Predicting piglet survival until weaning using birth weight and within-litter birth weight variation as easily measured proxy predictors

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PIGWEB

An infrastructure for experimental research for sustainable pig production

Work package 7: Model algorithms using existing proxies and methods and identification of possible trade-offs among growth performance, nutrient efficiency, carcass nutrient composition, and health and welfare status

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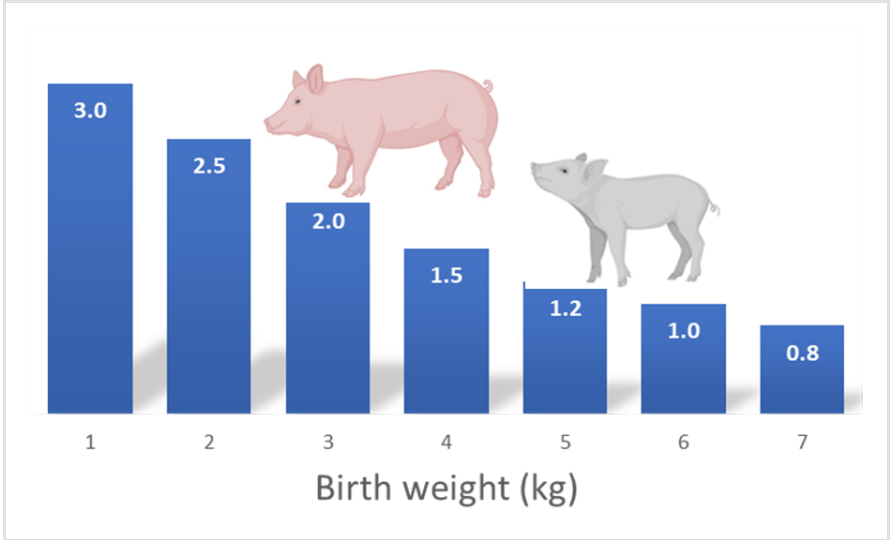
Introduction

- Model algorithms using existing proxies and methods that relate to piglet survival
- A proxy: a parameter that can predict a trait
  - It contains prognostic information about a trait that can either not directly or timely be measured or not easy to measure
- Survival/mortality can only be determined retrospectively
  - Birth weight **(BW0)** and the within-litter birth weight variation **(BWvar)** obtained at birth

Introduction

- Genetic selection of sows over the years has led to hyper-prolific sows resulting in more piglets born
- As litter size increases, the BWvar rises, with more low birth weight piglets being born in larger litters
- Direct competition for functional and productive teats limit the survival of light littermates during the suckling period



- Economic consequences: high preweaning mortality - directly affects profitability, increases costs and decrease overall herd productivity
- Welfare concerns

Stange et al., 2020. Scientific Reports 10, 6149

Objectives

- Use historical data from two research farms with different pig genotypes and management conditions to evaluate the effects of piglet BW0, BWvar and other potential sow and environmental factors on piglets' survival probability

- Use piglet BW0 and BWvar as easy-to-measure diagnostic indicators of survival during the suckling period and to establish functional cut-off values with predictive capabilities

- Develop predictive tools for piglet survival

Overview of the data

FBN

German Landrace breed

Data period: 2012-2021

Records after editing: 27,932 piglets from 751 sows

Fostering management

smaller piglets fostered out

Agroscope

Swiss Large White breed

Data period: 2005-2021

Records after editing: 40,741 piglets from 924 sows

Fostering management

larger piglets fostered out

68,673 piglet records from 1,675 sows

Statistical analysis: Logistic regression

Survival
Alive or dead at a given time point

Age and condition of the sow
Parity
Litter size
Within-litter birth weight variation

When was the record taken?
Year × season interaction

Residuals

$$Y_{ijklmn} = F_i + P_j + LS_j + BWvar_j + Sex_k + BW_k + yrs_l + A_m + e_{ijklmn}$$

Where was the data taken?
Farm effect
FBN, Agroscope

Individual piglet trait
Sex
Birth weight

Random Sow effect
Repeated measurements

Binary outcomes (survival= 0 or 1) were modelled using PROC GLIMMIX in SAS 9.4

Key factors affecting pre-weaning piglet survival

Test statistics for the fixed effects fitted in the logistic regression model

Total Number Born (**TNB**, Day 0)

