Resilience in Growing Pigs

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Resilience can be defined as the ability of the animal to rapidly recover its productivity despite the perturbations that might occur during its productive life.

body weight haptoglobin pigs resilience indicators vaccine challenge

1. Introduction

Selective breeding for improved resilience would provide resistant animals with robust phenotypes [1]. Thus, it would increase the profitability and the sustainability of the production systems. However, there is no straightforward quantification method for resilience. Resilience indicators have been elaborated based on productivity-related traits [2][3][4][5] and immune phenotypes [6][7] in several livestock species. In this review, a total of 445 commercial Duroc pigs were challenged with an attenuated Aujeszky vaccine at 12 weeks of age (experimental group) and 95 pigs were inoculated with phosphate-buffered saline (control group). The deviation from the expected body weight given the growth curve of control pigs (ΔBW) and the increment of the acute-phase protein haptoglobin (ΔHP) at 4 days post-vaccination (DPV) were suggested as resilience indicators in growing pigs. Challenged pigs that maintained their productivity and had a minor activation of the acute-phase protein haptoglobin were deemed resilient, whereas pigs that had low ΔBW values and high activation of haptoglobin were deemed susceptible. Pigs were also classified based on ΔBW relative to the expected body weight (BW) at 28 DPV (%BW) and ΔHP relative to the basal level of haptoglobin (%HP).

2. Descriptive Statistics for the Novel Resilience Indicators

Descriptive statistics for the suggested resilience indicators are given in **Table 1**. Average ΔBW and %BW were −0.68 kg and −1.42%, respectively, indicating that on average, the observed BW of challenged pigs at 28 DPV was lower than the expected BW given the theoretical growth curve. Average ΔHP and %HP were +0.03 mg/mL and +5.40%, respectively, showing an increment of haptoglobin concentration in plasma at 4 DPV. All the resilience indicators had high standard deviation values.

Table 1. Descriptive statistics for the resilience indicators in pigs from the experimental group.

Trait	Mean	SD [1]	Min	Max
ΔBW [2] (kg)	−0.68	3.64	−13.2	+10.1

Trait	Mean	SD [1]	Min	Max
%BW [3] (%)	−1.42	7.26	−24.4	+19.3
ΔHP [4] (mg/mL)	+0.03	0.70	−1.41	+2.65
%HP [5] (%)	+5.40	60.4	−89.2	+292

[1] Standard deviation; [2] Body weight deviation from the expected growth curve of control pigs at 28 days post-vaccination (DPV); [3] Ratio between ΔBW and the expected body weight at 28 DPV given the growth curve of control pigs; [4] Haptoglobin increment at 4 DPV; [5] Ratio between ΔHP and the basal level of haptoglobin.

Phenotypic correlations between the resilience indicators are reported in **Table 2**. A negative and low correlation was reported between ΔBW and ΔHP ($r = −0.09$, $p < 0.05$), suggesting that they capture different aspects of resilience.

Table 2. Correlations between the resilience indicators.

Trait	ΔBW [1]	ΔHP [2]	%BW [3]	%HP [4]
ΔBW	1	−0.09 *	0.99 ***	−0.14 **
ΔHP		1	−0.09 ns	0.94 ***
%BW			1	−0.14 **
%HP				1

[1] Body weight deviation from the expected growth curve of non-vaccinated pigs at 28 days post-vaccination (DPV); [2] Haptoglobin increment at 4 DPV; [3] Ratio between ΔBW and the expected body weight at 28 DPV given the growth curve of control pigs. [4] Ratio between ΔHP and the basal level of haptoglobin; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, ns non-significant.

3. Classification of Pigs' Resilience

Pigs were classified based on the resilience indicated by both the deviation from the expected growth curve and the increment of haptoglobin at 4 DPV. First, individuals were grouped into resilient or susceptible groups based on ΔBW and ΔHP (**Figure 1**). On average, the resilient pigs (N = 25) showed positive values of ΔBW (+3.54 kg) and %BW (+6.60%) and negative values of ΔHP (−0.71 mg/mL) and %HP (−61.2%). In contrast, the susceptible group (N = 33) had low and negative values of ΔBW (−6.00 kg) and %BW (−11.7%) and positive values of ΔHP (+1.17 mg/mL) and %HP (+108%) (**Table 3**). Thus, ΔBW and ΔHP allowed us to separate two groups with extreme responses to challenge.

