Climate control for high productive pigs in hot climate

AMVEC 20-23\textsuperscript{th} of July 2016

M.Sc. Agriculture - Poul Pedersen

Agenda

• Potential in high productive pig production
  • Production results in Denmark
• Climatically challenges in Mexico
  • Climate profiles from various locations
• Pigs reaction to hot climate
  • Farrowing and gestating sows
  • Grower-finishing pigs
• Influence of well-insulated houses
• Climate systems for reducing heat stress
  • Side ventilation with high pressure cooling
  • Tunnel ventilation with pad cooling
  • Combi tunnel systems

Potential in high productive pig production

Mexico ensures good climate condition in Denmark
Denmark

Meteonorm climate profiles for Mexico

Vera Cruz 33 m above sea level
Hermosillo 210 m above sea level

Jalisco app.1885 m above sea level

Cooling of pigs is essential in Mexico

- Sensible heat
  - Conduction
  - Convection
  - Radiation
- Latent heat
  - Evaporation
Effect of climate on respiration rate (60 kg pig)

Reference: Aarnink et al, 2006

Effect of climate on feed intake (60 kg pig)

Effects of high ambient temperatures on pig growth
Farrowing sows in hot climate

<table>
<thead>
<tr>
<th>Item</th>
<th>Temperature, °C (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>18 (64) 25 (77) 30 (86)</td>
</tr>
<tr>
<td>Litter weaning wt, kg</td>
<td>63° 61° 53°</td>
</tr>
<tr>
<td>Weaning sows</td>
<td>8.1 8.9 8.3</td>
</tr>
<tr>
<td>Pig weaning wt, kg</td>
<td>7.8° 6.9° 6.4°</td>
</tr>
<tr>
<td>Mortality, %</td>
<td>20° 12° 19°</td>
</tr>
<tr>
<td>Sow feed intake, kg/d</td>
<td>6.5° 6.1° 4.2°</td>
</tr>
<tr>
<td>Sow wt change, xp/lactation</td>
<td>-3.1° -7.1° -2.2°</td>
</tr>
</tbody>
</table>

* Means in the same row with different superscripts differ (P>0.05)

Gestating sows in hot climate

<table>
<thead>
<tr>
<th>Item</th>
<th>26 - 27°C (80° F)</th>
<th>30°C (86° F)</th>
<th>33°C (92° F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of sows</td>
<td>74</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>No. in oestrus</td>
<td>74</td>
<td>78</td>
<td>73</td>
</tr>
<tr>
<td>No. in anoestrus</td>
<td>0</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>No. returning to oestrus</td>
<td>2</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>No. of sows that conceived</td>
<td>67</td>
<td>67</td>
<td>52</td>
</tr>
<tr>
<td>Conception rate, %</td>
<td>90</td>
<td>85</td>
<td>78</td>
</tr>
</tbody>
</table>

* From Serres (1992)

Heat radiation from uninsulated roof

Short wave solar radiation: Colour is important

Long wave heat radiation: No influence of colour

Heat radiation is important in both cold and hot climate

Measurement of heat radiation – globe thermometer

<table>
<thead>
<tr>
<th>Room temperature</th>
<th>Globe temperature</th>
</tr>
</thead>
</table>
High productive pigs need well-insulated houses

Insulation equal to at least 5 cm sandwich is recommended

Ventilation systems for pig production

Low Power Ventilation (LPV)

Combi-Tunnel

Tunnel (only in tropical areas)

LPV ventilation with high pressure cooling
High-pressure cooling – pump and nozzles

Placement of high pressure cooling

- Wall placement
- Ceiling placement

Analysis for Wean to finish house in Jalisco

Combi tunnel with pad cooling
Hermosillo 210 m above sea level

Combi-tunnel or Tunnel

Recommended systems for pigs in Mexico
AMVEC 2016
CV for Poul Pedersen

• 1992-2012: Project manager at the “Danish Pig Research Centre”: Development and test of climate systems, housing systems, systems for reduction of ammonia and odour, etc.
• 2012: System Developer at R&D & Pig Specialist at SKOV

Danish Pig Research Centre

FOCUS

MRSA AND DANISH PIG PRODUCTION

There are several strains of MRSA bacteria, but one strain in particular, CC398, is associated with animals and is in Denmark primarily found in pigs.