Effect	DF	Den. DF	F Value	Pr > F
Birth weight	1	68,380	2,712.99	0.001
Farm	1	1,452	182.63	0.001
Parity	4	62,675	66.59	0.001
Sex	1	68,380	33.13	0.001
BWvar_TNB	1	33,788	11.87	0.001
Littersize_TNB	1	23,125	9.15	0.003
Parity*Farm	4	66,744	7.66	0.001

Number Born Alive (**NBA**, at day 3) + fostering effect

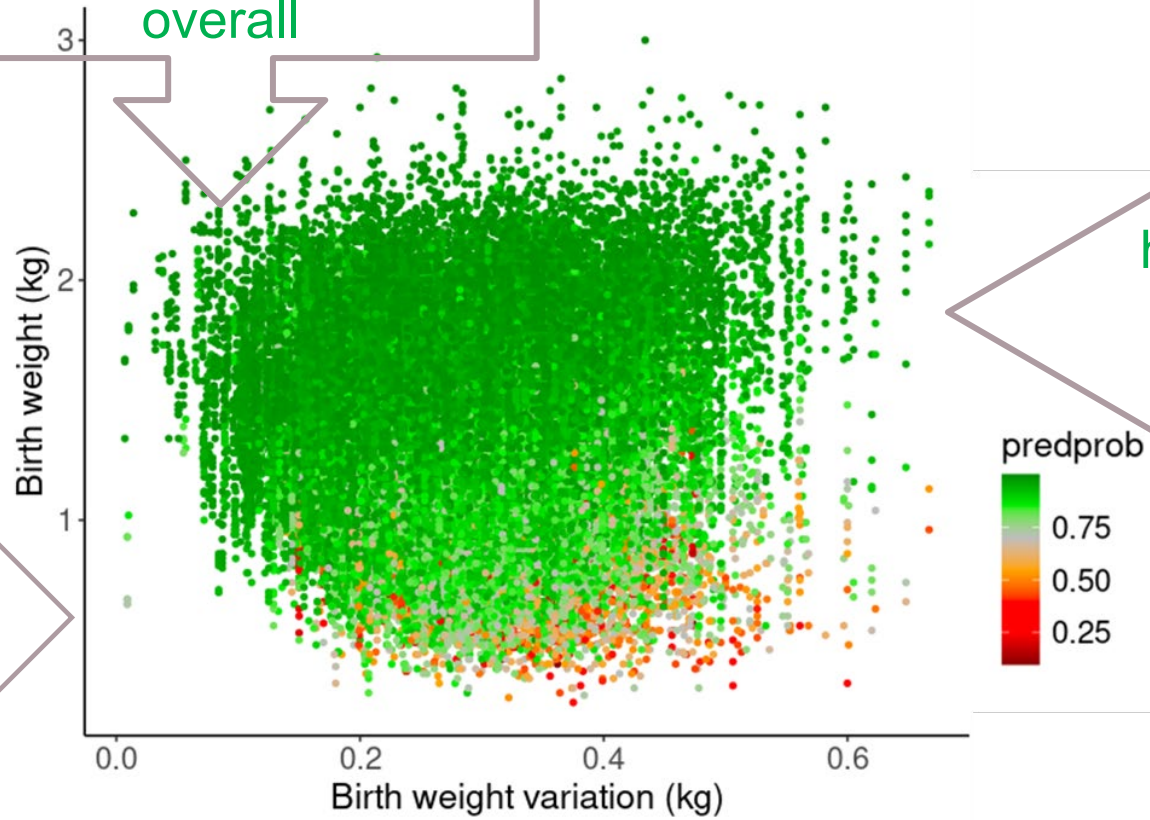
Effect	DF	Den. DF	F Value	Pr > F
Birthweight	1	58,533	5,745.24	0.001
Fostering	1	58,533	185.90	0.001
Sex	1	58,533	79.99	0.001
Littersize_TBA	1	15,454	16.95	0.001
Parity	4	58,533	9.28	0.001
Parity*Farm	4	58,533	8.89	0.001
Farm	1	1,529	6.35	0.012
Parity*fostering	4	58,533	2.36	0.050
BWvar_TBA	1	18,831	0.77	0.380

