RESILIENCE IN SOWS – DOES IT EXIST?

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1. Introduction

Breeding for high performance is generally associated with an increasing sensitivity of the animals to harmful environmental factors. These include, among other things, herd management, the climate, feeding, husbandry, but also pathogen loads of all kinds and diseases. In the case of the animals that react sensitively, this very often leads to a loss of performance, illnesses and to early departure from the herd. This has a negative effect on economic efficiency and above all represents an important animal welfare problem. It affects the ethical justification for us humans to breed, keep and use high-performance animals. This is particularly true for the very fertile sows in piglet production. A project group headed by Professor Bennewitz, University of Hohenheim, has drawn up a position paper on behalf of the DGfZ and published it as a basis for discussion in scientific journal Züchtungskunde Issue 3/2021 (BENNEWITZ et al., 2021). Today society and politics are increasingly pushing for extensive keeping and feeding conditions with the consequence that the concept of performance breeding is no longer the top priority.

Compared to earlier years, in which the production of food and raw materials by and with animals in one's own country had a different status for society than it is today, there is increasing talk of a welfare problem with regard to agricultural livestock husbandry. The health and well-being of farm animals are discussed intensively and negative connections to high performance are declared to be indispensable. Furthermore, livestock husbandry in society is discussed with a view to environmental impacts, resource consumption and food competition with humans. This applies to husbandry and feeding issues. The effects of this nationwide social discussion are already noticeable, meat consumption is tending to decrease more and more and in 2020 was only 57.33 kg, i.e. 3.6% less than in 2019. In order to cushion the effects of various housing and feeding conditions, pig lines with animals are required that have a high buffer capacity, resilience (BENNEWITZ et al., 2021).

The effects on high-performance animals, which are largely production diseases, are often the cause of reduced performance and premature abandonment. This is contrary to today's ideas about animal welfare and animal welfare. However, this problem cannot be viewed comprehensively in a monocausal manner because it is caused by multiple factors. The closely interrelated exogenous and endogenous factors play a role. The multitude of influencing variables, e.g. metabolism and fertility, interact via negative and positive feedback mechanisms. Thanks to the buffer capacity of the individual, there are often delayed reactions to the influencing factors. It is known that sows react very differently to individual influencing factors that have the same effect. This is where the term "resilience" comes in, which can be translated as "spring force" (cushioning). It represents the ability of the organism to maintain the initial state or to restore it in a short time after an external influence, e.g. a stress factor or an illness.

The aim of this article is to focus more on this natural "spring force" in high-performance sows. The question of which approaches are seen for early resilience diagnostics should be investigated. How is resilience expressed in high-performance sows, is it measurable and predictable and can the result be used in the breeding sense with a view to improved animal health with consequences for longevity?

2. Situation in sow husbandry

In pig breeding and piglet production, the fertility as well as the rearing performance of the sows has increased significantly for several years (BRANDT, 2010). For a long time, the increase in reproductive performance unfortunately tended to go hand in hand with a contrary development in the longevity and longevity of the sows (BRANDT, 2014). In addition, an increased susceptibility to disease in highly proliferative sows compared to animals bred less for high fertility was communicated (FLEISCHER et al., 2013). As a result, the causes for the excretion of the animals from the breeding stock are very diverse. It is also noticeable that unfortunately no clear cause was given for a large proportion of the animals lost (FREITAG and WITTMANN, 2009; DODENHOFF and BERGERMEIER, 2017), which of course contradicts all measures to reduce certain causes of departure. For a few years now, however, there has been an encouraging positive trend with regard to life performance of sows (HOY et al., 2017).

The susceptibility of high-yielding sows to disease and the high rates of loss at too early an age reflect the inability of the organism to adapt to the increased metabolic, physiological and endocrinological demands resulting from the rapid succession of reproductive cycles under the given environmental conditions. This particularly applies to the phases of insemination and conception, the transition from high pregnancy to birth (transit phase), suckling period and the phase between weaning and re-fertilization in which the sows' metabolism undergoes enormous adjustment processes (MENN, 2015; MAI et al., 2015) is exposed.

