Long tails in pigs

An *on farm* risk-assessment-tool

K.G.H. Kreuger Stolk BSc

Student number: 3889580

December 2018

Faculty of Veterinary Medicine, Utrecht University

Supervisors:

Ing. A.I.J. Hoofs – Wageningen Livestock Research, WUR

Dr. T.J. Tobias – Faculty of Veterinary Medicine, Utrecht University

Prefatory note

This paper describes the results of the research internship conducted by K.G.H. Kreuger Stolk at Wageningen Livestock Research and the Department of Farm Animal Health at the Faculty of Veterinary Medicine in Utrecht. The research was conducted from October to December 2018. This report is the shortened English version of the original Dutch report.

This research is based on a Dutch project in which pig farmers gain practical experience in keeping pigs with long tails. In a network context the pig farmers gain step by step experience. As part of this project the pig farmers also completed an *on farm* risk-assessment-tool, in collaboration with project supervisors. This 'tool' provides insight into possible risk factors on farm level, in relation to biting behavior. The completed tools form the basis of this research.

The purpose of this research internship was two-sided; first, the quality of this *on farm* risk-assessment-tool on the subject 'long tails in pigs' was scientifically assessed. Second, the feed component within this risk-assessment-tool is examined in more detail. The practical work consisted of carrying out the risk-assessment-tool at pig farms.

I would like to express my very great appreciation to Anita Hoofs for her enthusiastic guidance and the practical knowledge that I was able to gain from her. Her passion for pigs is inspiring and catching. Also the members of Wageningen Livestock Research, thank you for participating in your team during my internship period. I would also like to thank Tijs Tobias and Jan van den Broek for their insight and help to shape the scientific analysis of this research. Finally, I am particularly grateful for the support of Tijs Tobias in scientific writing.

Table of contents

Summary

The objective of this study was to test and fine-tune the first version of the *on farm* risk-assessment-tool for biting behavior in pigs, developed by the steering committee of the project ‘Intact tails 2017-2021’. This tool was used for a risk assessment on thirteen pig farms in the Netherlands in 2018. The quality of the *on farm* risk-assessment-tool was assessed on the basis of the data obtained. The overall objective was broken down in two aims.

The primary aim of this research was to examine to which extent animal-related indicators observations are associated with non-animal-related indicators observations in three age groups: suckling piglets, weaned piglets and fattening pigs/breeding gilts. Non-animal-related indicators are measurements in the pigs’ environment and include feed, space, climate, enrichment, hygiene and animal health. Animal-related indicators are measurements on the animal itself, such as body cleanliness, presence of an intact tail and body condition score. For four non-animal-related indicators in the category ‘feed’ in weaned piglets, it was examined whether there is an association with observations for the animal-related indicator 'tail intact end of rearing'.

The second aim was to study the association of four non-animal-related indicators in the category feed of weaned pigs with the animal-related indicator ‘tail intact end of rearing’. This association has been studied for the thirteen network farms as well as for three farms outside the network. Each of these three farms had an anamnesis of tail biting problems and/or the farmer had the ambition to stop tail docking.

In addition to these two main objectives, several recommendations for optimization of the design of the *on farm* risk-assessment-tool were formulated.

The results of the study indicate a strong, significant positive relationship between the percentage of deviating non-animal-related indicators and deviating animal-related indicators in the age groups of suckling piglets and weaned piglets. However, this did not apply to the age group of finishing pigs/breeding gilts; a weak positive but not significant association was found there. Regarding the category ‘feed’ of weaned piglets insufficient data was available to make a statement about a possible association between four separate non-animal-related indicators in relation to the animal-related indicator ‘intact tail end of rearing'.

In conclusion, the *on farm* risk-assessment-tool is usable and sufficiently reliable to identify risk factors for tail biting at farm level for suckling piglets and weaned piglets. It is recommended to expand the dataset of completed risk-assessment-tools, so that a potential trend in individual animal- and non-animal-related indicators can be clarified.

Introduction

First a short introduction about tail biting and underlying mechanisms is given, based on scientific literature. In this report it is assumed that tail biting means that one pig damages another pig's tail due to biting behavior. Next, the political context and legal framework are outlined and the current situation about keeping pigs with long tails in The Netherlands is discussed. Subsequently, the context of this research project is described. Finally, the objective of this research project is provided.

