

# The Effects of Biological and Production Changes on Animal Health

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## ■ Introduction

During the last few years there have been tremendous changes in the swine industry that have had an impact on swine health. The changes derive, for the most part, from moving to an intensive rearing of the animals and the practices associated with it. Modern production systems are required to be cost effective, which is achieved in part by having more efficient animals. Selection programs with focus on selection for feed efficiency, growth and reproductive traits, have been a main priority for breeding stock companies. A central question is whether selection programs with such objectives have had any effect on animal health and whether animals today are more susceptible to diseases than before.

In addition, adoption of multi-site systems has resulted in changes on the epidemiology of diseases such as *Mycoplasma hyopneumoniae*, *Haemophilus parasuis* and *Streptococcus suis*. Segregated production and multi-sourcing has greatly influenced disease presentation in modern systems with more severe outcome of diseases when these are present.

This paper discusses the effects that biological and production changes as a result of intensive production may have had on health.

## ■ Change in Production Systems

For the last 15 years, the swine industry has seen many changes in its production systems. Previously, farrow to finish operations of relatively small size (<500 sows) were the industry standard. Since the adoption of the

concept on multi-site production, the industry saw a revolution in the way pigs were raised. Structural changes were made in production systems with the segregation of the different stages of production, the adaptation of early weaning and the co-mingling of sources.

## Microbial Colonization Patterns

These changes in the production systems have had various effects on health. In one extreme, the strategy of segregation and early weaning has resulted in changes in the colonization pattern by commensal organisms. The rearing of replacement animals and sows separated from growing pigs has also resulted in a diminished microbial exposure of the sows, which has a direct effect on the levels of sow immunity and the subsequent effects on the levels of maternal immunity in the progeny.

In turn, these segregated systems have produced naive populations of growing pigs susceptible to infections by pathogens considered early colonizers (*H. parasuis*, *S. suis*, *A. suis*). In these instances, the level of colonization by pathogenic strains at weaning is correlated with the presence of disease during the growing stage. Low prevalence at weaning is thought to result in higher disease levels after weaning with the result that dissemination of infection to the majority of the pigs, and hence the occurrence of disease, will happen during the nursery stage when maternal immunity is low and the pigs have yet to develop active immunity. However, in the case of *M. hyopneumoniae* infection, which is considered to be a late colonizer, high prevalence at weaning is associated to classical enzootic pneumonia with coughing and losses seen during the nursery and early growing periods. When prevalence at weaning is low to moderate (10-20%), onset of disease may be seen later in the finishing period presenting itself very acutely and being difficult to control.

## Co-mingling Practices

Changes in the production systems have also resulted in co-mingling practices with piglets from multiple sources to allow the implementation of whole site all-in/all-out practices. Multi-sourcing of sites brings its own challenges, since sow populations will have different health statuses, and stocking of the sites with all animals having the same health and immunological status is impossible. A complicating factor on top of the aforementioned ones, is the fact that pigs need to be transported multiple times resulting in the mixing and adaptation of the pigs to different

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environments. In addition, transport brings an additional level of complexity. Stringent biosecurity measures in transport cannot always be followed, which may result in severe infections in the newly transported population.

Overall, the changes discussed in this section have had an impact on health. The presentation of clinical signs of disease tends to be more severe when these high health segregated populations get infected. Timing and severity of disease presentation can also be influenced by the level of pathogen colonization at weaning and the levels of immunity that the sows confer to their progeny. Therefore, changes in intervention practices need to be adapted to these disease manifestations.

## ■ Change in Biology of Animals

There is very little information available that allows us to determine the biological changes that have occurred as a result of genetic selection, and whether these changes had an effect on health. There are some examples from pigs, poultry and dairy that may shed light on this process.