References

1. H. A. Mulder; H. Rashidi; Selection on resilience improves disease resistance and tolerance to infections. *Journal of Animal Science* **2017**, *95*, 3346-3358, 10.2527/jas2017.1479.
2. Tom V.L. Berghof; Henk Bovenhuis; Han A. Mulder; Body Weight Deviations as Indicator for Resilience in Layer Chickens. *Frontiers in Genetics* **2019**, *10*, 1216, 10.3389/fgene.2019.01216.
3. Austin M. Putz; John C. S. Harding; Michael K. Dyck; F. Fortin; Graham S. Plastow; Jack C. M. Dekkers; PigGen Canada; Novel Resilience Phenotypes Using Feed Intake Data From a Natural Disease Challenge Model in Wean-to-Finish Pigs. *Frontiers in Genetics* **2019**, *9*, 660, 10.3389/fgene.2018.00660.
4. M. J. Argente; M. L. García; K. Zbyňovská; P. Petruška; Marcela Capcarova; A. Blasco; Correlated response to selection for litter size environmental variability in rabbits' resilience. *Animal* **2019**, *13*, 2348-2355, 10.1017/s1751731119000302.
5. G.G. Elgersma; G. De Jong; R. Van Der Linde; H.A. Mulder; Fluctuations in milk yield are heritable and can be used as a resilience indicator to breed healthy cows. *Journal of Dairy Science* **2018**, *101*, 1240-1250, 10.3168/jds.2017-13270.
6. Sarita Z.Y Guy; Li Li; Peter C Thomson; Susanne Hermesch; Quantifying the health challenges in an Australian piggery using medication records for the definition of disease resilience1. *Journal of Animal Science* **2019**, *97*, 1076-1089, 10.1093/jas/skz025.
7. Yulu Chen; Laura E. Tibbs Cortes; Carolyn Ashley; Austin M. Putz; Kyu-Sang Lim; Michael K. Dyck; Frederic Fortin; Graham S. Plastow; Jack C. M. Dekkers; John C. S. Harding; et al.Pig Gen Canada The genetic basis of natural antibody titers of young healthy pigs and relationships with disease resilience. *BMC Genomics* **2020**, *21*, 1-17, 10.1186/s12864-020-06994-0.
8. Roger Ros-Freixedes; J. Reixach; M. Tor; Joan Estany; Expected genetic response for oleic acid content in pork1. *Journal of Animal Science* **2012**, *90*, 4230-4238, 10.2527/jas.2011-5063.
9. Mary Clapperton; Abigail B Diack; Oswald Matika; Elizabeth J Glass; Christy D Gladney; Martha A Mellencamp; Annabelle Hoste; Stephen C Bishop; Traits associated with innate and adaptive immunity in pigs: heritability and associations with performance under different health status conditions. *Genetics Selection Evolution* **2009**, *41*, 54-54, 10.1186/1297-9686-41-54.

10. M. Henryon; P. M. H. Heegaard; J. Nielsen; P. Berg; H. R. Juul-Madsen; Immunological traits have the potential to improve selection of pigs for resistance to clinical and subclinical disease. *Animal Science* **2006**, *82*, 597-606, 10.1079/asc200671.