Introduction tail biting

On most pig farms tail docking is nowadays a standard procedure to prevent tail biting as much as possible (D'Eath et al., 2014). Tail biting occurs in both conventional, free-range, as well as organic livestock farming (Bracke et al., 2012; Taylor et al., 2010). Tail biting is considered as abnormal behavior. Underlying motivation is the strong need for a pig to explore and forage. In addition, tail biting is multi-factorial in origin (D'Eath et al., 2014; Nannoni et al., 2014; Van der Peet et al., 2016) and the causes often vary per farm and situation (Van der Peet et al., 2016).

According to Taylor et al. (2010) there are three types of tail biters, see below. The *on farm* risk-assessment-tool (explained later) aims to identify the risk for all three types of tail biters. The three types are:

1. Two-step: Step 1: a gentle, investigative way of tail manipulation, due to a lack of activities in the environment. Step 2: damaging biting. Step 1 is considered as normal pig behavior; it is part of the natural foraging and exploration behavior of pigs. Only a few pigs proceed to Step 2;
2. Suddenly powerful: This was originally aggressive behavior, probably caused by frustration due to a lack of feed, water, lying space, etc.;
3. Obsessive: This is typically seen in only a single animal. The pig in question is fixed on tails of pigs in the same area and literally goes from one tail to the next. It is unknown how this behavior arises, it can occur both spontaneously or accelerated after a tail with bite wounds or blood has been seen.

The development of tail-biting behavior is also described as an imaginary bucket that gets filled with risk factors, specific to each farm. If too many unfavorable factors (risk factors) are present at a farm, the bucket will overflow figuratively and biting behavior may occur. In the EFSA report (2007) risk factors for tail biting are divided into two main groups, namely animal-related risk factors and non-animal-related risk factors. Examples of animal-related risk factors are breed and genetics, gender, weight/age. Non-animal-related risk factors are rearing, social factors, stocking density, floor type, enrichment, diet and feeding, health and climate.

Political context and legal framework

Although tail docking is conducted routinely on a large scale in the Netherlands and many other European countries, this is officially prohibited by the European Union (EU) since 1991. The most recent version of this legislation was updated and published by the European Council on December 18th of 2018 in Directive 2008/120/EG. This directive describes the establishment of minimum standards for the protection of pigs.

Given that social and political attention is increasingly focused on animal welfare, action has been taken by, among others, the Netherlands Agriculture and Horticulture Organization (LTO), the Dutch trade union for pig farmers (NVV), Dutch Society for the Protection of Animals and various chain parties. Together they have established the so-called Declaration of Dalfsen in 2013 and offered it to the state secretary of Agriculture at that time. This declaration was based on a scientific study on the risk factors related to tail biting by the 'Workgroup Intact tails' and described a two-step-route plan on how to stop tail docking step by step. Step 1 comprises the start of a demonstration project and a practice network. Step 2 was carried out later and will be explained on the next page.

In March 2016, the European Commission prioritized compliance to the ban on routinely tail docking and the EU now requires Member States to work actively towards a stop of routinely tail docking. In this Recommendation (2016/336), the European Commission states that all Member States must ensure that pig farmers carry out a risk assessment based on animal-related and non-animal-related risk factors (referred to as indicators), in order to determine the risk of tail biting at farm level. On the basis of this risk assessment, the farmers have to draw up a plan of action so that they will no longer routinely keep tail docking in pigs.

From 8 to 12 May 2017, an audit was carried out in the Netherlands by the Food and Veterinary Office (FVO; now DG Health and Food Safety) to assess to which extent the Netherlands meets the aim of the European Commission (described in Recommendation 2016/336 of the European Commission). This audit was also carried out in other European countries. The conclusion of the audit in the Netherlands was that the Dutch authorities do not enforce the provisions of Directive 2008/120/EG and consequently fail to comply. Based on this audit, recommendations were made for the Netherlands on how to comply with the directive. These recommendations are shown in Appendix 1 'Summary Audit & Recommendations'.

In November 2017, Step 2 of the Declaration of Dalfsen was put into operation (demonstration project, a second practical network and international cooperation) and a 'Steering Group Pig Tails' was established. This Steering Group consists of the POV (Producers Organization for Pig Farming), 'Dutch Society for the Protection of Animals' and the Ministry of Agriculture, Nature and Food safety (in Dutch: LNV). Furthermore, Wageningen University & Research is executing a project called 'Pigs with an intact tail'.

On 5 February 2018, minister Carola Schouten (LNV) responded to parliamentary questions on the subject of tail docking. She has indicated that she will be actively working on this topic with the sector.