PRODUCT STANDARD

TRANSPORT STANDARD

THE USE OF ANTIBIOTICS

ANIMAL WELFARE IN DENMARK

DANISH BREEDING SYSTEM

DANAVL - THE DANISH BREEDING SYSTEM FOR PIGS.
## World pig meat production and pig population

### Million piglets 2012

- **D**: 45.8
- **E**: 41.1
- **DK**: 29.2
- **F**: 24.4
- **NL**: 24.1

### Pigmeat production

<table>
<thead>
<tr>
<th>Country</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>4,941</td>
<td>5,085</td>
</tr>
<tr>
<td>Spain</td>
<td>3,527</td>
<td>3,527</td>
</tr>
<tr>
<td>France</td>
<td>2,312</td>
<td>2,301</td>
</tr>
<tr>
<td>Poland</td>
<td>1,811</td>
<td>1,783</td>
</tr>
<tr>
<td>Italy</td>
<td>1,577</td>
<td>1,570</td>
</tr>
<tr>
<td>Denmark</td>
<td>1,888</td>
<td>1,931</td>
</tr>
<tr>
<td>Netherlands</td>
<td>1,800</td>
<td>1,818</td>
</tr>
<tr>
<td>Belgium/Luxembourg</td>
<td>1,114</td>
<td>1,127</td>
</tr>
<tr>
<td>UK</td>
<td>771</td>
<td>803</td>
</tr>
<tr>
<td>Austria</td>
<td>507</td>
<td>519</td>
</tr>
<tr>
<td>Hungary</td>
<td>340</td>
<td>322</td>
</tr>
<tr>
<td>Rumania</td>
<td>393</td>
<td>378</td>
</tr>
<tr>
<td>Portugal</td>
<td>310</td>
<td>315</td>
</tr>
<tr>
<td>Czech Rep.</td>
<td>267</td>
<td>258</td>
</tr>
<tr>
<td>Sweden</td>
<td>264</td>
<td>262</td>
</tr>
<tr>
<td>Finland</td>
<td>197</td>
<td>195</td>
</tr>
<tr>
<td>Ireland</td>
<td>219</td>
<td>221</td>
</tr>
<tr>
<td>Greece</td>
<td>115</td>
<td>115</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>69</td>
<td>69</td>
</tr>
<tr>
<td>Other EU-27 countries</td>
<td>350</td>
<td>334</td>
</tr>
<tr>
<td><strong>EU-27 total</strong></td>
<td>22,772</td>
<td>22,883</td>
</tr>
</tbody>
</table>

### Pig population

<table>
<thead>
<tr>
<th>Country</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>China (incl. Hong Kong)</td>
<td>51,070</td>
<td>49,700</td>
</tr>
<tr>
<td>USA</td>
<td>10,177</td>
<td>10,289</td>
</tr>
<tr>
<td>Brazil</td>
<td>3,220</td>
<td>3,260</td>
</tr>
<tr>
<td>Russia</td>
<td>2,331</td>
<td>2,400</td>
</tr>
<tr>
<td>Canada</td>
<td>1,926</td>
<td>1,136</td>
</tr>
<tr>
<td>Mexico</td>
<td>1,175</td>
<td>1,180</td>
</tr>
<tr>
<td>Japan</td>
<td>1,291</td>
<td>1,250</td>
</tr>
<tr>
<td>Rep. Of Korea</td>
<td>1,110</td>
<td>835</td>
</tr>
<tr>
<td>Ukraine</td>
<td>630</td>
<td>650</td>
</tr>
<tr>
<td><strong>Total selected countries</strong></td>
<td>95,702</td>
<td>93,593</td>
</tr>
</tbody>
</table>

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1) Provisional figures  Source: CIRA
Climate zones
Climate zones in Mexico
Climate profile for RyC Atlixco 1899 m above sea level
Climate profile for Puebla 2166 m above sea level
Climate profile for Puebla 2166 m above sea level

Temperature Conditions

- Mean dry temperature: 15.62°C
- Mean dewpoint temperature: 7.17°C
- Mean wet bulb temperature: 11.48°C
- Max. dry temperature: 30.30°C
- Min. dry temperature: 2.40°C
- Max. dewpoint temperature: 17.01°C
- Min. dewpoint temperature: -3.03°C
- Max. wet bulb temperature: 19.01°C
- Min. wet bulb temperature: 1.62°C

Atmospheric pressure: 101.3 kPa
Max. humidity after cooling: 100.0%
Climate profile for Puebla 2166 m above sea level

Temperature Conditions

Temperature
- Mean dry temperature: 16.62°C
- Mean dewpoint temperature: 7.17°C
- Mean wet bulb temperature: 11.48°C
- Max. dry temperature: 30.30°C
- Min. dry temperature: 2.40°C
- Max. dewpoint temperature: 17.01°C
- Min. dewpoint temperature: -3.03°C
- Max. wet bulb temperature: 19.01°C
- Min. wet bulb temperature: 1.62°C