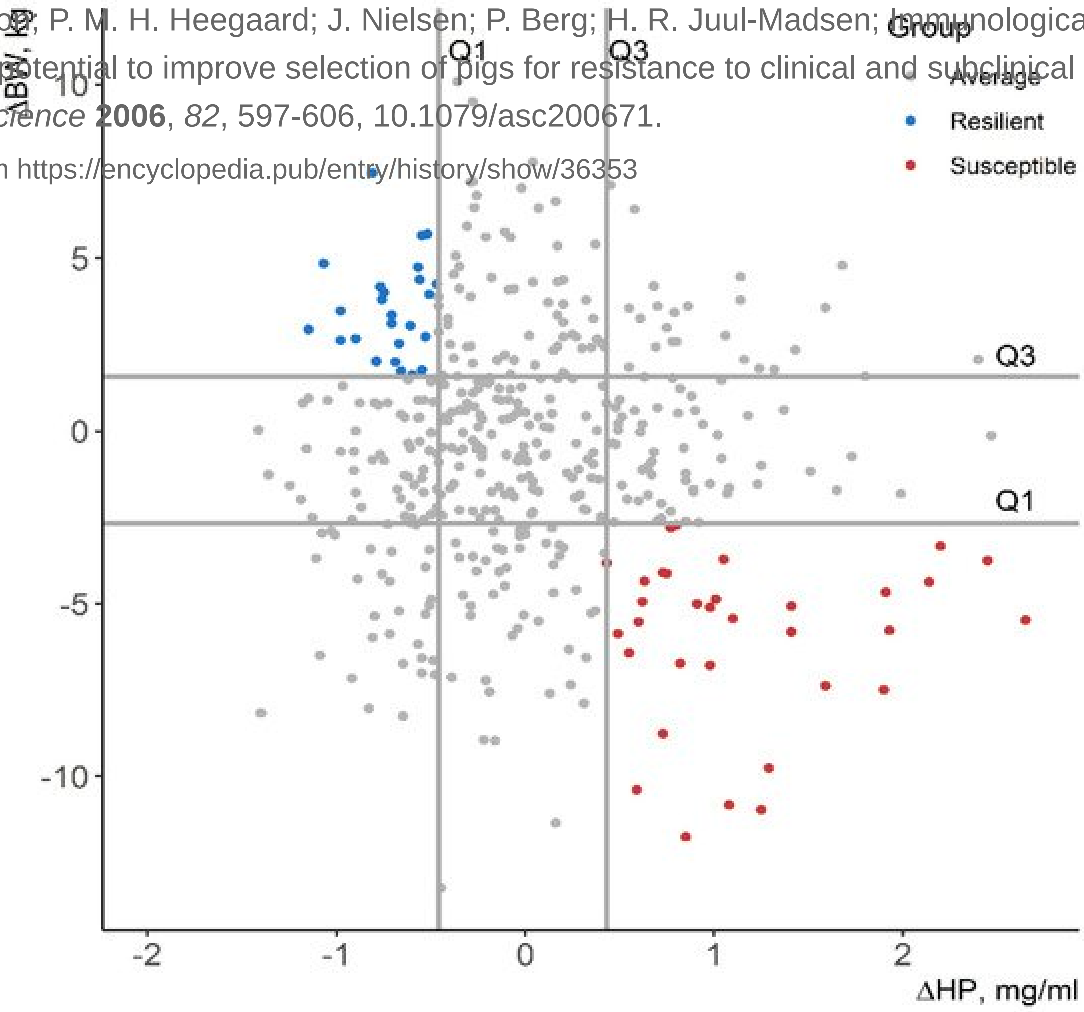

Figure 1. Classification of pigs as resilient, average, and susceptible based on the first (Q_1) and the third (Q_3) quartiles of ΔBW and ΔHP. ΔBW: body weight deviation from the expected growth curve of control pigs at 28 days post-vaccination, ΔHP: haptoglobin increment at 4 days post-vaccination.

Table 3. Mean and standard deviation (SD) of the resilience indicators of pigs from the resilient (R, N = 25) and susceptible (S, N = 33) groups.

Trait	Group	Mean	SD
ΔBW [1] (kg)	R	+3.54	1.42
	S	−6.00	2.44
%BW [2] (%)	R	+6.60	2.81
	S	−11.7	5.13
ΔHP [3] (mg/mL)	R	−0.71	0.18
	S	+1.17	0.61

Trait	Group	Mean	SD
%HP [4] (%)	R	−61.2	18.9
	S	+108.4	68.2

[1] Body weight deviation from the expected growth curve of control pigs at 28 days post-vaccination (DPV); [2] Ratio between ΔBW and the expected body weight at 28 DPV given the growth curve of control pigs; [3] Haptoglobin increment at 4 DPV; [4] Ratio between ΔHP and the basal level of haptoglobin.

