Acute phase proteins as biomarkers of disease and stress in pigs

Carlos Piñeiro, Joaquín Morales, Matilde Piñeiro
PigCHAMP Pro Europa SL
Content

Background.
- Physiological basis of stress
- The acute phase reaction

Effects related
- Health
- Performance
- Transport
- Meat
- Transversal through chain
- Linkage between stress and acute phase response (non inflammatory effects)

And from here, where to?
Background

Restrictive and getting worse

- Environment (IPPC-DEI, Gothemburg, Kyoto)
- Animal Welfare (UE 2013, States in USA, Canadá, Australia or companies - Macdonalds-)
- Antiinfectives use restriction
- Food safety

Trust the final product
Background

The potential of the current genetic lines often limited by stressors present in the productive system:

- Social stress
- Mixing
- Non adequate feeding
- Stocking density,
- Temperature
- Pathogens

Stress: biological response of an individual when a threat to homeostasis is perceived

(Moberg, 2000)
Background

- **Stress**
  - Does not represent a threat
  - Represents a threat (distress)
    - Welfare
    - Health
    - Productive performance
    - Carcass-meat quality

- **Response** (Baumann, 1994)
  - Behavior
  - Central Nervous System
  - Neuroendocrine System
  - Immune System

Acute Phase Response
TISSUE DAMAGE

Trauma, wounds, burns, surgery, infection, stress

Release of pro-inflammatory cytokines (IL-1, IL-6, TNFα)

Platelet activation, activation of complement and coagulation pathways, endotelium activation, increase of vasel permeability, release of inflammatory cells

Enhancement of pro-inflammatory cytokines release

Activation of hypothalamic-pituitary-adrenal (HPA) axis

Systemic reaction
Proinflammatory Cytokines

- TNFα
- IL-1
- IL-6

**Acute Phase response (II)**

- Decrease of food intake
- Decrease of intestinal motility and higher mucus production
- Fever
- Decrease of Vit. A, Zn and Fe serum levels
- Osteoclastes activity
Proinflammatory cytokines

- TNFα
- IL-1
- IL-6

Alteration of nutrients metabolism:
- Lipids
- Carbohydrates
- Muscle catabolism

Liver

Free Aminoacids

Proliferation and activation of immune cells

- Fibrinogen
- Haptoglobin
- C-reactive Protein
- Pig-MAP...

Synthesis of Acute Phase Proteins

Acute phase response (III)
IMMUNOLOGICAL STRESS

Metabolic cost
(Hipocrates’s ‘ponos’ )
APP functions

- Defense mechanisms / Restoration of homeostasis

✓ Opsonization and complement activation
✓ Neutralization of free radicals
✓ Removal of released hemoglobin
✓ Neutralization of proteolitic enzymes
✓ Participation in regulatory processes
APP in pigs, from basic knowledge to practical application.

Initial studies (mainly from late 90’s)

- Which are the main APPs in pigs
- What does elevate pig APPs?
- Basal levels/Acute phase levels
- Variability (animal/herd)
- Behaviour in commercial conditions
- Availability of assays

Application of APP in animal production
Measuring APP

- **Availability of Assays:**
  
  A range of assays adequate for the different APP in different species have been developed.

- **Assays should be validated:**
  
  Specificity
  Accuracy
  Precision
  Sensibility...

- **Importance of the standard:**
  
  Use of common standards for comparing the results. Species specific.
  European Reference Serum for pig APP (European concerted action QLTR-1999-01531)
APP in swine health and production

- Reflects the presence of immunological stress
  - That has a cost!
    - Losses of productive performance
    - Increased susceptibility to acute disease outbreaks
APP’s in infectious diseases
APP during a bacterial infection: S. suis

- 5 weeks old SPF pigs.
- Infection with S suis serotype 2 (strain SS02-0119), $10^{10}$ CFU, on day 0

APP during a bacterial infection: H. parasuis

Martin AJ et al, Comp Immunol Microbiol Infec Dis 2008

Mean values ± SD of the serum concentration of pig MAP in the experimental groups after infection with a lethal dose of *H. parasuis*.