Project description 'Roadmap Intact tails 2017-2021'

As mentioned before, the European Commission Recommendation 2016/336 states that all Member States must ensure that a risk assessment is carried out at farms, in which animal-related and non-animal-related indicators are determined. In the Netherlands the project 'Roadmap Intact tails 2017-2021' has been launched. This project consists of five components, such as an on farm risk-assessment-tool and a practice network, together with communication, financing and international cooperation.

A steering group has been set up for this project, supplemented by a scientific team, a coach team and a farmer support team. The scientific team is involved in the scientific substantiation of the *on farm* risk-assessment-tool and for background knowledge for the practice network. The coaching team consists of four experts from different disciplines such as WUR, a breeding organization, the animal feed industry, and a veterinarian. These experts have received further training about the theory on tail biting and corresponding risk factors, as well as an explanation how to use the *on farm* risk-assessment-tool. During the process of gaining practical experience, they will guide the farmers. The farmer support team consists of the farmers own veterinarian and/or feed advisor.

The aim of the *on farm* risk-assessment-tool component is to develop, test and fine-tune a tool for detection of risks that may contribute to biting behavior at farm level. This tool can be used to determine to which extent biting behavior occurs and it will clarify which risk factors are present at a farm. The tool consists of three parts: the three age groups suckling piglets, weaned piglets and finishing pigs/breeding gilts each have their own tool. In the long run, the pig farmer together with his/her farm adviser(s) must be able to use the tool to obtain data and to determine necessary steps to minimize or eliminate risk factors related to biting behavior. At the end of 2017, the first draft of this tool was delivered by the Steering Group of Pig Tails to the Ministry of LNV.

The practical network consists of thirteen pig farmers and the support team. The risk-assessment-tool was executed at the network farms in mid-2018. The network also started to gain step-by-step practical experience

in keeping pigs with intact tails. To participate in this project, the farmers in the network are at all times responsible in the process of gradually stopping tail docking. The experts are only involved as adviser.

Based on the experience gained in the practical network, the steering group will provide a responsible advice to the Ministry of LNV if, when and under which conditions it is possible to stop routinely tail docking. At the end of the project, the risk-assessment-tool may become part of a farm quality certification system, such as the chain quality system 'Holland pig'.

Research internship

My research internship contributes to the further development and quality testing of the *on farm* risk-assessment-tool. The quality of the *on farm* risk-assessment-tool will be assessed based on data obtained from the thirteen network farms.

The primary aim of this research was to examine to which extent animal-related indicators are associated with non-animal-related indicators for three age groups: suckling piglets, weaned piglets, and fattening pigs/breeding gilts. In addition, the association between four non-animal-related indicators in the category feed, in weaned piglets and animal-related indicators was examined. Finally, recommendations are made to fine-tune the design of this first draft version of the risk-assessment-tool (see Appendix 4: Recommendations fine-tuning the *on farm* risk-assessment-tool).

The practical work consists of visiting pig farms that have an anamnesis of (tail) biting problems and/or farmers who are interested to also start with keeping pigs with long tails.

Material and Methods

Type of research and hypotheses

In this observational retrospective cross-sectional study, the quality of the *on farm* risk-assessment-tool was assessed. The tool was executed at thirteen pig farms in the period May-June 2018. The data were analyzed between October and December 2018.

The aim of this study is to investigate whether the tool is reliable and usable to determine the risks of tail biting and the degree of biting behavior at farm level.

Individual risks within the tool were derived from separate scientific sources. However, the tool needs to aid in identifying and quantifying all risks for tail biting on the farm. Therefore, it is important to make an inventory whether there is sufficient coherence within the tool as a whole. Therefore, we quantified the association between non-animal-related indicators and animal-related indicators for three age groups: suckling piglets, weaned piglets and finishing pigs/rearing gilts. These are discussed in Hypothesis I, II and III, respectively.

As indicated before, there is a total number of 13 farms in the network. However, not all three age groups are present at all farms. In total 12 farms had suckling piglets, 12 farms weaned piglets and 11 farms had finishing pigs/breeding gilts.

The primary hypothesis that was tested is:

H_0 = There is no relationship between animal-related indicators and non-animal-related indicators per age group (suckling piglets/weaned piglet/finishing pigs+rearing gilts) at the 13 pig farms in the network;

H_1 = There is a relationship between animal-related indicators and non-animal-related indicators per age group (suckling piglets/weaned piglets/finishing pigs+rearing gilts) at the 13 pig farms in the network;

In addition, four hypotheses have been drawn up. These hypotheses aim to clarify a potential association between a specific non-animal-related indicator and a specific animal-related indicator for weaned piglets in category ‘feed’.

