Recording haemoglobin levels in sows, piglets and growing pigs on farm

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Haemoglobin - a selection criterion in pig breeding programs

Using haemoglobin levels in blood as a selection criterion for iron content in pork was proposed at the previous AGBU Pig Genetics Workshop (Jones and Hermesch, 2010). Since then, a project has been completed demonstrating that haemoglobin levels recorded on farm using the HemoCue Hb 201$^+$ analyser can indeed be used as a selection criterion for iron content in pork and other pork quality traits. Haemoglobin levels in growing pigs had moderate genetic correlations with iron content in pork, redness of pork and pH 24 hours *post mortem* (Hermesch and Jones, 2012). However, it was also noted that the recording procedures used on farm during the project should be modified to improve the accuracy of on-farm measures of haemoglobin levels.

Haemoglobin levels above 100 g/l are considered adequate, whereas haemoglobin levels of 80 or 70 g/l are generally considered borderline anaemic or anaemic (National Research Council, 1998). Piglets raised in intensive production systems do not have access to soil, a natural source of iron, and require supplementation of iron to prevent piglet iron deficiency anaemia. This requirement was first described in the 1920s as outlined by Payne (2009) who provided a comprehensive review of the numerous studies conducted over the last 90 years to evaluate alternative husbandry practices and their effects on iron status in piglets.

A recent study found that piglets with higher haemoglobin levels at birth had higher survival rates prior to weaning (Rootwelt *et al.* 2012). The mean haemoglobin levels of piglets surviving or dying until weaning were 105 g/L versus 99 g/L. In sows, a gradual reduction in mean haemoglobin levels with increasing parities was found in a survey of herds conducted in Western Australia (Gannon *et al.*, 2011). The authors concluded that progeny of sows with marginal haemoglobin levels of below 100 g/L were at greater risk of iron deficiency. Based on a review of the literature, Capozzalo *et al*. (2009) hypothesised that iron deficiency in older sows is expected to be mirrored in their progeny. However, the review also showed that supplementation of sows with iron during gestation did not raise iron levels in piglets.

There is a paucity of studies investigating the genetic configuration of haemoglobin and its genetic associations with other traits. A small selection experiment for high haemoglobin levels in piglets was initiated in the early 1960s based on eight Yorkshire sows (Fahmy and Bernard, 1978). Information from this selection experiment is very limited and 'the experiment was terminated abruptly after the fourth generation because of an unexpected reproductive problem.' The information available indicated differences in haemoglobin levels in piglets between the selection line for higher haemoglobin levels in piglets and a control line. The authors concluded that 'the problem is worthy of further investigations'.

A series of experiments were conducted in mink to evaluate genetic differences of haemoglobin levels between breeds and between selection lines within breed (Geddes-Dahl and Helgebostad, 1971). The experiments showed that fecundity and haemoglobin levels were interdependent traits and had to be considered simultaneously. The comparison of breeds showed lower fecundity for the breed with lower haemoglobin levels. Progeny from sires with high haemoglobin breeding values tended to be more viable and fecundity was far superior for the within-breed selection line for higher haemoglobin levels. Overall, these early results indicate that genetic associations between haemoglobin levels and viability or fecundity exist.

Haemoglobin levels may therefore be used as a selection criterion for reproductive performance of sows and piglet viability. The study by Hermesch and Jones (2012) concluded that recording procedures used during their study should be modified. Therefore, it was the aim of this study to evaluate the accuracy of a modified recording procedure for haemoglobin levels in sows, piglets and growing pigs.

Haemoglobin levels in sows

1. Recording procedure

Evaluation of recording procedures for haemoglobin levels in sows prior to farrowing and one-day old piglets were based on 47 sows from two maternal lines. These sows represented first (15 sows), second (15 sows) and third (17 sows) parity sows. Sows were ear pricked on entry to the farrowing house to collect drops of blood for two replicates of measuring haemoglobin levels in blood. The time was recorded when each sow was measured for haemoglobin levels indicating that it took on average about two minutes to record each sow for both haemoglobin measures.

2. Results

Haemoglobin levels in sows were 106.2 to 107.9 g/L for the duplicate measures (Table 1). The coefficient of variation was low with values around 8%. In comparison, the coefficients of variation were considerably higher for sow weight and fatness depth in sows. Larger variation in sow weight is expected due to the large parity effects for sow weight. Fat depth recorded in sows has been found to be more variable in Australian data sets in comparison to European data sets (Gilbert *et al.*, 2012).