Atmospheric pressure: 101.3 kPa
Max. humidity after cooling: 100.0%

Dry bulb

Wet bulb
Climate profile for Puebla 2166 m above sea level

- **Dry bulb**
- **Wet bulb**

**Temperature Conditions**

- Temperature:
  - Mean dry temperature: 16.62°C
  - Mean dewpoint temperature: 7.17°C
  - Mean wet bulb temperature: 11.48°C
  - Max. dry temperature: 30.30°C
  - Min. dry temperature: 2.40°C
  - Max. dewpoint temperature: 17.01°C
  - Min. dewpoint temperature: -3.03°C
  - Max. wet bulb temperature: 19.01°C
  - Min. wet bulb temperature: 1.62°C

**Graphic**

- Dry temperature (Tair)
- Dew point temperature (Tdew)
- Wet bulb temperature (Twet)
- Difference dry temp./dewpoint
- Difference dry temp./wet temperature
- Relative humidity
- Relative humidity after cooling
- T + R²
- T2 + R²

- Atmospheric pressure: 60 kPa
- Max. humidity after cooling: 100.0%
Cooling is important – three ways of doing it

- Ventilation capacity
- Evaporative cooling
  - Sprinkling system
  - High-pressure cooling
  - Pads
- Increasing air velocity
  - Wall and ceiling inlets
  - Tunnel ventilation
Pigs can’t sweat

But as a pig producer, you don’t want to sweat like a pig
**Heat production of the pigs**

1 Heat Production Unit
Total heat: 1000 W
Sensible heat: 650 W
Moisture production: 0.50 kg/h
Carbon dioxide production: 0.35 kg/h

1 HPU = 4 finishing pigs at 98 kg
8 weaning pigs at 30 kg
3 pregnant sows of 270 kg
1 farrowing sow of 270 kg + 12 piglets of 4 kg
Heat loss from a pig

- Sensible heat
  - Conduction
  - Convection
  - Radiation
- Latent heat
  - Evaporation
Naturally ventilated pig houses in Spain
Pigs reaction to hot climate
Heat stress – respiration rate increases
Effect of climate on respiration rate (60 kg pig)

Source: Aarnink et al, 2006
Effect of temperature on water to feed ratio

Figure 4. Broken line relationship between ambient temperature and water to feed ratio; □ ◇ △ are means of measured data.
Effect of temperature on skin temperature

Figure 5. Linear relationship between ambient temperature and skin temperature; □ ◊ △ are means of three marked pigs.
Effect of climate on feed intake (60 kg pig)
Effect of heat stress on pigs

• Behavioural change starts at approx 20°C
• Productivity drop starts at approx 25°C
• Sensitivity to heat stress depends on the category of pigs
  • Most sensitive: Finishing pigs and lactating sows
  • Less sensitive: Weaning pigs and gestating sows
Effects of high ambient temperatures on pig growth

A meta analysis of effects of high ambient temperature on growth performance of growing finishing pigs
Rendaudeau et. Al., 2011
Effects of high ambient temperatures on pig growth

A meta analysis of effects of high ambient temperature on growth performance of growing finishing pigs
Rendaudeau et. Al., 2011

![Graph showing the effects of high ambient temperatures on pig growth](image-url)
Effects of high ambient temperatures on pig growth

A meta analysis of effects of high ambient temperature on growth performance of growing finishing pigs

Rendaudeau et. Al., 2011
High-pressure cooling – pump and nozzles

- Built-in filter
- Anti-drip valve
New placement of high pressure cooling – why?

Wall placement

Ceiling placement
New placement of high pressure cooling – why?

Wall placement

Ceiling placement
Climate profile for Puebla 2166 m above sea level
Climate profile for Puebla 2166 m above sea level

Temperature Conditions

- Mean dry temperature: 16.62°C
- Mean dewpoint temperature: 7.17°C
- Mean wet bulb temperature: 13.29°C
- Max. dry temperature: 30.30°C
- Min. dry temperature: 2.40°C
- Max. dewpoint temperature: 17.01°C
- Min. dewpoint temperature: -3.03°C
- Max. wet bulb temperature: 21.44°C
- Min. wet bulb temperature: 2.40°C

Max. humidity after cooling: 80.0%
### Natural versus mechanical ventilation with cooling

<table>
<thead>
<tr>
<th></th>
<th>Natural ventilation</th>
<th>Mechanical ventilation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient temperature, °C</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>+ pigs heat production, °C</td>
<td>+2.5</td>
<td>+2.5</td>
</tr>
<tr>
<td>÷ cooling, °C</td>
<td></td>
<td>-7.5</td>
</tr>
<tr>
<td>÷ chill effect, °C</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Experienced temperature, °C</td>
<td>27.5</td>
<td>20</td>
</tr>
</tbody>
</table>
Effect of climate on feed intake (60 kg pig)

Source: Aarnink et al, 2006
Climate condition in the zone occupied by the pigs
Pigs behavioural reaction to temperature

Always look at the pigs!

