THE RELATIONSHIP BETWEEN SERUM ACUTE PHASE PROTEINS, HEALTH AND PERFORMANCE IN FINISHING PIGS

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1. Introduction

Health status of pigs is a major determinant of performance, but is difficult to determine in an objective way in the live animal. Acute Phase Proteins (APP) are a group of liver-derived plasma proteins that change in concentration in animals subjected to infection, inflammation or stress (Murata et al., 2004). Studies (e.g. Petersen et al., 2002; Magnusson et al., 1999) have indicated the significance of the APP Haptoglobin as a clinically useful parameter for measuring the occurrence and severity of inflammatory responses in pigs. It has therefore been suggested that serum levels of APP might provide an index of health status, which could be used for such purposes as farm specific modelling of performance responses. However, data to demonstrate relationships between APP and performance are still lacking.

In a large scale study of different finishing systems for pigs carried out over a three year period (MLC, 2005; Scott et al., 2006), a number of different parameters were measured to assess the performance, health, welfare and environmental implications of two contrasting housing systems for finishing pigs. The results of this study showed that levels of APP were elevated in finishing pigs maintained in a fully-slatted relative to a straw-based system, but this did not appear to be related to clinical health indicators or growth rate differences at a population level (Scott et al., 2005). Detailed lifetime information on a subset of focal animals across the trial period was collected, and this has been used to investigate the relationships between serum APP levels and clinical health indicators, serology and performance at an individual pig level.

2. Materials and Methods

2.1. Experimental design and housing systems

Four consecutive studies were carried out over a three-year period, from April 2002 to December 2004, to generate data allowing investigation of the relationships between acute phase proteins, health and performance of finishing pigs housed in two different housing systems located adjacently on the same site. In each study, contemporary animals were housed in either a fully-slatted (FS) or straw-bedded (ST) building with scrape-through dunging passage. The buildings were, in other respects, of similar design and management (full details can be found in MLC, 2004 and Scott et al., 2006).

2.2. Animals

In each study, 1024 externally sourced (Large White x Landrace) x Large White pigs were received, at ~12 weeks of age, in eight equal batches at intervals of 1-2 weeks. Batches were allocated alternately between the housing systems, with each batch being divided into four groups of 32 pigs and each group randomly allocated to one of four pens within a single room. Numbers per pen were reduced at week six (mid-point) to 25 in the FS system (0.8m^2

per pig) and 20 in the ST system (1.1m^2 per pig), in accordance with normal commercial stocking densities for these housing types. Pigs were slaughtered at ~104 kg liveweight.

2.3. Measurements

At entry, three males and three females in each pen were selected to serve as representative 'focal' animals. These animals were used for detailed investigations of health and serology.

2.3.1. Growth and health records

Pigs were weighed at the start of the study, at the mid-point before pen reduction and at slaughter. They were inspected twice daily for signs of ill health and poor welfare. A health record was kept that included any symptoms of illness or injury, administration of drugs or other health related treatments and reasons for removing any animals from the experiment. Clinical diagnoses were made by a veterinarian according to criteria detailed within Taylor (1999).

2.3.2. Blood samples

A blood sample was taken from each focal pig at the start, at the mid-point (~60 kg) and at slaughter (~104 kg) for determination of the serum concentration of two APP: C-Reactive protein (CRP) and Haptoglobin (Hp). The concentration of Hp in serum was determined according to the haemoglobin binding method described by Eckersall et al. (1999), on a MIRA biochemical analyser (Roche Diagnostics). The inter-assay coefficient of variance (CV) was 5.3%, the intra-assay CV was 1.5%, and the limit of detection was 0.02 mg/ml. Serum concentration of CRP was determined by ELISA using the Phase Porcine CRP (Tridelta Development Ltd., Bray, Co Wicklow, Ireland) according to the manufacturer's instructions. This assay has an inter-assay CV of 6.1%, an intra-assay CV of 3.1% and a limit detection of 0.01 µg/ml.

For 4 batches of pigs in each system within each study, the serum taken from each focal pig at the start and mid-point was tested for antibodies to Porcine Reproductive and Respiratory Syndrome virus (CIVTESTsuis PRRS E/S ELISA); *Actinobacillus pleuropneumoniae* (CIVTESTsuis APP E/S ELISA); and to *Mycoplasma hypneumoniae* (Dako Mycoplasma hyopneumoniae ELISA).

