Breeding pigs with improved disease resilience

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Resilience

The "ability to maintain a relatively undepressed production level while infected" was defined as resilience by Albers *et al.* (1984). In sheep breeding, selection for resistance versus resilience to nematode challenge has been well investigated. A third avenue is breeding for disease tolerance. Differences between disease resistance and disease tolerance have been outlined by Guy *et al.* (2012) in this workshop. Specific definitions and measurements of resilience used by various authors were discussed by Bisset and Morris (1996), who pointed out that both resistance and tolerance mechanisms may contribute to the expression of resilience, when it is defined in terms of productivity relative to a standard challenge level.

This definition of disease resilience also implies that information is required about productivity, health and physiology of pigs, as well as measures of the environment to quantify the challenge level that pigs experienced.

Pig measurements

The following measurements may be used to quantify how pigs respond to selection for resilience.

1. Performance and physiological parameters

Growth has been used as a proxy for growth and negative genetic associations between some immune traits and weight gain have been demonstrated (Clapperton *et al.*, 2005, 2008, 2009). Growth as a proxy for health may be more useful than incidence of disease, since Henryon *et al.* (2006) found no genetic associations between baseline levels of a number of immune traits and resistances to respiratory, lameness and other diseases. Significant genetic associations were only found between haptoglobin and lameness. Further, disease resilience implies that a reasonable level of production is maintained by pigs when they face infection (Albers *et al.*, 1987), highlighting the importance of repeated weight measurements over the growth trajectory of the pig.

2. Clinical and subclinical diseases

Henryon *et al.* (2001) showed that genetic variation exists for clinical and subclinical diseases. This occurred even when simple on-farm measurements were used to describe the incidence of various diseases, such as treatment of a pig for a specific disease or incidence of simple characteristics (lameness, respiratory diseases, diarrhoea, skin disorders, sneezing, coughing). Further, rectal temperature and respiration rate have been used as additional physiological parameters to quantify the response of pigs to climatic stressors (Huynh *et al.*, 2005) and to infection with a specific disease such as porcine reproductive and respiratory syndrome virus (PRRSV) (Doeschl-Wilson *et al.*, 2009).

3. Immune parameters

A wide range of immune parameters have been shown to be moderately to highly heritable (Flori *et al.* 2011, Henryon *et al.* 2006, Clapperton *et al.* 2005, 2008, 2009). The range of immunity traits was grouped by Flori et al (2011) into traits describing global immunity, cell-mediated adaptive immunity, humoral-mediated adaptive immunity, innate immunity and other haematological traits. So far, there is no consensus among scientists about which specific immunity traits to use in pig breeding programs. However, Bishop *et al.* (2002) point out that heritability estimates for traits describing general disease category tend to be lower than heritabilities for traits measuring specific immune responses. This trend may also explain the significantly high heritability estimates (above 0.5) found by Flori *et al.* (2011) for 25 of the 32 immune traits investigated. In this study blood samples were collected three weeks after pigs had been vaccinated for *Mycoplasma hyopneumoniae*. Therefore, blood samples to record immunity traits should be collected following vaccination or following another unspecified immune challenge.

White blood cells may be used as an indicator of infection level for a group of pigs. Further, a higher heritability was found for white blood cells at a lower health status (Clapperton *et al.*, 2008), indicating that genetic variability for this trait may be better expressed in low health environments. White blood cell count was also higher in dominant pigs in the study by Sutherland *et al.* (2006) and may be a useful indicator of social status of pigs within a group.

Acute phase proteins provide a tool for veterinary applications to measure health status that are based on the extent of inflammation and tissue damage (review by Petersen *et al.* 2004). Subclinical disease may not lead to overt disease but impact on suboptimal growth and reduced animal welfare. Higher haptoglobin levels are believed to be signs of subclinical disease and have been shown to be associated with reduced growth (Petersen *et al.*, 2004; Clapperton *et al.*, 2005). Further, a number of infections including *Escherichia coli*, *Actinobacillus pleuropneumonia* and *Mycoplasma hyorhinis* lead to increased haptoglobin levels in pigs (Petersen *et al.*, 2004). The authors suggested using haptoglobin levels as a marker of herd health status in pigs.

Measures of the environment

1. Environment of the group of pigs housed together (contemporary group)

Information about which animals were housed together along with pedigree information can be used to derive a number of environmental parameters that affect performance and health status of animals, as identified by Madec and Leon (1999) and Black *et al.* (2001). This concept was used by Jones *et al.* (2011), who identified a number of group characteristics like number of pigs and litters per group, mean flight time of pigs in each group, and proportion of Duroc pigs in a group that affected performance of individual pigs. Further, the dimensions and designs of each pen, as well as the dimensions of the shed, can be collated to obtain more detailed information about the pen environment within each shed. This should include information about feeder space (Madec and Leon, 1999), as well as proportion of slatted floors versus solid floors and level of soiling of the solid, which has been shown to be affected by temperature and body weight of pigs (Aarnink *et al.* 2006). Over the growth trajectory, pigs are housed in different environments (sheds or pens) and ideally this information should be available for each environment an animal is housed in during each growth phase.

2. Air quality and climatic conditions.

"Decrease the presence of agents that elicit an immune response" was listed as the first strategy to improve immune response, health and productivity outcomes in the recent review of Black and

Pluske (2012, Review of the Immune system in pigs. Executive summary, Review for APL.). A number of handheld devices are commercially available that allow measurement of air quality on farm.

Climatic conditions have been shown to affect pig performance (review by Black *et al.* 2001) and a number of physiological parameters (Huynh *et al.* 2005). Information available from the nearest meteorological station has been used successfully for evaluation of genotype by temperature interactions using Australian (Lewis and Bunter, 2011) and Dutch data (Bergsma and Hermesch, 2012). However, more specific information about temperature and humidity recorded in the shed may be recorded from time to time to describe specific environmental conditions within the shed more precisely.

In summary

Genetic parameters are required for a range of growth, health and immune and physiological traits taking variation in environmental challenges into account. Models will have to be developed to describe the response of individual genotypes in key traits to variation to environmental conditions, as defined by group characteristics, pathogen load, air quality and climatic conditions. Results from this study will identify key environmental parameters and potential selection criteria for disease resilience.

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