<table>
<thead>
<tr>
<th>Treatment group&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Pig MAP concentration (mg/ml)</th>
<th>day 0</th>
<th>day 1</th>
<th>day 3</th>
<th>day 6</th>
<th>day 9</th>
<th>day 13</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td></td>
<td>0.6 ± 0.1</td>
<td>5.7 ± 0.4</td>
<td>16.0</td>
<td>16.0</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>n = 4</em></td>
<td><em>n = 2</em></td>
<td><em>n = 1</em></td>
<td><em>n = 1</em></td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>P &lt; 0.0001</em></td>
<td><em>P &lt; 0.0001</em></td>
<td><em>P &lt; 0.0001</em></td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>II</td>
<td></td>
<td>0.7 ± 0.3</td>
<td>2.9 ± 2.1</td>
<td>1.8 ± 0.9</td>
<td>1.1 ± 0.3</td>
<td>0.8 ± 0.2</td>
<td>0.8 ± 0.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>n = 5</em></td>
<td><em>n = 5</em></td>
<td><em>n = 5</em></td>
<td><em>n = 5</em></td>
<td><em>n = 5</em></td>
<td><em>n = 5</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>P = 0.0011</em></td>
<td><em>P = 0.0766</em></td>
<td><em>P = 0.5526</em></td>
<td><em>P = 0.8083</em></td>
<td><em>P = 0.7872</em></td>
<td><em>P = 0.7314</em></td>
</tr>
<tr>
<td>III</td>
<td></td>
<td>0.6 ± 0.1</td>
<td>4.3 ± 1.7</td>
<td>3.3 ± 0.2</td>
<td>1.8 ± 0.2</td>
<td>1.3 ± 0.3</td>
<td>0.9 ± 0.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>n = 4</em></td>
<td><em>n = 4</em></td>
<td><em>n = 2</em></td>
<td><em>n = 2</em></td>
<td><em>n = 2</em></td>
<td><em>n = 2</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>P &lt; 0.0001</em></td>
<td><em>P = 0.0034</em></td>
<td><em>P = 0.2048</em></td>
<td><em>P = 0.4166</em></td>
<td><em>P = 0.7314</em></td>
<td><em>P = 0.9076</em></td>
</tr>
<tr>
<td>IV</td>
<td></td>
<td>0.6 ± 0.2</td>
<td>3.1 ± 1.4</td>
<td>1.6 ± 0.1</td>
<td>1.2 ± 0.2</td>
<td>0.8 ± 0.1</td>
<td>0.7 ± 0.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>n = 4</em></td>
<td><em>n = 3</em></td>
<td><em>n = 2</em></td>
<td><em>n = 2</em></td>
<td><em>n = 2</em></td>
<td><em>n = 2</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>P = 0.0006</em></td>
<td><em>P = 0.1066</em></td>
<td><em>P = 0.3801</em></td>
<td><em>P = 0.7147</em></td>
<td><em>P = 0.9076</em></td>
<td><em>P = 0.9313</em></td>
</tr>
<tr>
<td>V</td>
<td></td>
<td>0.6 ± 0.2</td>
<td>1.6 ± 0.6</td>
<td>1.3 ± 0.2</td>
<td>1.1 ± 0.2</td>
<td>0.8 ± 0.1</td>
<td>0.7 ± 0.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>n = 3</em></td>
<td><em>n = 3</em></td>
<td><em>n = 3</em></td>
<td><em>n = 3</em></td>
<td><em>n = 3</em></td>
<td><em>n = 3</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>P = 0.2422</em></td>
<td><em>P = 0.4864</em></td>
<td><em>P = 0.6443</em></td>
<td><em>P = 0.8663</em></td>
<td><em>P = 0.9313</em></td>
<td><em>P = 0.9313</em></td>
</tr>
<tr>
<td>VI</td>
<td></td>
<td>0.5 ± 0.1</td>
<td>1.7 ± 0.2</td>
<td>1.5 ± 0.3</td>
<td>1.1 ± 0.2</td>
<td>0.8 ± 0.1</td>
<td>0.9 ± 0.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>n = 3</em></td>
<td><em>n = 3</em></td>
<td><em>n = 3</em></td>
<td><em>n = 3</em></td>
<td><em>n = 3</em></td>
<td><em>n = 3</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>P = 0.1934</em></td>
<td><em>P = 0.2517</em></td>
<td><em>P = 0.5213</em></td>
<td><em>P = 0.7423</em></td>
<td><em>P = 0.6527</em></td>
<td><em>P = 0.6527</em></td>
</tr>
</tbody>
</table>
Pneumonia, differentiation between pleuritis (P-, P+) and cranio-ventral consolidation (M-, M+)