A maximum difference between two replicates of a specific measure of 10% of the mean is often used as a criterion to evaluate the accuracy of a measurement. Only measurements from one sow exceeded this threshold value, haemoglobin measures in all other sows achieved this criterion. The correlation between both haemoglobin measurements was 0.89 and the close association between both measurements is further illustrated in Figure 1.

Table 1. Data statistics for sow traits.

Variable	N	Mean	SD	CV	Min	Max
Sow weight (kg)	47	249.4	42.32	17.0	180	316
Sow fat depth (mm)	47	21.6	5.127	23.7	13.5	39.2
Haemoglobin - 1st measure (g/L)	47	106.2	9.95	9.37	79	128
Haemoglobin - 2nd measure (g/L)	47	107.9	8.48	7.86	85	122
Average haemoglobin level (g/L)	47	107.1	8.96	8.36	82.5	123

SD, standard deviation; CV, coefficient of variation; Min and Max, minimum and maximum.

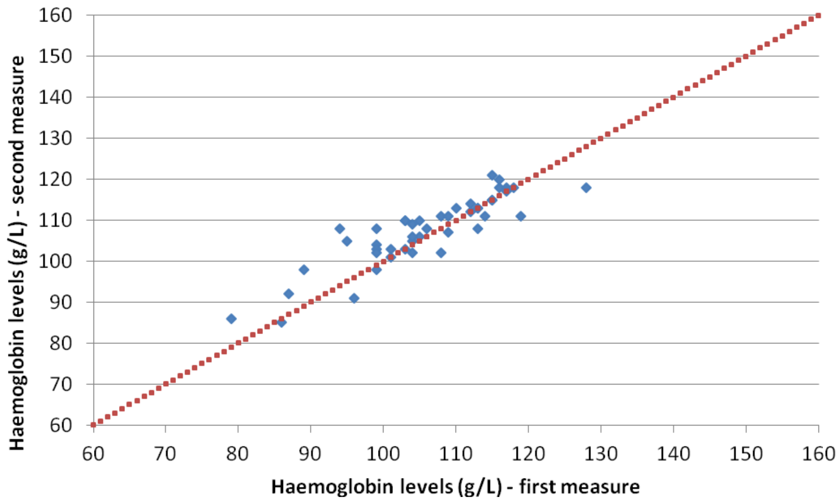

Figure 1. Plot of first versus second measure of haemoglobin levels recorded in sows.

Haemoglobin levels in piglets

1. Recording procedure

Shortly after farrowing, two male and two female piglets were chosen based on their birth weight. Each litter was represented by a light, two medium and one heavy piglet. Two blood samples were collected from the ear and two blood samples from the cut-off tail of one-day old piglets. The design was fully cross-classified within each litter in regard to the order of haemoglobin measurements from each blood-collection site on the piglet. These piglets had not received any iron injection prior to recording haemoglobin levels. On average it took about four minutes to record all four haemoglobin measures on each piglet.

2. Results

Duplicate haemoglobin levels in piglets were recorded at two locations using either the ear or the cut-off tail to collect droplets of blood. Mean haemoglobin levels were higher for measurements taken at the ear in comparison to the measurement based on the tail (Table 2). The average haemoglobin level based on the first two ear measurements was 88.6 g/L in comparison to 83.6 g/L for the equivalent measurement taken at the tail. Analysis of variance using a generalised linear model showed that location was the only significant effect for haemoglobin levels in piglets in these data.

The coefficients of variation varied from 16 to 18% for measures taken on the ear in comparison to coefficients of variation ranging from 21 to 23 % for measures based on the tail. The higher coefficients of variation for haemoglobin measures taken from the tail indicate a larger measurement error for this site to collect blood droplets.

Measurements taken later on the pig increased the mean haemoglobin levels from 88.6 g/L to 92.7 g/L for measurements taken at the ear of the piglet. An increase of 5.1 g/L may be of biological importance although this increase was statistically not significant (P: 0.55) since it was only observed at the ear. The order of measurements did not increase the mean tail measurement, which may be expected given that the tail has been removed from the animal.

Handling piglets including cutting the tail poses a certain level of stress to the animal, which has been shown to increase haemoglobin levels (Dubreuil *et al.* 1993). However, the increase in haemoglobin levels observed in the current study of about 5 g/L was lower than the increase in haemoglobin levels of about 20 g/L observed by Dubreuil *et al.* (1993) following a five-minute snare.

Table 2. Data statistics for haemoglobin levels in piglets.