BWvar more significant than litter size at birth

BWvar not significant after day 3

Predicted probabilities for piglet survival at birth

piglets from litters with less variation in BW0 tended to be heavier overall



high-birth-weight piglets had high neonatal survival probabilities

Low BW0, low survival probability

statistical analysis: ROC curve analysis

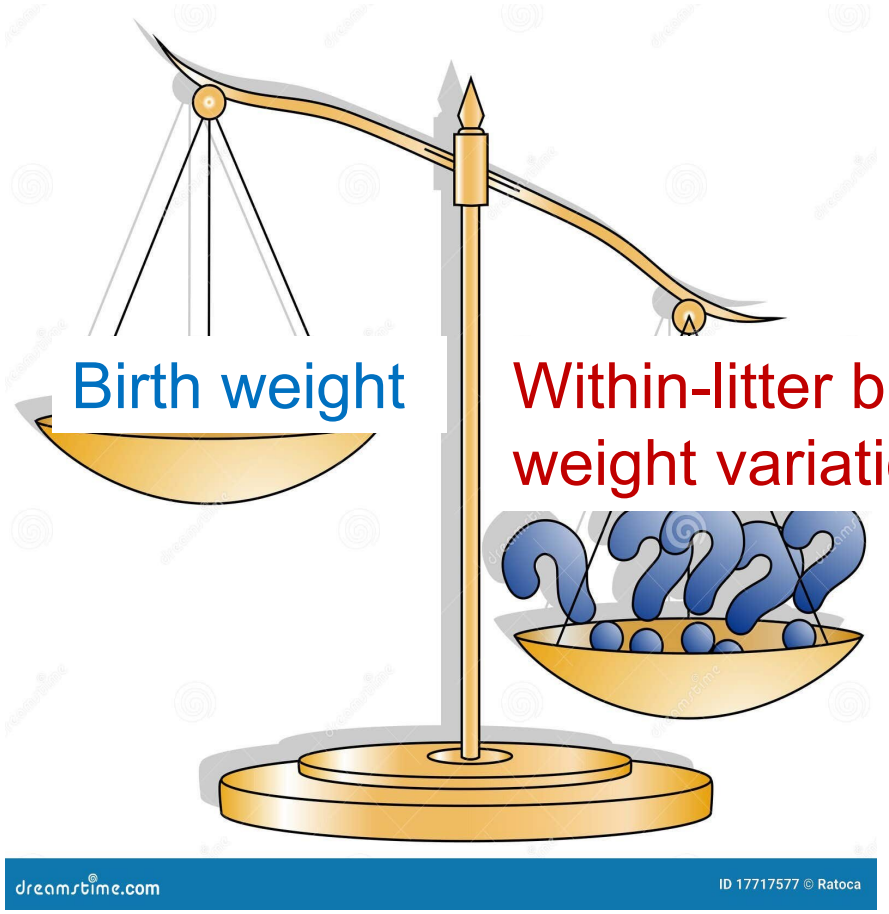


Photo from:www.dreamstime.com

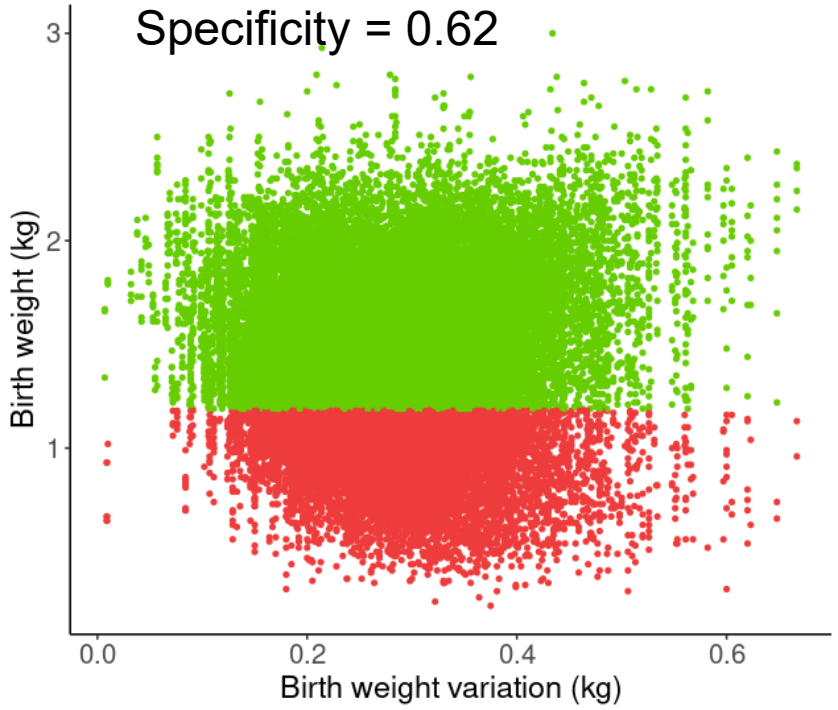
- Critical cut-off point values estimated using receiver operating characteristic **(ROC)** curve analysis
- ***cutpointr*** package version 1.1.2 of R
- Critical cut-off value was identified using the Youden Index (J = sensitivity + specificity -1) and accuracy

Greiner et al., 2000. Prev Vet Med 45, 23-41.
Thiele and Hirschfeld, 2020, " *arXiv preprint arXiv:2002.09209*"