<table>
<thead>
<tr>
<th></th>
<th>Haptoglobin (g/L)</th>
<th>Pig-MAP (g/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Interval</td>
</tr>
<tr>
<td>P−M−</td>
<td>1.31&lt;sup&gt;a&lt;/sup&gt;</td>
<td>±0.19</td>
</tr>
<tr>
<td>P+M−</td>
<td>1.59&lt;sup&gt;a&lt;/sup&gt;</td>
<td>±0.25</td>
</tr>
<tr>
<td>P−M+</td>
<td>1.45&lt;sup&gt;a&lt;/sup&gt;</td>
<td>±0.23</td>
</tr>
<tr>
<td>P+M+</td>
<td>1.91&lt;sup&gt;b&lt;/sup&gt;</td>
<td>±0.23</td>
</tr>
<tr>
<td>Kruskal–Wallis test</td>
<td>14.99 (P = 0.002)</td>
<td></td>
</tr>
<tr>
<td>P−</td>
<td>1.38</td>
<td>±0.15</td>
</tr>
<tr>
<td>P+</td>
<td>1.76</td>
<td>±0.17</td>
</tr>
<tr>
<td>Mann–Whitney’s U</td>
<td>22333.0 (P = 0.001)</td>
<td></td>
</tr>
<tr>
<td>M−</td>
<td>1.45</td>
<td>±0.16</td>
</tr>
<tr>
<td>M+</td>
<td>1.68</td>
<td>±0.16</td>
</tr>
<tr>
<td>Mann–Whitney’s U</td>
<td>23051.5 (P = 0.033)</td>
<td></td>
</tr>
</tbody>
</table>

Groups with different letter showed significant differences (Kruskal–Wallis test).
Pneumonia, differentiation between pleuritis (P-, P+) and cranio-ventral consolidation (M-, M+)

- Pigs with pleuritis (P+) showed higher concentration of APP’s (PigMAP, Hp, CRP) than (P-).
- Pigs with higher incidence of CVPC (M+) showed higher concentrations of PigMAP and Haptoglobin.
- Pigs from farms (P+ M+) showed higher concentration of APP’s (PigMAP, Hp, CRP) than (P-M-). PigMAP was the best biomarker to differentiate these farms.
- PigMAP was the only APP able to discriminate between farms P-M- and farms with prevalence of just one of the lesions (P-M+, P+M-).

Commercial farms affected by PMWS (PCV2)

7 farms, longitudinal study. Animals euthanised at the PMWS outbreak and classified as:

- PMWS (35)
- Healthy (29)
- Wasted non-PMWS (43)

APP and productive performance
Changes in the pattern of feeding (Ad libitum -AL- vs Disordered –DIS-)

<table>
<thead>
<tr>
<th>AL group</th>
<th>74–88</th>
<th>88–102</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>ADG</td>
<td>FGR</td>
</tr>
<tr>
<td></td>
<td>523$^a$</td>
<td>1.96</td>
</tr>
<tr>
<td>Female</td>
<td>439$^b$</td>
<td>2.36</td>
</tr>
<tr>
<td>DIS group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>398$^b$</td>
<td>2.61</td>
</tr>
<tr>
<td>Female</td>
<td>445$^b$</td>
<td>2.11</td>
</tr>
<tr>
<td>s.e.</td>
<td>22.0</td>
<td>0.263</td>
</tr>
</tbody>
</table>

Significance:
- Treatment: **
- Sex: +
- Interaction: **

Piñeiro et al., 2007, Animal 1, 133-139
Changes in the pattern of feeding

Feeding: AL: ad libitum, DIS: disorderly

Piñeiro et al., 2007, Animal 1, 133-139
E. Coli outbreak

- Nursery trial
- 2 different sources of Zn
- Comparison of productive performance and acute phase reaction

Table 1. Growth performance in the starter phase (42 to 63 d of age).