Climate condition in the zone occupied by the pigs

Max = 30.8
Avg = 27.5
Min = 25.8
SKOV ventilation systems for pig production

**Low Power Ventilation (LPV)**

**Tunnel (only in tropical areas)**

**Combi-Tunnel**
LPV as much as possible

• LPV advantages
  • Identical climate conditions in all pens
  • Control of the air flow pattern within the pen
Identical climate conditions in all pens
Different climate conditions within the pen is optimal

- **Resting area**
- **Activity area**
- **Dunging area**
Air distribution in hot periods

Diagram showing air circulation and heat distribution in a structure during hot periods.
Farrowing pen – micro climate is important
Farrowing pen – micro climate is important
Piglet nest – micro climate is important
Floor heating – heating tubes in installation tubes
Floor heating – heating tubes cast in concrete
Design and control of heating plates are important.
Design of heating tubes – max 2-3 °C difference
Adjustment of floor heating system is important

Important with a manifold with adjustable valves
Two-climate versus one-climate systems in DK

**Two-climate system**
- Start temperature: 22-24°C
- Heating capacity: 20 W/pig
- Heat consumption: 3 kWh/pig

**One-climate system**
- Start temperature: 28-30°C
- Heating capacity: 100 W/pig
- Heat consumption: 15 kWh/pig
- Slurry curtains should be implemented
Principle in two-climate systems

+6 °C
Principle in two-climate systems

- Optimal design
  - Comfortable for the pigs
  - Up to +6 °C
Two-climate system

- Not comfortable
  - Opening reduced too much
  - Too hot and humid
  - Too bad air quality
  - Too big temperature variation
Two-climate system

- Not comfortable
  - Too deep two-climate system
  - Too hot and humid
  - Too bad air quality
  - Too big temperature variation
  - Too high air speed

+10 °C
Two-climate system for weaning pigs - design

- 0.08-0.10 m² per pig
- Max 1.6 m
- 40-60 cm
Two-climate – reduced opening height the first weeks
Two-climate system only with solid floor

- **Fully slatted flooring**
  - Risk of draft and bad air quality in the resting area under two-climate system

- **Solid flooring**
  - Eliminates the risk for draft from the slurry pit
Houses for high performance pigs must be insulated.
Heat radiation from uninsulated roof

Short wave solar radiation: Colour is important

Long wave heat radiation: No influence of colour
Heat radiation is important in both cold and hot climate
Measurement of heat radiation – globe thermometer

Room temperature: 20 °C

Globe temperature: 24 °C
Measurement of heat radiation – globe thermometer

Room temperature: 20 °C

Globe temperature: 16 °C
Radiation – discomfort for human beings

The diagram shows the relationship between the percent of unsatisfied individuals and the radiation temperature asymmetry (Δt_{pr}) for different conditions:

- **Warm ceiling**
- **Cold wall**
- **Cold ceiling**
- **Warm wall**

The graph plots unsatisfied percent on the y-axis against radiation temperature asymmetry on the x-axis. The curves indicate how unsatisfied percent increases with increasing radiation temperature asymmetry for each condition.
### Benefits of insulation

Example: Outside 0 °C, inside 20 °C & 70 % RH

<table>
<thead>
<tr>
<th>Insulation</th>
<th>None</th>
<th>1 cm</th>
<th>3 cm</th>
<th>5 cm</th>
<th>10 cm</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>U-value, W/m²/°C</strong></td>
<td>5.9</td>
<td>2.4</td>
<td>1.1</td>
<td>0.70</td>
<td>0.37</td>
</tr>
<tr>
<td><strong>Surface temp., °C</strong></td>
<td>4.7</td>
<td>13.8</td>
<td>17.2</td>
<td>19.0</td>
<td>19.5</td>
</tr>
<tr>
<td><strong>Condensation, %RH</strong></td>
<td>36</td>
<td>67</td>
<td>84</td>
<td>94</td>
<td>97</td>
</tr>
</tbody>
</table>

- Insulation equal to at least 5 cm of mineral wool insulation is needed
Questions?