2.4. Statistical Analyses

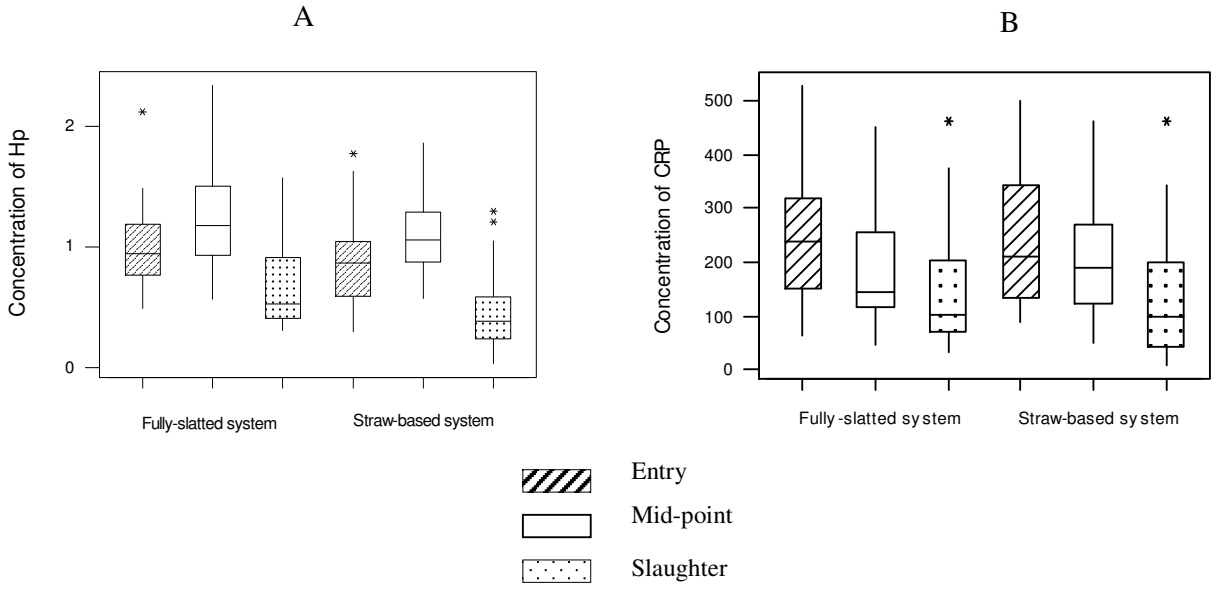
A database from a total of 384 focal pigs (96 per study) for which detailed performance, health measurements, serology and APP results were recorded, was used to investigate the relationship between these parameters. General linear models were used to investigate the effects on APP titres of clinically-diagnosed illness and seroconversion to the tested infectious agents, taking account of study and housing system in the analysis. Regression analyses were used to test the correlations between APP levels and growth rate.

3. Results

3.1 APP levels

The distributions of APP levels in each housing system at each stage are shown in Fig 1a and 1b. Hp was significantly higher in the FS system at slaughter ($P<0.01$) with a similar tendency at the mid-point ($P<0.09$). Despite a similar numerical trend, differences in CRP levels between systems were not significant. At each time point, there was a highly significant correlation between level of Hp and CRP: start $r=0.364$, $P<0.001$; mid-point $r=0.515$, $P<0.001$; slaughter $r=0.703$, $P<0.001$.

Fig 1. Box plots showing the median and inter-quartile range for levels of serum APP in different housing systems at three different sampling points: A- Haptoglobin (mg/ml) and B- CRP (µg/ml)



3.2. APP levels and clinical health status

A total of 26 pigs received veterinary treatment for clinical illness in the grower phase (start to mid-point). These pigs showed no differences in the level of either APP at the end of this stage of growth compared with pigs that had not been diagnosed with illness and consequently not received any form of veterinary treatment (Table 1). Indeed, levels of CRP were numerically lower for pigs that received veterinary treatment. When individual reasons for veterinary treatment were considered (e.g. lameness, pneumonia, PMWS), none showed a statistical difference in the levels of CRP or Hp in comparison with untreated pigs.

Table 1. Effect of veterinary treatment during the grower phase on mid-point levels of C - Reactive Protein and Haptoglobin.