Variable	N	Mean	Std Dev	CV	Min	Max
	Ear was first location to collect blood					
Piglet birth weight	89	1.61	0.32	0.20	0.53	2.40
1st haemoglobin measure - ear	94	88.5	15.5	0.17	50.0	130.0
2nd haemoglobin measure - ear	94	88.7	15.9	0.18	54.0	127.0
3rd haemoglobin measure - tail	94	81.6	19.1	0.23	39.0	134.0
4th haemoglobin measure - tail	94	83.5	18.0	0.22	43.0	132.0
Average haemoglobin level - ear	94	88.6	15.4	0.17	52.0	128.5
Average haemoglobin level- tail	94	82.6	17.7	0.21	41.5	133.0
	Tail was first location to collect blood					
Piglet birth weight	88	1.60	0.34	0.21	0.55	2.38
1st haemoglobin measure - tail	92	82.3	19.0	0.23	27.0	126.0
2nd haemoglobin measure - tail	92	85.0	17.6	0.21	28.0	125.0
3rd haemoglobin measure - ear	92	93.5	16.8	0.18	53.0	146.0
4th haemoglobin measure - ear	92	91.9	15.2	0.16	54.0	138.0
Average haemoglobin level - tail	92	83.6	17.6	0.21	27.5	125.5
Average haemoglobin level - ear	92	92.7	15.4	0.17	53.5	138.0

SD, standard deviation; Min and Max, minimum and maximum; CV, coefficient of variation

The Pearson correlation between duplicate measurements was highest (0.92) for haemoglobin levels based on the two first measures of the ear. This correlation dropped to 0.86 when the two measurements at the ear were taken after the tail had been cut off. The correlations between duplicate measures based on blood droplets collected from the tail were 0.85 and 0.83 for the first and second pair of duplicates recorded on the tail. The higher repeatability of measurements based on the ear versus the tail is illustrated in Figure 3 and Figure 4.

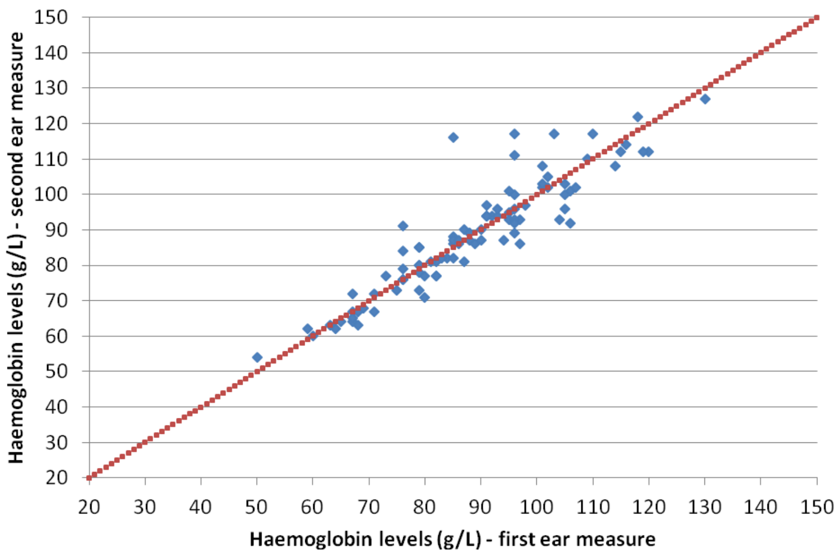

Figure 2. Plot of first versus second ear measure of haemoglobin levels recorded in piglets.

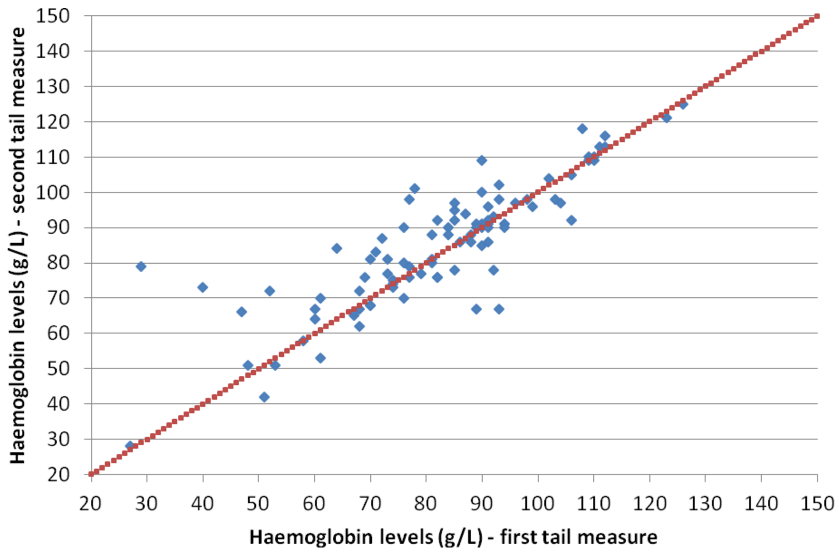

Figure 3. Plot of first versus second tail measure of haemoglobin recorded in piglets.