3 Resilience

In 1973, HOLLING defined the term resilience as a stability concept for ecological systems. Resilience, the spring force related to the animal, its health and performance, is the ability of the organism to maintain its initial state after an external influence or to return to it after a deflection. As early as 1950, BERTALANFFY described resilience or spring force in his system-theoretical considerations by referring to the ability of the organism "to maintain or restore the system in its own condition in the event of disturbances caused by external influences" (VOIGT, 2001). COLDITZ and HINES (2016) associate the term resilience with the ability of an animal to be either only minimally influenced in the face of an acute disturbance induced by environmental influences or to be able to immediately return to the state it was in before exposure. Animals, as well as humans, are basically able to return to a state of equilibrium within a wide range of variables after they have been deflected (LEPHERD et al., 2009).

According to CARPENTER (2004), this state of equilibrium is regulated via the network of a complex system in which interactions with positive feedback loops for building up and negative feedback mechanisms for controlling are effective. The build-up leads to instability of the system, which then has to be controlled. According to LIU et al. (2012) distinguished three different phases, the normal state, the state immediately before the strong deflection and the state of the extreme deflection. This applies to the case of illnesses as well as strains with effects on the metabolism, the circulatory system and / or the natural immune threshold.

In the normal state, the organism succeeds in preventing the deflection or the organism is in a stable equilibrium. This equilibrium becomes unstable in phase 2. The organism reacts sensitively to external influences, whereby it can normally return to the normal state without any problems. However, it can also happen that in this state the organism already reacts to minor external influences with a critical transition into phase 3, i.e. into the phase of extreme deflection. In this case, the organism becomes sick or it is subject to the stress factor. The system falls over. Production diseases are examples of such deflections from the normal state. A disease, apart from hereditary diseases, can therefore also be seen as the result of excessive, exogenous influence or as the result of low tolerance, immunity or a lack of resilience.

Both exogenous (environment-related) and endogenous (animal-related) factors play a role in the development of production diseases. Within a certain range, the animal is able to react to exogenous influences, as already described above, so that it is either not deflected from its normal state at all or returns to the normal state after a short phase of deflection. The sow's metabolism follows the rules of a complex system consisting of a large number of variables that interact with one another via positive (reinforcing) or negative (inhibiting) feedback mechanisms. Stability in a complex system is primarily ensured by the presence of negative feedback mechanisms, while positive, i.e. reinforcing, feedback mechanisms tend to contribute to the instability of the system. An unstable organism is usually located in the border regions of the reference range for one or more variables. The disproportion between the "input" of nutrients and the "output" in certain production phases of the animal is the cause of such "deflections", i.e. of so-called production diseases. The transit phase and lactation are such phases. Here, however, not only the absolute level of the milk yield is to be mentioned, but above all the milk ingredients. A consideration of the reaction situation, i.e. the metabolic situation of the sow from just one point of view is, as this example shows, not sufficient to clarify the complex phenomenon.