Pigs were also grouped into resilient and susceptible groups based on the resilience indicated by %BW and %HP (**Figure 2**). Individuals were colored according to their group classification using ΔBW and ΔHP in order to visualize the concordance between the first and the second classifications. The concordance was high with a kappa value of 0.8 and an overall agreement of 95%, indicating that ΔBW and ΔHP are not sensitive to the animal's expected BW nor the basal level of haptoglobin and are consequently potential indicators of resilience.

Pigs were also classified into resilient, average, and susceptible based on the observed BW at 28 DPV (Figure S1) and the combination of the BW deviation from the expected BW at 28 DPV estimated based on each pig's average daily gain before challenge (ΔBW_{ADG}) and ΔHP (Figure S2). The concordance was low (kappa = 0.1) between the classification obtained by the observed BW at 28 DPV and the combination of "ΔBW and ΔHP" indicating that ΔBW and ΔHP do not only capture the differences in the observed BW. The concordance was moderate (kappa = 0.5) between the classification indicated by "ΔBW_{ADG} and ΔHP" and "ΔBW and ΔHP". Thus, pigs could be consistently classified as resilient, average or susceptible based on ΔBW_{ADG} and ΔHP without using a control group.

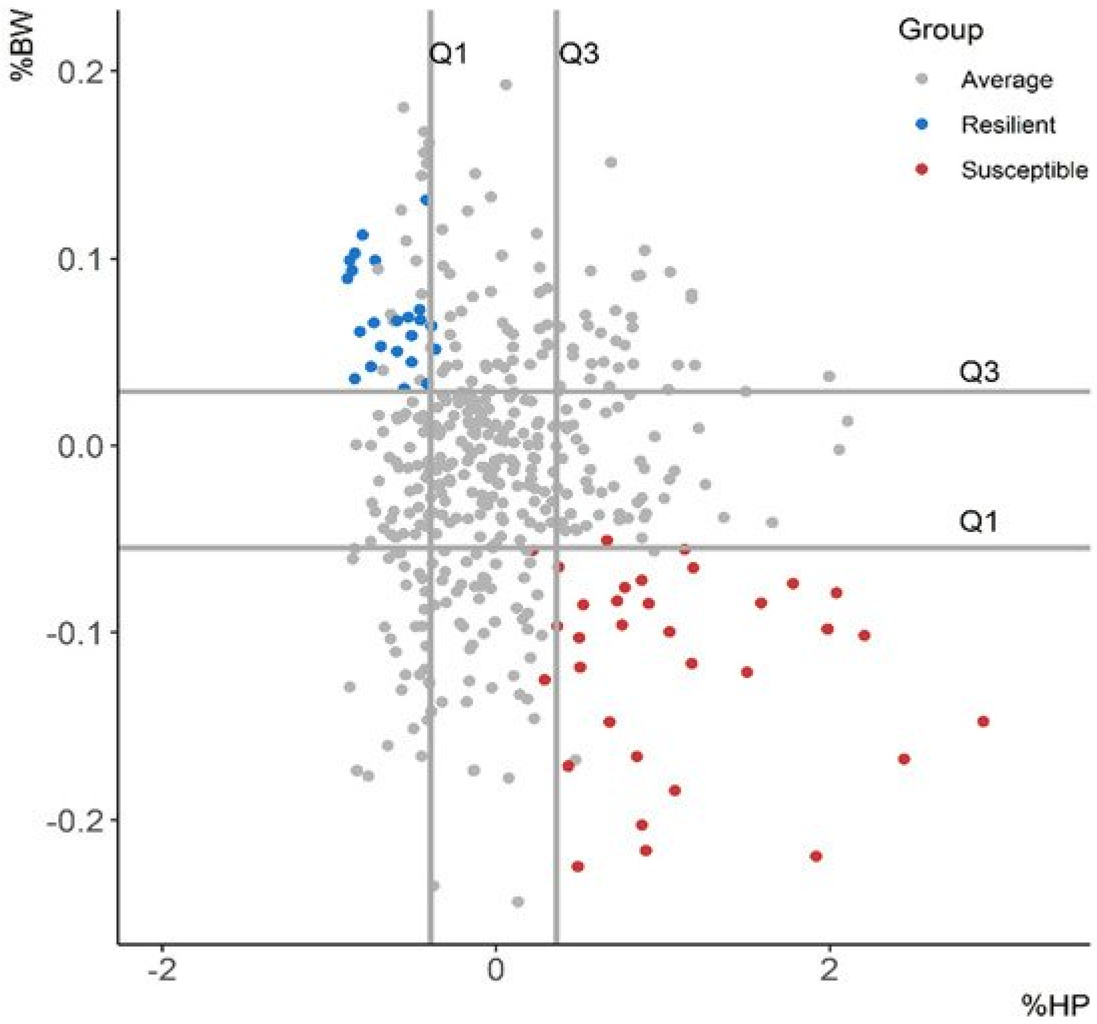

Figure 2. Projection of the resilient, average, and susceptible groups obtained with the first (Q_1) and third (Q_3) quartiles of ΔBW and ΔHP on the plane defined by %HP and %BW. Individuals were colored according to their group classification using the criterion from Figure 1 to visualize concordance between both methods. ΔBW: body weight deviation from the expected growth curve of control pigs at 28 days post-vaccination (DPV), ΔHP: haptoglobin increment at 4 DPV, %BW: ratio between ΔBW and the expected body weight at 28 DPV, %HP: ratio between ΔHP and the basal level of haptoglobin.

The growth curves of animals from the resilient and susceptible groups were similar at the beginning of the experiment (**Figure 3**). After the challenge at 12 weeks of age, resilient animals were able to withstand the perturbations and showed faster growth than susceptible ones. At the end of the fattening period (30 weeks of age), the resilient pigs showed a greater carcass weight than susceptible ones (107.7 and 92.1 kg, respectively).