<table>
<thead>
<tr>
<th></th>
<th>Final BW, kg</th>
<th>ADG, g/d</th>
<th>G:F, g/g</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1-ZnO</td>
<td>16.51</td>
<td>358.8</td>
<td>0.586</td>
</tr>
<tr>
<td>T2-HiZox</td>
<td>17.93</td>
<td>424.3</td>
<td>0.694</td>
</tr>
<tr>
<td>SEM, n = 12</td>
<td>0.208</td>
<td>7.315</td>
<td>0.0069</td>
</tr>
<tr>
<td>Probability</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Feed efficiency and APP in over stocking

- F:E (g/g)
- Pig-MAP (mg/mL)

<table>
<thead>
<tr>
<th>Room 1</th>
<th>Room 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.25 m²/animal</td>
<td>1.25 m²/animal</td>
</tr>
<tr>
<td>0.75</td>
<td>0.75</td>
</tr>
<tr>
<td>0.55</td>
<td>0.55</td>
</tr>
</tbody>
</table>

Own data, not published
Effect of addition of butyrate in a weaned piglet diet on the acute phase response in nursery piglets

• ADG : only significant correlation (p<0.001) for PigMAP with the highest $r^2=0.40$
• PigMAP was the best correlated with differences in mortality
APP and transport
APP and transport

A) 24h, Average conditions
1.5 m²/boar, no sawdust, with no feed and water provided

B) 48h, Excellent conditions
2 m²/boar, sawdust, feed and water provided

Piñeiro et al., 2007, Vet J 173,669-674
APP and transport

A) 24h, Average conditions
1.5 m²/boar, no sawdust, with no feed and water provided

B) 48h, Excellent conditions
2 m²/boar, sawdust, feed and water provided

<table>
<thead>
<tr>
<th>Transport 1 (n = 16)</th>
<th>Arrival</th>
<th>1 Month later</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pig-MAP (mg/mL)</td>
<td>3.28 ± 1.50</td>
<td>0.94 ± 0.24</td>
<td>0.0004</td>
</tr>
<tr>
<td>Haptoglobin (mg/mL)</td>
<td>1.15 ± 0.54</td>
<td>0.48 ± 0.50</td>
<td>0.0011</td>
</tr>
<tr>
<td>CRP (µg/mL)</td>
<td>19.5 ± 12.8 (15)*</td>
<td>15.6 ± 9.0 (6)*</td>
<td>–</td>
</tr>
<tr>
<td>Albumin (mg/mL)</td>
<td>29.0 ± 2.2</td>
<td>25.2 ± 3.6</td>
<td>0.0858</td>
</tr>
<tr>
<td>Total protein (mg/mL)</td>
<td>91.5 ± 3.3</td>
<td>82.9 ± 7.4</td>
<td>0.0382</td>
</tr>
<tr>
<td>Cortisol (ng/mL)</td>
<td>29.0 ± 17.0</td>
<td>28.9 ± 11.3</td>
<td>1.0000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transport 2 (n = 32)</th>
<th>Arrival</th>
<th>1 Month later</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pig-MAP (mg/mL)</td>
<td>1.39 ± 0.75</td>
<td>0.96 ± 0.14</td>
<td>0.001</td>
</tr>
<tr>
<td>Haptoglobin (mg/mL)</td>
<td>0.75 ± 0.61</td>
<td>0.65 ± 0.33</td>
<td>0.532</td>
</tr>
<tr>
<td>CRP (µg/mL)</td>
<td>22.5 ± 14.8 (12)*</td>
<td>17.0 ± 5.3 (5)*</td>
<td>–</td>
</tr>
<tr>
<td>Albumin (mg/mL)</td>
<td>29.1 ± 2.1</td>
<td>25.8 ± 2.5</td>
<td>0.0000</td>
</tr>
<tr>
<td>Total protein (mg/mL)</td>
<td>88.8 ± 6.9</td>
<td>79.9 ± 6.2</td>
<td>0.0003</td>
</tr>
<tr>
<td>Cortisol (ng/mL)</td>
<td>26.2 ± 17.0</td>
<td>25.8 ± 11.0</td>
<td>0.857</td>
</tr>
</tbody>
</table>

Piñeiro et al., 2007, Vet J 173,669-674
APP and transport

4 groups, T1, T3, T5, T14, T28

Measuring transport effect and later adaptation

Conclusion suggest stress effect on APP besides of inflammatory classical explanation

Salamano G et al., 2007, Vet J
Stress and acute phase response; an inconspicuous but essential linkage

• Strictly speaking, induction of APPs due to transportation stress has already been found in cattle (Murata and Miyamoto, 1993; Arthington et al., 2003) but the study of Pineiro and colleagues is the first to confirm the stress APP linkage in pigs under commercial conditions, suggesting that the APP response is inducible to a considerable extent by stressful events to which domestic animals are ubiquitously exposed during daily management.