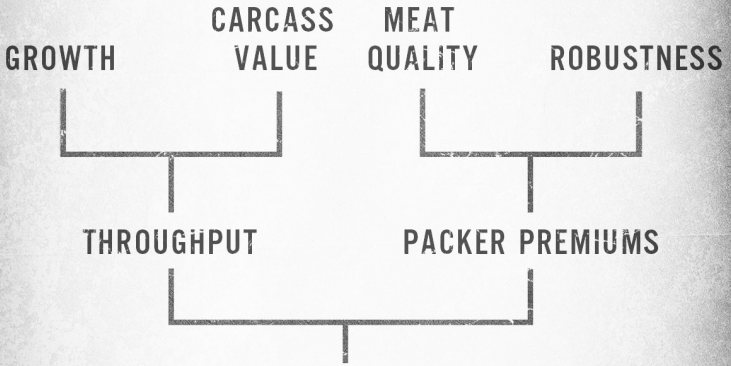
Biological changes in animals result from the ongoing adaptation to their environment. Nowadays, biological change is more the result of intensive breeding selection. Genetic selection has been one of the most important tools used to increase production levels (growth efficiency and reproduction capacity) for livestock species. However, apart from specific examples, information is often lacking on nature of the relationships between production and health traits. Cases where unfavourable relationships exist tend to derive from situations where considerable genetic pressure has been placed on a single trait, and this has led to detrimental and unforeseen side effects. Therefore selection programs should include selection for more than production traits alone.

In addition, since selection is basically a black box technique, the underlying physiological processes on which genetic selection acts are generally unknown. An increased knowledge of biological processes that will result from genetic research should offer the opportunity to understand, anticipate and prevent undesirable side effects of selection.

### **Pigs**

In pigs, one example on the effect of selection on production parameters is the effect on leg structure and soundness. Information on selection for high lean tissue growth rate in an experimental study with Lacombe boars showed an effect on leg weakness (Sather, 1987). Study pigs had a greater incidence of leg weakness in the fore leg (29.5%) and rear leg (41.5%) than non-selected

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control pigs. In addition, in several different studies, pigs with high leanness and growth rate also had worse leg scores and worse osteochondrosis scores in both the elbow and the knee joints (Lundeheim, 1987). When selecting for leanness and growth, leg score should be part of the selection index in order to avoid leg weakness in future generations. Indeed, this strategy has now been incorporated into PIC's breeding programmes for a number of years.

## Dairy

In dairy cattle, selection for high genetic merit in terms of milk production has been associated with more cases of digestive disorders, foot rot, skin or skeletal disorders, udder edema and mastitis, when such cows are compared with lower genetic merit cows. Currently, much focus in dairy cattle breeding programs is directed towards halting the decline in fertility and the increase in mastitis incidence that arises as a consequence of genetic increasing milk yield.

## Poultry

In poultry, the effect that selection for high body weight has had on the immune response has been documented. For example, broilers selected for high growth rates showed lower antibody responses when challenged with sheep erythrocytes, however, little or no difference was found between lines in macrophage and natural killer cell functions. Differences in mortality among lines selected for high body weight were observed in turkeys exposed to a natural outbreak of erysipelas, and when challenged with either *Pasteurella multocida* or Newcastle disease virus. In broilers one of the best documented examples of undesirable correlated responses has resulted in an increasing incidence of heart failure and circulatory problems, i.e. ascites. However, this and other problems such as leg weakness have been recognised by the major breeding companies and are being addressed in their breeding programs.

## Breeding Programs

Until recently, in poultry breeding programs, selection had almost been based on single trait selection, e.g. body weight at a certain age or egg number, with a high selection intensity and a short generation interval. In

*Intensive selection for production traits alone has had a negative effect on health*

species like cattle and pigs, selection has generally been less intensive, for more traits and for fewer generations. In addition, undesirable side effects may be camouflaged because of the multi-factorial nature of most problems.

In conclusion, intensive selection for production traits alone has had a negative effect on health for traits such as leg structure and circulatory problems. Information on the impact of selection on resistance to infectious diseases is less clear. However, in order to prevent potential negative effects, genetic programs must utilize selection indexes that emphasize traits such as robustness and survivability. Although knowledge of the underlying physiological processes on which genetic selection acts is hard to obtain, it is important to gain information on the biological processes underlying selection. Therefore, it is important to understand the genetic control of physiological processes, and in this way anticipate and prevent negative side effects of selection on health. New genomic technologies available to researchers should help us to achieve this.