Critical BW0 and BWvar cut-off values

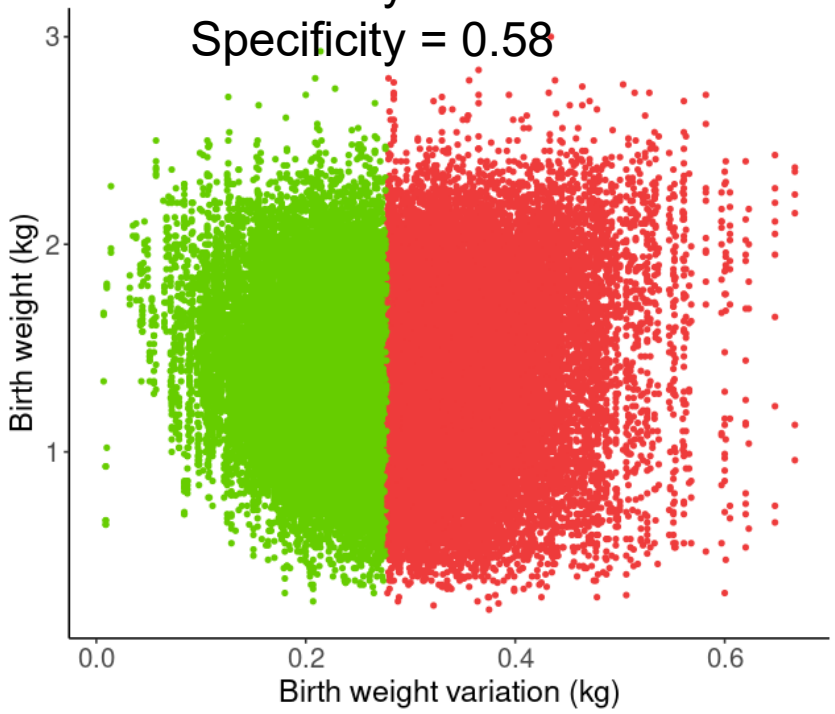
BW0 cut-off = 1.18 kg

Accuracy = 0.73
Sensitivity = 0.75
Specificity = 0.62



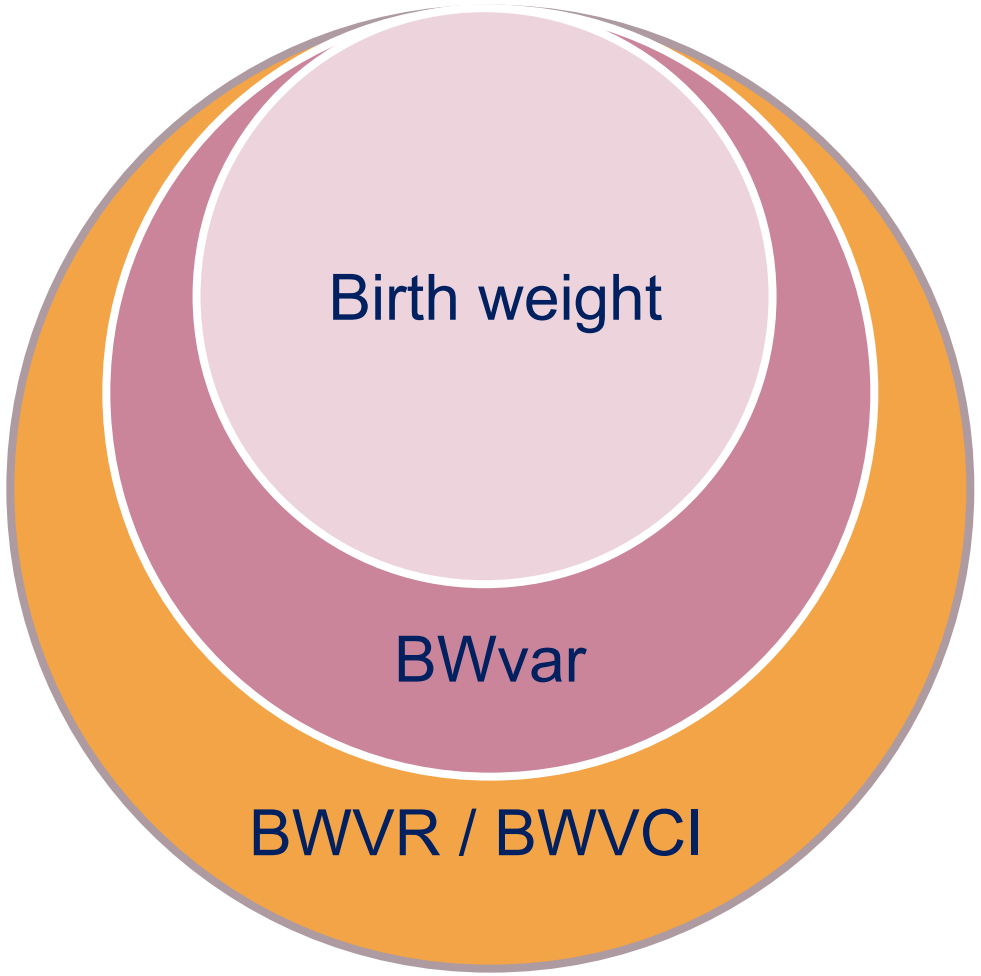
BWvar cut-off = 0.277

Accuracy = 0.50
Sensitivity = 0.49
Specificity = 0.58



Red colour indicates piglets classified as at higher risk of mortality at birth and green colour as otherwise safe