• In this editorial, I propose a hypothesis that could explain the nature of the stress-APP linkage. The hypothesis is based on a neuroendocrine-immune network concept. Briefly,

  (1) signals originating in sensory organs in response to stress (in this case, non-inflammatory and psychophysical stress) are transmitted via afferent sensory nerve fibres to the brain and,
  (2) activate the neuroendocrine centres including the sympatho-adrenal axis and the hypothalamic-pituitary-adrenal (HPA) axis.
  (3) this activation leads to the release of catecholamines and glucocorticoids, which neurotransmitters
  4) directly and/or indirectly (through induction of pro-inflammatory cytokines in immunity-related cells) activate the production and release of APP in the liver, thereby
  5) augmenting peripheral APP levels in stressed animals.

Murata, H., 2007, Vet J. Guest editorial
Stress and acute phase response; an inconspicuous but essential linkage; hypothesis for APP induction in stressed animals

Murata, H., 2007, Vet J. Guest editorial
APP and management
Mixing at the entry of the fattening barn

Four experimental groups: M: mixed, NM: non mixed, 12 animals/pen, 8 animals/pen.

APP In pig production, QLK5-CT-2001-02219,
APP at abattoir
APP at abattoir

- Assessment of health status of pigs. Meat inspection.

- Possibility of measuring in blood or meat juice

Figure 4.6: Meat juice container (Nielsen et al. 1998)
APP at slaughter: wasting pigs.

Yamane et al., 2006. Increases in Pig Major Acute Phase Protein in Wasting Pigs Brought to the abattoir. J. Vet Med. Sci. 68(5): 511-13

- Difficulties in establishing a criteria to determine if these animals are adequate for human consumption
- Need of new diagnostic tools
Proteomic analysis:
Identification of pig-MAP as a protein increasing significantly in wasting pigs.

Pig-MAP concentration 7 times higher in wasting pigs
(n=20 animals per group)
APP can be also determined in meat juice

- Obtaining of paired samples of slaughter blood and meat (*pars costalis diaphragmatidis*)

- Meat juice collected after frozen (-20ºC) and thawing (24h, 4ºC) of the meat.

*Piñeiro et al., 2009, Res Vet Sci 87, 273-276*
Correlation of APP concentration in blood and meat juice

Pig-MAP

Haptoglobin

$r = 0.858, p < 0.001 (n = 292)$

$r = 0.695, p < 0.001 (n = 298)$

Piñeiro et al., 2009, Res Vet Sci 87, 273-276
APP and production chain
Is everything coherent when combined?

Investigation of pig health and welfare, measured by APP concentration in serum-saliva (PigMAP, HP) with:

- **Pig performance data**
- **Carcass – meat quality attributes**
- **Organ findings**

through correlation coefficients

Results

APP’s and performance

- Correlations with feed efficiency were stronger for PigMAP and become more significant to the time point of slaughter

APP’s and meat quality traits

- Positive significant correlation with IMF and negative correlation with water content in *L. dorsi*

Results

APP’s and carcass composition

- Higher PigMAP concentrations resulted in lower weight of loin and reduced proportion of belly.
- Hp and PigMAP negatively correlated with lean meat carcass and belly content.
- PigMAP positively correlated with fat / meat ratio.

Results

APP’s as predictors of increased risk for organs findings

- No clinical symptoms during the study but 18 out of 99 showed organ findings (only one case with AB treat.)
  - 9 pneumonia
  - 2 pericarditis
  - 3 milk spots
  - 5 combinations of above
- PigMAP and Hp showed positive correlations (HP r=0.180 p=0.017 and PigMAP r=0.194 p=0.027)

Results

Number of significant correlations identified through the age of the pigs (57 PigMAP, 37 Hp)

What APP should we determine?