	Treatment	**No treatment**	**S.E.D.**	**P**
Grower phase:				
C-Reactive protein (µg/ml)	152	199	39.7	NS
Haptoglobin (mg/ml)	1.19	1.06	0.141	NS

In the finisher phase, a total of only 7 pigs received veterinary treatment for clinical illness. With this very small sample, there were again no differences in the levels of either APP at the end of this stage of growth and for these pigs compared with those who had not been diagnosed with illness.

3.3. APP levels and serology

There was no significant difference (P>0.2) in levels of either Hp or CRP at the start of the experimental period between pigs which tested positive or negative for antibody presence of

Actinobacillus pleuropneumoniae (AP), Porcine Reproductive and Respiratory Syndrome (PRRS) or *Mycoplasma hypneumoniae* (EP).

Pigs which showed positive seroconversion for PRRS between the start and mid-point of the study had significantly lower levels of Hp at the end of the grower phase than pigs who's PRRS status remained unchanged (P<0.01; Table 2). Conversely, pigs which showed positive seroconversion for AP tended to have higher Hp levels than pigs who's AP status remained unchanged (P=0.09). There were no significant differences in the levels of CRP between pigs which showed seroconversion for AP, PRRS or EP and those which did not.

Table 2. Mid-point levels of C-Reactive Protein (µg/ml) and Haptoglobin (mg/ml) for pigs which showed seroconversion during the grower phase (Y) and those which did not (N).

Infectious agent	**AP**			**PRRS**			**EP**		
Seroconversion	**Y**	**N**	**S.E.D.**	**Y**	**N**	**S.E.D.**	**Y**	**N**	**S.E.D.**
C-Reactive protein	217	190	27.95	201	207	25.11	205	202	23.85
Haptoglobin	1.31	1.14	0.098#	1.09	1.34	0.088**	1.23	1.21	0.084

# P <0.09; ** P < 0.01

3.4 APP and growth performance

Daily live weight gain (DLWG) in the grower phase was significantly correlated with both Hp level at the end of the grower phase (r = -0.209; P<0.001) and CRP level at the same stage (r = -0.153; P<0.01). There was no significant correlation between levels of CRP at slaughter and DLWG in the finisher period; however levels of Hp were significantly correlated with finisher DLWG (r = -0.187; P<0.01).

Stepwise regression to investigate the relative importance of factors related to DLWG in the grower phase showed that Hp levels at the mid-point had the most significant (negative) effect (R^2 = 4.18; P<0.001), followed by start weight (P<0.01) and CRP level at entry (P<0.01). Step-wise regression on finisher DLWG showed that housing system had the most significant effect (R^2 = 6.12; P<0.001), followed by gender (P<0.001), Hp level at slaughter (P<0.05) and CRP level at slaughter (P<0.05).

4. Discussion

Hp levels at slaughter were significantly higher in FS pigs than ST pigs at both a larger population level (Scott et al., 2006) and for the subset of focal pigs. A similar trend was observed in mid-point Hp levels; although the statistical effect was stronger at the larger population level (P=0.054; Scott et al., 2006) compared with individual pig level. Levels of CRP at slaughter were higher in FS pigs than ST pigs at a population level (P=0.054); however there was only a numerical trend towards this amongst the focal subset. Significant correlations between levels of CRP and Hp at the same time point (start, mid-point, slaughter) were found at both a population level and at individual pig level. Chen et al. (2003) also reported positive correlations between levels of CRP and Hp in pigs.

Despite elevated levels of APP in finishing pigs maintained in FS relative to a ST system, this did not appear to be related to clinical health indicators or growth rate differences at a population level. Similarly, no relationship could be detected between clinical symptoms of disease and APP at an individual pig level. Petersen et al. (2002) reported higher levels of Hp in lame and tail bitten pigs. No such relationship could be detected in the present study, possibly because levels of Hp had returned to normal levels after the acute episode of response. However, a weak, but significant, negative relationship was detected between levels

of Hp and growth, suggesting that Hp levels may be a useful indicator of sub-clinical infection affecting performance.

5. Conclusions

Levels of the acute phase proteins CRP and Hp did not reflect observed clinical symptoms of ill health in finishing pigs. However, the weak but significant negative relationship between Hp and growth rate suggests that this might be a useful indicator of sub-clinical infection affecting performance.

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