Derivation of birth weight-to-variation ratio and composite index



Easy-to-measure trait

Calculated as standard deviation, separately for males and females then pooled

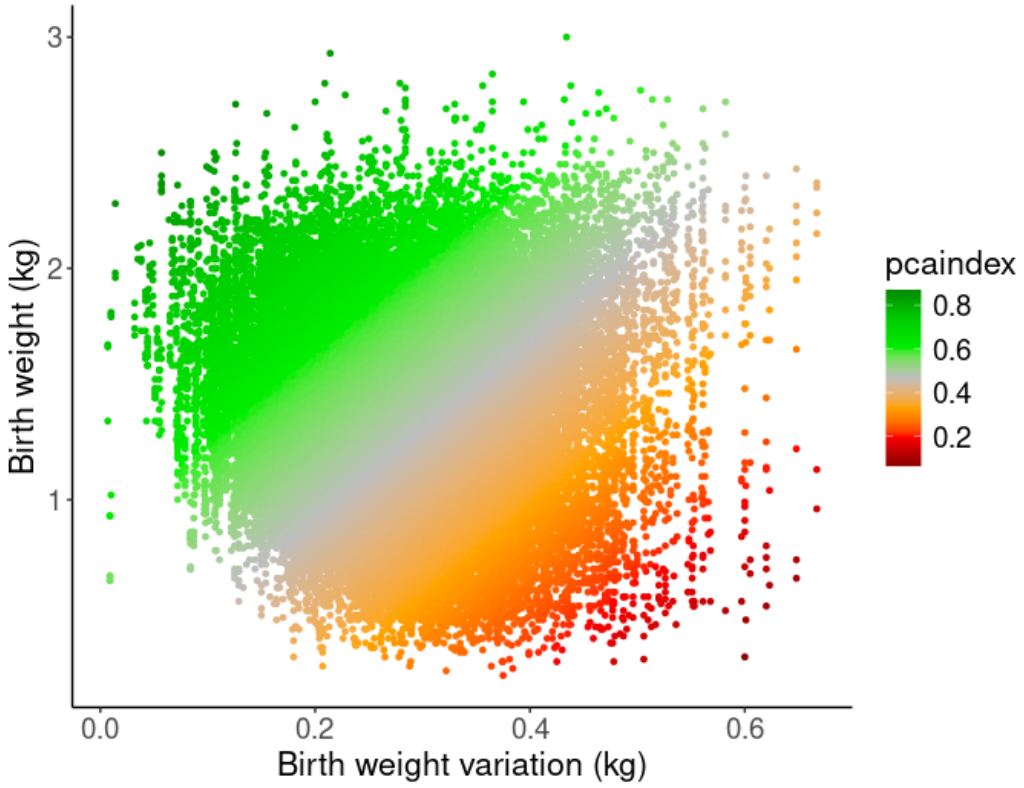