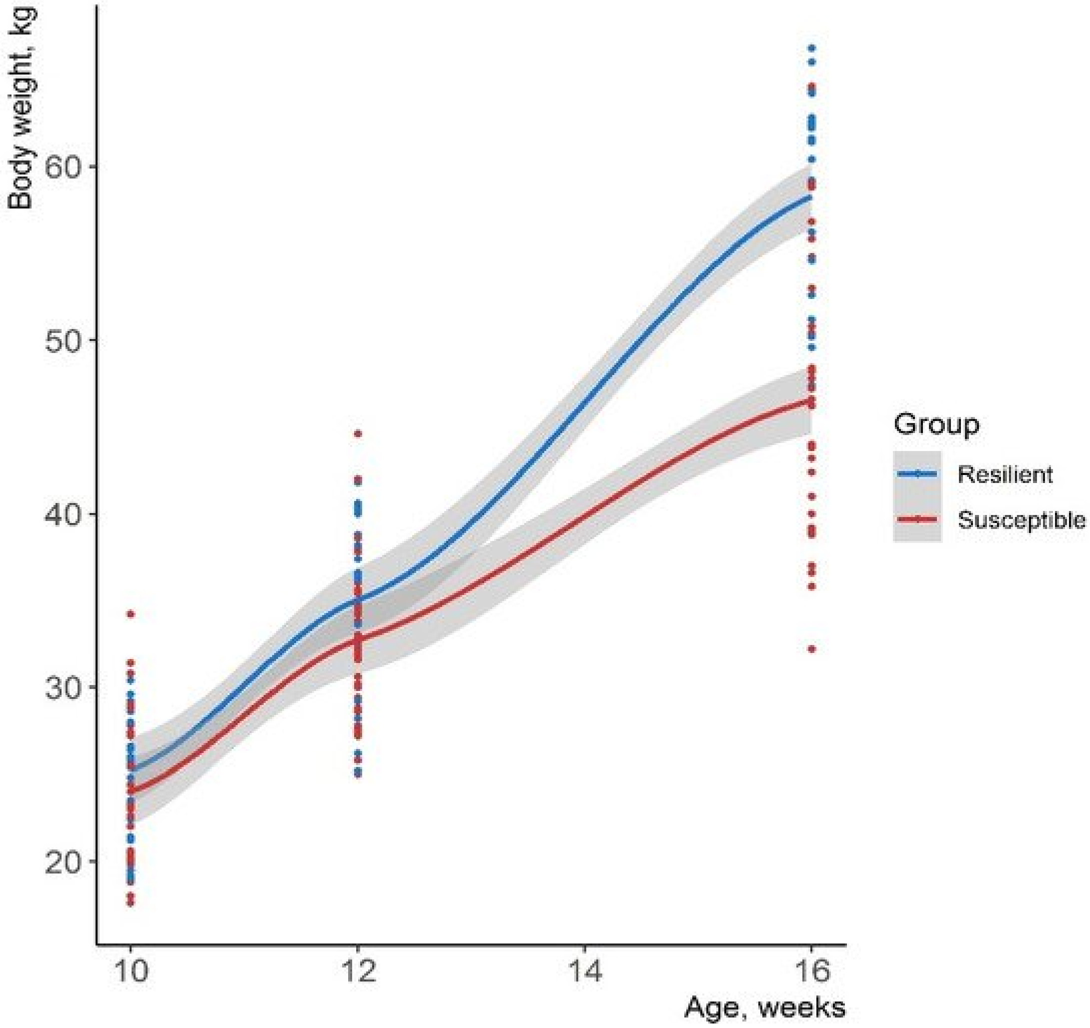

Figure 3. Growth curves of pigs from the resilient and susceptible groups. The grey band represents the confidence interval. Individuals were colored according to their group classification using the criterion from Figure 1.

4. Heritability Estimates

The features of the marginal posterior distributions of the heritability estimates for the resilience indicators are displayed in **Table 4**. Both ΔBW and %BW had a moderate heritability of 0.33 and 0.37, with $P_{0.10}$ (i.e. the probability of the heritability being greater than 0.10) of 0.94 and 0.93, respectively. Heritability estimates of ΔHP and %HP were 0.16 and 0.13, with $P_{0.10}$ of 0.66 and 0.53, respectively. Heritabilities for ΔBW at 28 DPV have not been reported before but our estimated value is similar to the heritability of BW reported in Duroc pigs at 180 days of age (0.31) [8]. Our heritability estimates for haptoglobin are within the range of those reported in the literature [9][10]. The experimental sample size limits the accuracy of the heritability estimates. However, $P_{0.10}$ showed that the resilience indicators are genetically controlled and consequently, may be improved through selective breeding