## ■ **Are the Changes in the Biology of the Pig Responsible for the Changes in the Pathogens and the Emergence of New Diseases?**

Emergence of new diseases and evolution of pathogens is an issue of critical importance. Complex host-pathogens interactions guide the evolution of both hosts and pathogens. It is almost impossible to assess the absolute risks of pathogen evolution and it is also difficult to determine what changes in the host force the changes in the pathogens.

### **Pathogen Evolution**

The risk of pathogen change depends on multiple factors such as: the primary nature of the resistance mechanism (e.g. tolerance vs. resistance), the selection pressure, the number of genes responsible for resistance, the genetic diversity of the host, the host and pathogen generation intervals, the mechanisms of resistance, the pathogen meta-population dynamics and whether the selection for disease resistance is by genetic markers or by phenotypic indicator traits.

All these factors contribute to the likelihood of pathogen evolution. These factors are not only responsible for pathogen change but they also determine the rate at which pathogens change. However, since it is assumed that a pathogen will continue to evolve in response to a change in the host by natural evolution, a more relevant question is whether pathogen change or pathogen emergence is more likely to happen under genetic control strategies in the host compared to other health control strategies, such as antibiotic usage or vaccines.

Generally speaking, applying genetic change in host populations will result in weaker selection pressures on the pathogen than the use of biological measures such as vaccines or pharmacological products. Therefore the use of genetic control strategies in the host should result in approaches that pose a lower risk of inducing pathogen change and these strategies should be therefore more sustainable in the longer term.

## **Genetic Change and Pathogen Evolution**

In addition, since any health control strategy is not absolute and it is fair to say that any disease control measure aimed at reducing pathogen replication may lead to genetic changes in the pathogen to escape the control measure, it should be noted that the best control strategies should combine different approaches.

Under most circumstances using genetic changes in the host to help control disease should be at least as sustainable as other disease control measures such as vaccines or pharmacological products, and possibly more so in the longer term. The risk of inducing the emergence of new diseases due to genetic changes in the host should also not be greater than the risk posed by other approaches.

However, this is a field of research that needs further study. To the question of whether the changes in the pig are responsible for the emergence of diseases such as PRRS or PMWS, it must be concluded that this is completely unknown at this time – at best just a guess. As discussed above, the area of pathogen and host interactions is a complex subject and it is unlikely that genetic change in the host alone is the mechanism responsible for the emergence of new diseases.

## **■ Conclusion**

Changes in animal health are the result of multiple factors. Among these factors, changes in both the livestock production practices and the underlying biology of the pig are important to consider. Nowadays these changes are under more scrutiny due to the practices associated with intensive animal production and breeding programs with an emphasis on production traits.

The most important changes in livestock production practices with a direct effect on health include the adoption of multi-site and co-mingling practices.

Information on changes in the biology of the pig resulting from genetic selection, and their direct effect on health is limited. There are documented cases in pigs, dairy and poultry, that show that selection for single production

traits can have a detrimental effect on health traits such as leg structure, mastitis and heart and circulatory problems. Therefore, it is critical that breeding stock companies include robustness and survivability traits as part of production selection indexes. However, most large-scale breeding companies do recognise these issues and they generally do include fitness-related traits in their selection programs.

In addition, a question that warrants further research is whether the changes in the biology of the pig are responsible for changes in the pathogens and the emergence of new diseases. Pathogens and hosts continue to evolve through complex interactions. It is almost impossible to assess the absolute risks of pathogen evolution and it is also difficult to determine what changes in the host force the changes in the pathogens. However, it is unlikely that genetic change in the host alone is the mechanism responsible for the emergence of new diseases such as PMWS or PRRS.

## ■ References

- Bishop SC, Stear MJ (2003). Modeling of host genetics and resistance to infectious diseases: understanding and controlling nematode infections. *Vet Parasitology*. 115:247-166.
- Lundeheim, N (1987). Genetic analysis of osteochondrosis and leg weakness in the Swedish pig progeny testing scheme. *Acta Agric. Scand.* 37, 159-173.
- Sather AP (1987). A note on the changes in leg weakness in pigs after being transferred from confinement housing to pasture lots. *Anim Prod* 44: 450-453.