BW0 / BWvar = Birth weight-to-variation ratio **(BWVR)**

BW0 & BWvar principle component analysis (PCA) = Birth weight-to-variation composite index **(BWVCI)**

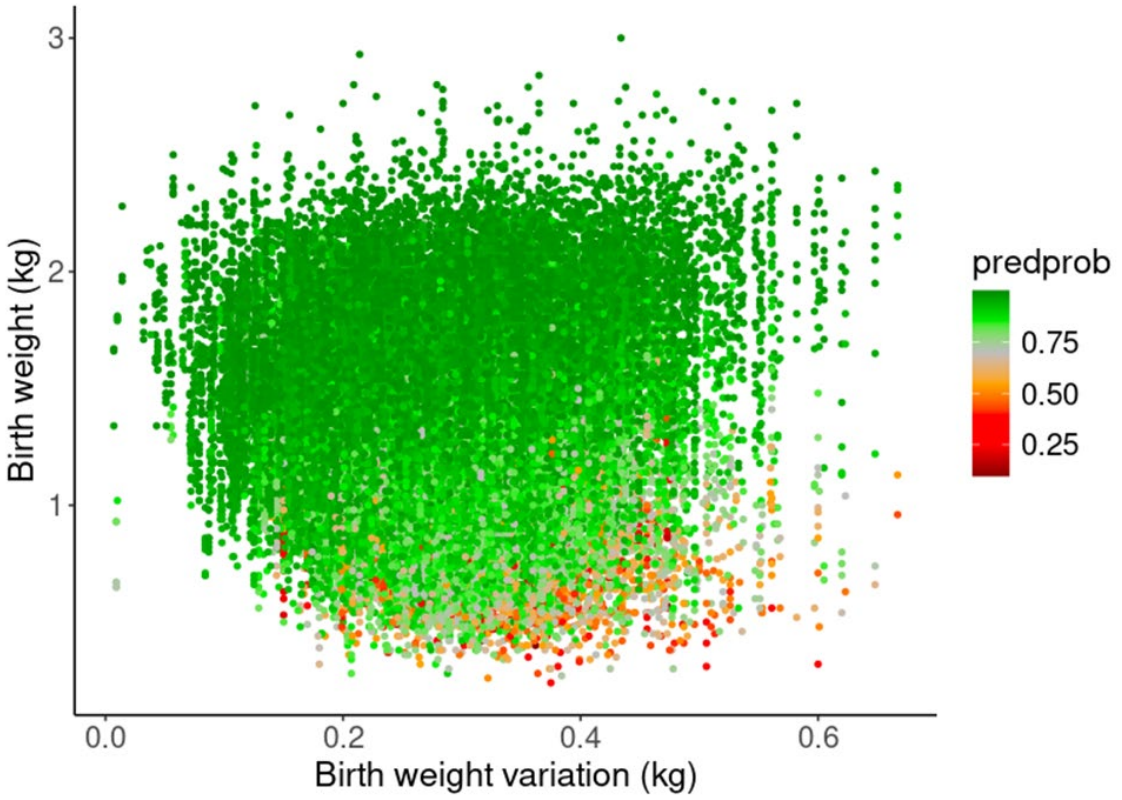
The PCA-adjusted weights for BW0 = 0.52 and BWvar = 0.47