Haemoglobin levels in growing pigs

1. Recording procedure

Haemoglobin measurements were also evaluated on 50 male and 48 female growing pigs from one maternal line. Most pigs were recorded on one day (N=84), while the remaining pigs were recorded on the subsequent day. The recording time of haemoglobin levels was much more variable for growing pigs as the larger animal had to be secured for the collection of blood droplets from the ear.

2. Results

The mean haemoglobin level of these pigs was 109 g/L based on the average of both measurements (Table 3). Using a replicate value reduced the variation slightly in comparison to the single measurements. The mean difference between both haemoglobin measures was small with 2.25 g/L although there was considerable variation in the difference between both haemoglobin measures observed for individual pigs.

Table 3. Data statistics for haemoglobin levels in growing pigs.

Variable	N	Mean	SD	CV	Min	Max
Live weight (kg)	98	74.21	9.29	12.5	50	103
1^{st} haemoglobin measure (g/L)	98	109.8	11.7	10.6	70	153
2^{nd} haemoglobin measure (g/L)	97	107.9	11.5	10.7	71	137
Average haemoglobin level (g/L)	97	109.0	10.4	9.55	83	136

SD, standard deviation; Min and Max, minimum and maximum; CV, coefficient of variation

A maximum difference between two replicates of a specific measure of 10% was not achieved for 13% of pigs for which the difference between both haemoglobin measures exceeded 11 g/L. The Pearson correlation between these two measures was 0.68. This comparably low correlation between the two measurements was due to some extreme outliers for one measurement as indicated in Figure 4.

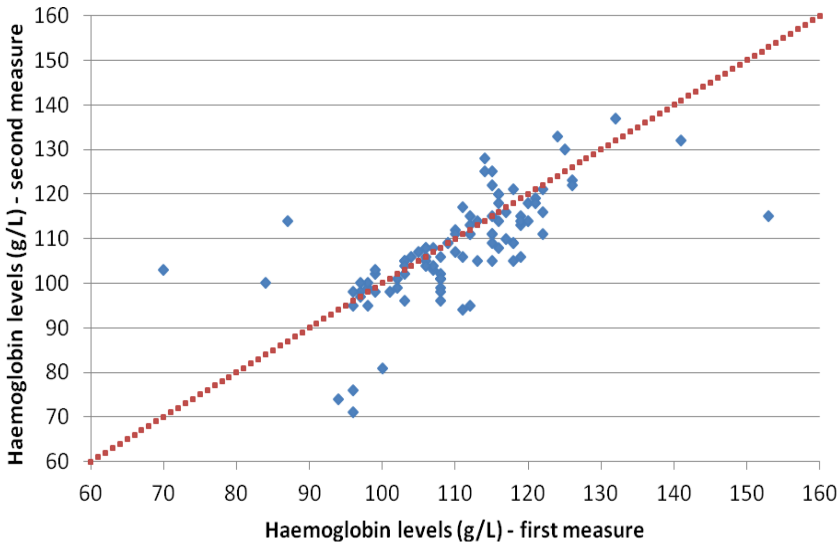

Figure 4. Plot of first versus second measure of haemoglobin levels recorded in growing pigs.

Summary

Sows. The collection of droplets of blood of sows staying in farrowing crates has worked well and can be recommended. The procedure can easily be done in the shed when sows are placed in the farrowing crate. The high repeatability indicates that one measure is sufficient once the recording procedure has been established on farm for each operator by taking repeated measures initially.

Piglets. Haemoglobin levels can be recorded in one-day old piglets using drops of blood from the ear. Measurements were highly repeatable in the current study and one measure should be sufficient once an operator has become familiar with the testing procedure on farm.

Growing pigs. It is possible to use ear pricking as a methodology to collect drops of blood for measuring haemoglobin levels. However, growing pigs will have to be secured by a snout rope during the collection process to ensure the safety of the operator. The correlation between repeated haemoglobin measurements was lower than corresponding correlations between haemoglobin measures obtained in sows and piglets. It is recommended to use two replicates for the measurement of haemoglobin levels in growing pigs with the HemoCue Hb201^{+} system on farm.

Acknowledgements

This project was funded by Australian Pork Limited under project APL 1025.

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