperiod
- Others: genetic, management, previous exposure...

Criteria: FR%, Litter size...

Method of evaluation:
- Experiments with strictly controlled T°
- Field trials: outside T°, large fluctuations
Mechanisms of heat-stress associated disorders need further investigations

Models to fit complex real exposures: variability, micro-environments, long-term

More efficient use of Alleviating solutions

- Hormonal support
- Other treatments
- Feeding strategies
- Environmental management
- Triggering resistance through controlled exposures
- Selecting resistant females (bio-markers?) ...

Thank you for your attention

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