BWVCI versus the predicted probabilities

BWVCI



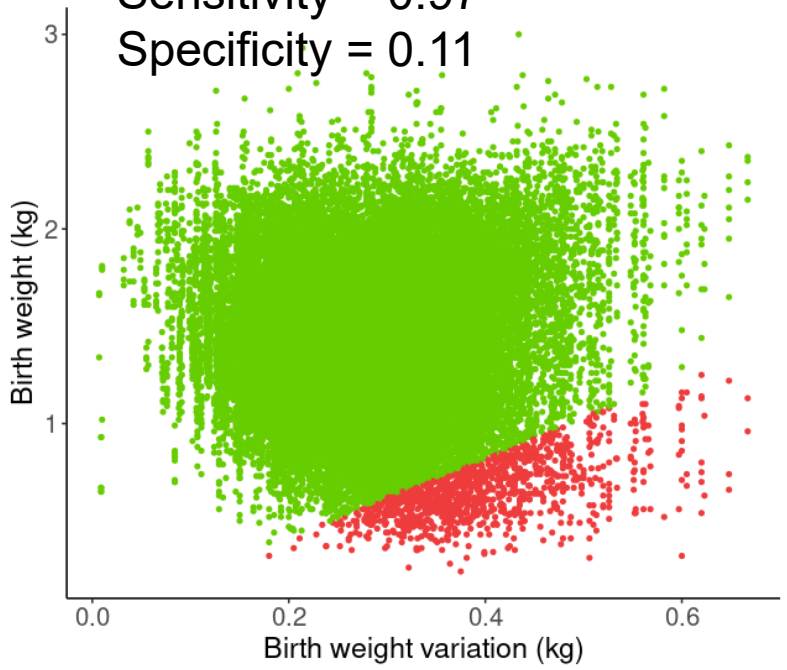
Predicted probabilities



Critical BWVR and BWVCI cut-off values

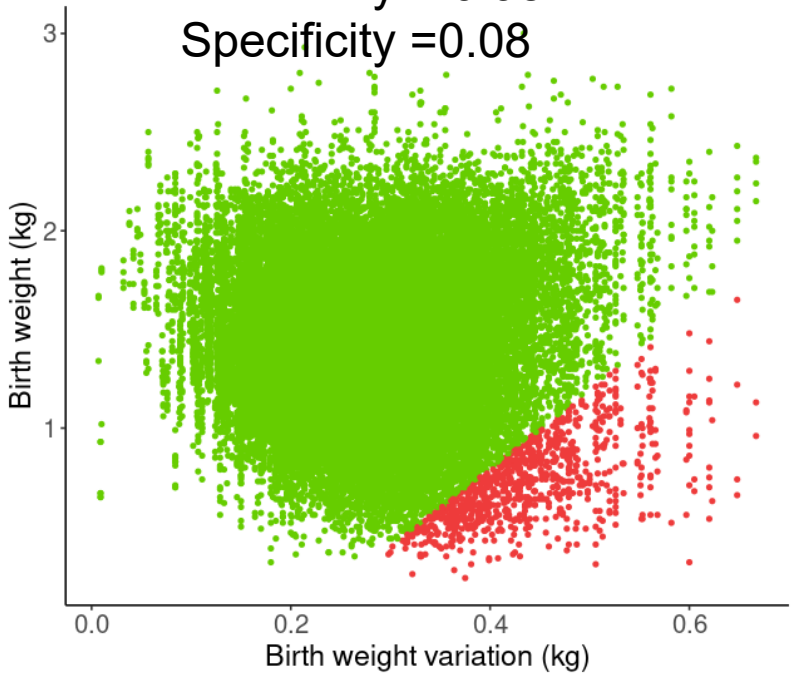
BWVR Cut-off value = 2.06

Accuracy = 0.89
Sensitivity = 0.97
Specificity = 0.11



BWVCI cut-off value = 0.30

Accuracy = 0.89
Sensitivity = 0.98
Specificity =0.08



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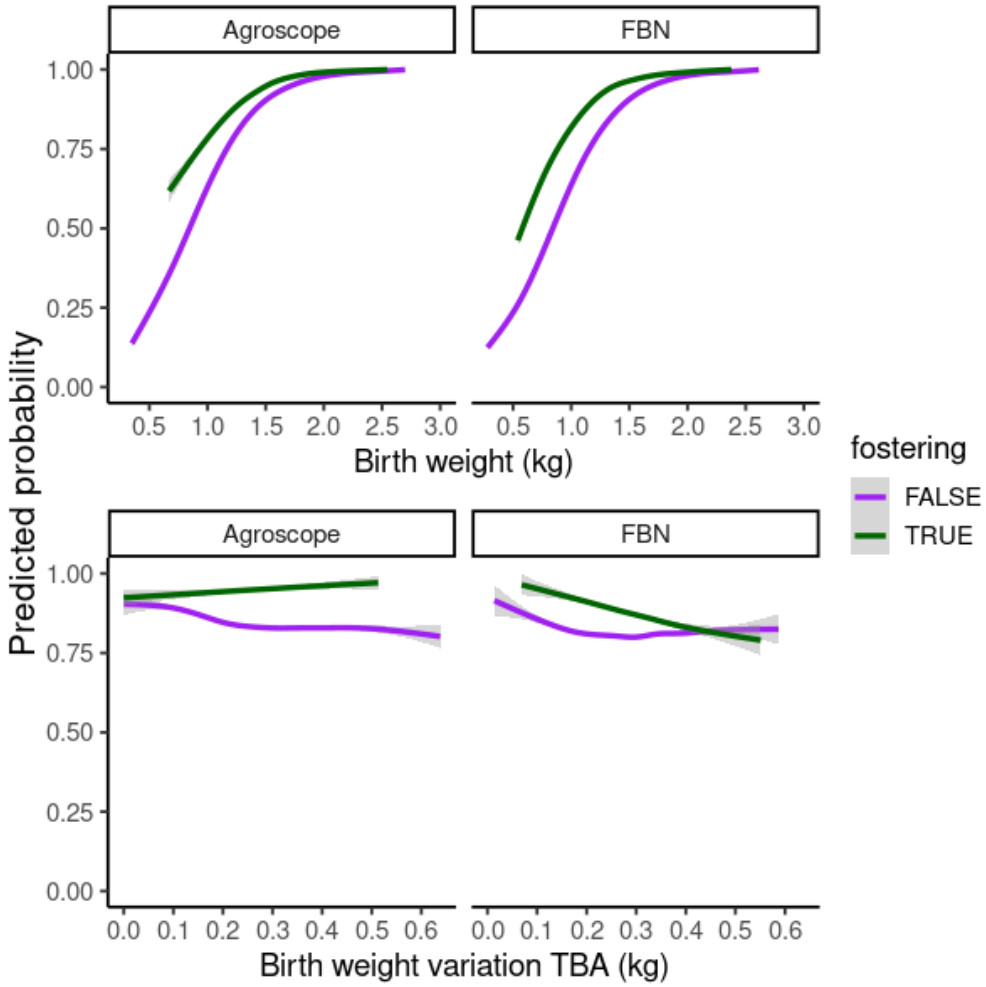
Strategies to improve pre-weaning survival rates

- **Monitoring and intervention**
  - Routine birth weight recording
  - Timely intervention for low-birth-weight piglets
- **Fostering**
- **Breeding for uniformity**
- **Management strategies**



Conclusions: Key findings

BW0 The most important single predictor for pre-weaning survival

BWvar

More important than litter size at birth

No significant influence after day 3 of age, most likely because of cross-fostering, and the litter size evening out

BWVR
BWVCI

Greatly improves the accuracy of predicting which piglets have an increased risk of neonatal mortality

Thank you

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