Table 4. Heritability estimates for the resilience indicators.

Trait	Mean [1]	$P_{0.10}$ [2]	$HPD_{95\%}$ [3]
ΔBW [4]	0.33	0.94	0.02–0.65
%BW [5]	0.37	0.93	0.02–0.74
ΔHP [6]	0.16	0.66	0.00–0.38
%HP [7]	0.13	0.53	0.00–0.32

[1] Mean of the marginal posterior distribution of the heritability; [2] Probability of the heritability estimate being greater than 0.10; [3] Highest posterior density interval at 95% of probability; [4] Body weight deviation from the expected growth curve of non-vaccinated pigs at 28 days post-vaccination (DPV); [5] Ratio between ΔBW and the expected body weight at 28 DPV given the growth curve of control pigs; [6] Haptoglobin increment at 4 DPV; [7] Ratio between ΔHP and the basal level of haptoglobin.

5. Conclusions

Altogether, we propose ΔBW and ΔHP as novel resilience indicators in growing pigs. The suggested indicators are easy to measure, genetically controlled and show substantial variability between animals. Thus, they may be improved through selective breeding. This approach may be applied to quantify resilience in other species using different infectious and non-infectious challenges. Moreover, genomic studies on resilient and susceptible animals can help in elucidating the molecular basis of the resilient response.