Acute phase index (the best option using 1, 2 or 3 of them)

Heegaard et al., 2011, vet res 42, 50
APP economics
Would anyone be surprised if the result is that this is costing a lot of money?

We are putting our money in keeping the immune system active!

(energy, aminoacids,...)
APP concentration at the beginning of the rearing period was associated with hygienic status in the breeding farm.

Pigs with lower growth rate had higher APP concentration at the end of the rearing period (> or < 450 g/day, APP measured 3 days before moving to the fattening).

Animals with a higher antibiotic treatment cost during the rearing period, had higher APP concentration at the beginning of the rearing period.
And now what? What is the practical use?

1. **Research** (immunity, diseases, health, welfare, ...)

2. **Trials aiming the assessment of products** (AIF, vaccines), production systems or health plans

3. Quality of production evidences within **certification schemes**
Incorporation into Quality Assurance Schemes

Ensuring the health and management of animals delivered

Under a certain threshold of APP’s, absence of clinical disease or poor management can be ensured.
Monitoring APP in pig production.

Incorporate into quality assurance schemes

- **supplier oriented receiving inspection.**
  Analysis of new animals entering the farm
- **farm oriented in-process inspection.**
  Evaluating health, management and welfare status of herds or farms
- **customer oriented final inspection.**
  Animals to be delivered. End point analysis at slaughter line.
Rapid method
Stick PigMAP

- Immunocromatographic method (dipstick)
- Results in 15 minutes
- Positive with pig-MAP above 1.5 mg/mL
- No need of laboratory equipment
- For serum or whole blood
RISK ORIENTED INSPECTION SYSTEM

Option A) FARM

- Finishing pigs to slaughter
- Blood sample
- Pig-MAP analysis
  - < 0.75 mg/mL low risk
  - > 0.75 mg/mL, high risk

Option B) ABATTOIR

- Group sample
- Blood sample
- Pig-MAP analysis
  - < 0.75 mg/mL low risk
  - > 0.75 mg/mL, high risk

- Categorization system for farms.
- Decision on final destination of the pigs/meat.
- Classification on a quality basis.
- Risk oriented meat inspection.
- Feedback of the health status of the farms

Consider the effect of transport
Conclusions APP

1. General marker of health and welfare
2. Unespecific but sensitive, accurate enough to discriminate subtle situations and quantitative
3. Detects problems independently of its origin
4. Early detection
5. Increases with
   1. Diseases (clinical or subclinical)
   2. Stress caused by poor management during raising period and transport
6. Correlates with
   1. Increased medicines costs
   2. Losses of productive performance
   3. Higher risk of organ findings in abattoir
APP monitoring

- APP-Screening
  - cut-off
    - animal group without deviation
    - animal group with deviation
      - failure in the production
        - systematic weak-point-analysis
        - looking for infectious diseases
          - yes: findings
            - trouble shooting
          - no: weak-point-analysis to be continued

control of success
Questions to consider when Measuring APP

• How many animals to sample?
  10 animals per age group will be enough for many applications.

• Enough to detect the problem
  • Not too much because of cost.

• Take samples randomly. Do not focus in runts or chronically sick animals.

• Record information about the animal (sex, age) and management and health conditions at the farm. This will help you to interpretate the results.
Questions to consider when Measuring APP

• Avoidable Changes
  • Disease
  • Bad management condition causing stress

• Unavoidable Changes
  • Parturition
  • Weaning
  • Transport
  • Vaccination...

Detect problems in your productive system

Take into account when sampling
Pig-MAP and Haptoglobin reference values in commercial farms.

Piñeiro et al. 2009, Vet J 179, 78-84
Pig-MAP and Haptoglobin reference values in commercial farms.

Piñeiro et al, 2009, Vet J 179, 78-84
APP during a crowding period

Crowding period:
0.25m²/pig

No clinical signs

Marco-Ramell et al, 2011
Veterinary Journal.

Eight Duroc × (Landrace × Large White) male pigs (18–20 kg bodyweight) were housed in a pen with a slatted floor at a density of 0.50 m²/pig (100 kg/m², lower density, LD) at day 1, and the density was changed to 0.25 m²/pig (200 kg/m², higher density, HD) for two 4-day periods over 26 days by moving the fence (Fig. 1). The