4. Approaches to resilience diagnosis

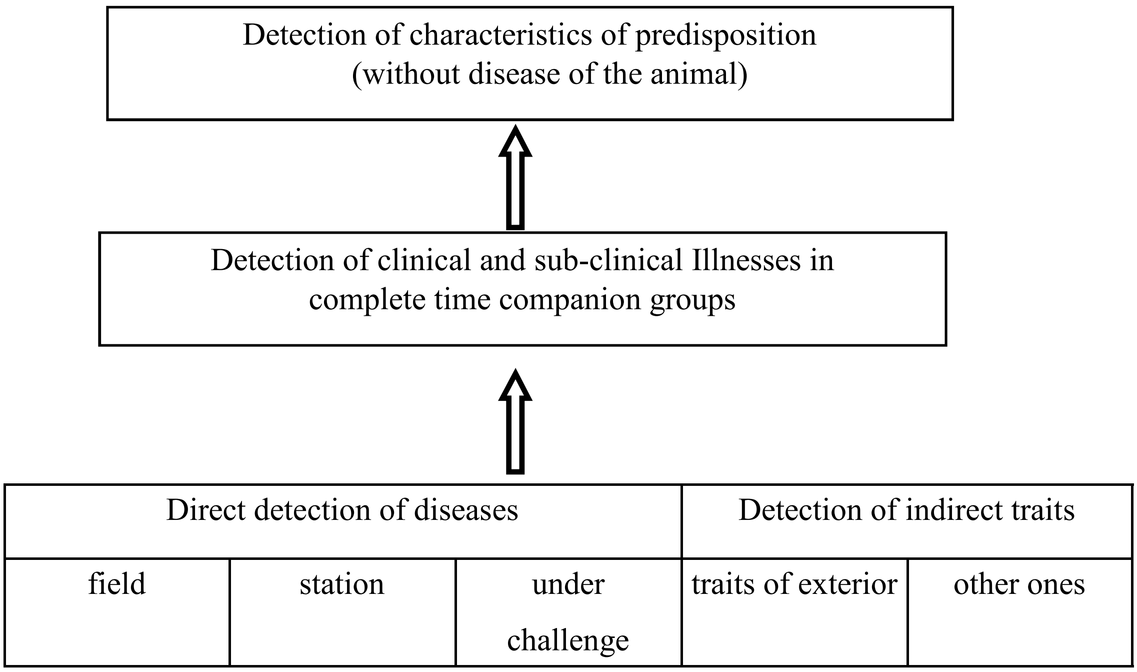
From a scientific and practical point of view, it is therefore extremely interesting to get information in good time from animals that have an increased risk of disease, i.e. a low exposure threshold in defined production phases, or on the other hand are characterized by a high level of robustness (resilience). The aim of such a scientific project would be to enable a prediction with a close-knit measurement system to determine representative parameters. With the help of progress studies in the form of activity measurements and determination of metabolic metabolites over time, resilience in farm animals can be investigated relatively reliably with the means that are already available today. Scientific studies on resilience in sows can help to keep sows healthy and to increase their life expectancy by reducing the incidence of production diseases with the breeding goal of recruiting more robust female offspring from resilient sows for stock restoration. For example, fertility is known to be a very sensitive complex of characteristics in relation to environmental influences. Characteristic for high-risk sows are, among other things, a prolonged weaning-oestrus interval or lack of oestrus after weaning of the piglets, non-pregnancy or smaller litters as well as poor rearing performance. Hopeful possibilities arise from genotyping to counter this problem sustainably.Such studies are already known in cattle. In the Netherlands, the “Veerkracht” project aimed to identify cows with an increased risk of developing a production disease in the transit phase in advance. The hypothesis was that an increased risk could be identified by carefully determining certain parameters in advance, in this case before calving. Before calving, intensive, sensor-based behavioral observations, clinical examinations, rumen temperature, blood and fecal examinations were carried out. According to the results, which are based on the course of the dry period at the level of the individual animal, it is possible to quantify the risk of developing a production disease after birth (according to GROSSE and MÜLLER, 2018). In cows, the calcium level in the blood can be used, which in risk animals returns to the reference range immediately after calving much more slowly than in cows that remain healthy during the transit phase (GROSSE and MÜLLER, 2018).

Analogous procedures are indicated for high-performance sows, because the metabolism of the sow in the transit phase is also subject to enormous adaptation processes (MENN, 2015). Here it has to switch from anabolic to catabolic. Research results by ROSENBAUM (2013) indicate that the sow also develops metabolic stress at the beginning of lactation. This process falls under the term “oxidative stress”. In the synthesis of functional proteins from amino acids in the context of protein turnover, an intermediate step, the so-called folding, is incomplete or incorrect. Misfolded proteins are not available as functional proteins (MENN, 2015) and thus worsen protein utilization. Under certain conditions, the development of metabolic diseases and inflammation in the gastrointestinal tract is promoted (GARG et al., 2012). These relationships underline the importance of the inflammatory metabolic situation in the sow's transit phase for subsequent lactation. This incorrect process can be detected in advance by measuring the gene expression of the target genes.

KNAP (2019) presented two alternative ways of improving resistance, tolerance and resilience in animals in breeding. On the one hand, there is the selection for higher performance under practical conditions, which are recorded on half-siblings and processed via BLUP. Reference must be made here to the need for an exact performance test. A principle for this is: "If one wants to improve breeding performances effectively and not only indirectly, features that characterize these performances must be recorded in performance tests in order to use them for the evaluation, ie for the breeding value estimation" (RITTER et al., 1988) .

With the exception of hereditary diseases, health is mainly influenced by the design of the environment. When parameters related to the disease are recorded, a genetic predisposition can often be demonstrated (SWALVE, 2009). In this respect, information on the resilience of the animals can also be obtained. An almost optimal performance test with the collection of very reliable data is the indispensable prerequisite for this (Fig. 1), whereby all time companions in a company or in a station must be taken into account. Modern approaches mean that classic breeding methods are now complemented by molecular methods.

Figure 1. Performance evaluation for disease traits (SWALVE, 2008)



On the other hand, resistance and / or tolerance are recorded and a certain index of the two is selected via BLUP. It is extremely difficult to determine a tolerance. It assumes repeated measurements with a known amount of pathogen. The genetic correlation between the traits is of crucial importance. An improvement in resistance and / or tolerance leads to improved resilience. Due to the higher reaction norm in the body, resistance prevents the amount of pathogen and tolerance makes the body less sensitive to a certain amount of pathogen because of a more favorable reaction norm. In animal breeding practice, resistance therefore seems to be of greater importance. In this context, KNAP (2019) reported on the PRRS-resistant pig.

A negative correlation between resistance and tolerance can lead to reduced resilience. If complete resistance could be achieved, possibly with the help of gene editing, then tolerance is no longer necessary. On the other hand, fully tolerant animals do not need resistance. An example of this is African swine fever, where this is to be achieved with the help of gene editing (KNAP, 2019).

The first results of current studies on the relationship between stress and the intestinal microbiome are promising (RÖHE, 2019). The intestinal microbiome includes all the microorganisms that live in the intestine, i.e. bacteria, archaea, protozoa and fungi. The genetic influence of the animal on the composition of its gastrointestinal microbiome is known in cattle (ROEHE et al., 2016) and also in pigs (CAMAINHA-SILVA et al., 2017). The following sentence still applies: "If the intestine is healthy, the animal is healthy."

Several studies have reported the influence of the intestinal microbiome on the health of animals, especially in cattle (AUFFRET et al., 2017). There are interactions between the intestinal microbiome and the immune system of the animal. Most of the microbiome supports the immune system. It is also known that the intestinal microbes produce messenger substances that affect the central nervous system. But the brain also has an effect on the composition of the intestinal microbiome via the hypothalamus-pituitary-adrenal cortex axis. This interaction allows the conclusion that stress in any form has an influence on the composition of the microbiome and is therefore important for the health of animals. RÖHE (2019) demonstrated in pigs that stressors, e.g. the regrouping of animals, led to an increase in pathogenic intestinal microbes. Conclusions can be drawn from this for breeding in the form that the intestinal microbiome can be suitable as a biomarker for improving resistance to pathogenic intestinal bacteria and, with a view to resilience, as an indirect marker for increased tolerance and resistance to stress. In terms of animal health, identifying antimicrobial resistance based on the microbiome is of great importance.

When considering the possibility of an early diagnosis of a high tendency to resilience in breeding sows, functional characteristics are also taken into account (KRIETER, 2010). Functional characteristics are those that only indirectly affect performance. So far, those are particularly well-known that are particularly important for fertility and rearing performance (HELLBRÜGGE et al., 2008a, b) but also for longevity and life performance. Longevity and life performance are in turn related to the health, robustness, i.e. resilience of the animals. In this respect, functional characteristics are suitable for a diagnosis of the resilience disposition.

Summary

Yes, sows also have a tendency to be resilient. Naturally, there is great individual variability. It is known that sows react very differently to individual influencing factors that have the same effect. This is where the term "resilience" comes in, which can be translated as "spring force" (cushioning). Resilience is a prerequisite for the conservation of species and the ability of individuals to survive in different environments. At the present time, when farm animal husbandry is subject to a broad social discussion with regard to extensification, animal welfare and resource protection, it is necessary to breed pigs with a high degree of resilience. This is because performance breeding generally goes hand in hand with an increasing sensitivity of the animals to harmful environmental factors and the variety of environmental factors that have an impact is increasing. These include, among other things, herd management, the climate, feeding, husbandry, but also pathogen loads of all kinds and diseases. High-performance sows react to this to different degrees. In the case of the animals that react sensitively, this very often leads to a loss of performance, illnesses and to early departure from the herd. This has a negative effect on economic efficiency and above all represents an important animal welfare problem. It directly affects the ethical justification for us humans to breed and keep high-performance animals. This is particularly true for the very fertile sows in piglet production. This problem cannot be viewed in a single-causal way, because the production diseases, causes of reduced performance and early departures are multifactorial. The closely interrelated exogenous and endogenous factors play a role. The multitude of influencing variables, e.g. metabolism and fertility, interact via negative and positive feedback mechanisms. Thanks to the buffer capacity of the individual, there are often delayed reactions to the influencing factors. Thanks to promising scientific studies and results including gene editing, reliable answers can already be given to the question of how resilience is expressed in high-performance sows, is it measurable and predictable and is the result with a view to improved animal health with consequences for longevity in the breeding senses usable.

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