The four hypotheses are shown in Table 1 (only H_0 is shown). Each hypothesis is tested twice; once for the 12 farms with weaned piglets in the network and once for these 12 farms supplemented with three additional farms. These three farms were visited outside the network and, as described in the introduction, each farm has a history of tail biting problems and/or has a farmer with ambition to stop tail docking. The analysis with additional data aims to reveal whether a higher number of observations influences the reliability of the data.

Table 1: Sub-hypotheses ‘Weaned piglets – Category ‘feed’

Sub-hypothesis 1	*H_0: There is no relationship between animal-related indicator ‘tail intact end of rearing’ and non-animal-related indicator ‘digestible protein: lysine day 3-7 after weaning’ in weaned piglets;*
Sub-hypothesis 2	*H_0: There is no relationship between animal-related indicator 'tail intact end of rearing' and non-animal-related indicator 'number of piglets per drinking place' for weaned piglets;*
Sub-hypothesis 3	*H_0: There is no relationship between animal-related indicator ‘tail intact end of rearing’ and non-animal-related indicator ‘accessibility feed and water’ in weaned piglets;*
Sub-hypothesis 4	*H_0: There is no relationship between animal-related indicator ‘tail intact end of rearing’ and non-animal-related indicator ‘water yield per minute from drinking nipple’ in weaned piglets.*

Risk-assessment-tool & Farms in the network

As mentioned, 13 pig farmers are involved in the practical network. After an informative start-up meeting, they registered voluntarily at the POV to participate. The assumption is that these farmers are motivated to gain experience in keeping pigs with intact tails. There are two types of farms: farms with their own breeding from birth to first insemination and farms that are partially or completely closed (or both breeder and pig farmer participate together).

Participation in the network means that the risk-assessment-tool is executed on the farms. A supervisor from the guidance team, together with the farmers and the farm-advisor(s) (veterinarian and/or feed-advisor) completed the risk-assessment-tool during the first visit within this project. Additionally to executing the risk-assessment-tool, practical experience is gained with keeping pigs with intact tails. The obtained data are handled confidentially. The farmers can decide themselves to publicly their participation in the network.

Inclusion criteria for participation are first that participating farms are situated in the Netherlands and that finishing pigs are slaughtered in the Netherlands. Secondly, the farm structure and equipment must be fairly uniform within every age group, meaning that farms with many different types of accommodation are excluded. The last requirement is that a monthly farm visit is carried out by the farms own veterinarian or feed-adviser, who is the first contact person for all visitors (related to this project) at the farm.

Design risk-assessment-tool

Indicators in the tool are divided into non-animal-related indicators (measurements in the pig's environment) and animal-related indicators (measurements on the animal itself). Table 2 shows which categories of indicators are assessed. Each category consists of several indicators.

Table 2: Non-animal- and animal-related-indicators in the *on farm* risk-assessment-tool

Non-animal-related indicators	**Animal-related indicators**
Enrichment	Comfortable lying behavoir
Feed and water	Respiratory problems
Space	Body cleanliness
Thermal comfort/air quality	White sclera/tear line
Hygiene	Intact head and ears
Animal health	Intact tail
	Intact knees
	Body condition score
	Respiratory rate

Three age groups are considered, namely:

1. Suckling piglets;
    - 31 non-animal-related indicators and 8 animal-related indicators;
    - Suckling piglets are assessed one week before weaning;
2. Weaned piglets;
    - 57 non-animal-related indicators and 18 animal-related indicators;
    - Weaned piglets are assessed both one week after weaning as well as at the end of the rearing period;
3. Finishing pigs/breeding gilts;
    - 54 non-animal-related indicators and 18 animal-related indicators;
    - Finishing pigs/breeding gilts are assessed at 4-5 weeks and 11-12 weeks after entering the finishing barn.

The tool is designed as a traffic light method with two (yes/no) or three categories. All questions are based on scientific literature and have been created by the scientific team. The yes/no questions are based on studies specifically focused on tail biting behavior in pigs. The ordinal-arranged questions are not specifically focused on tail-biting behavior, but in a broader welfare-related context. Furthermore, the risk-assessment-tool is not solely intended to identify the risk of developing tail biting, but also of developing biting behavior in general (ears, flank and tail).

Risk factors are classified by the scientific team in green (low risk), orange (medium risk) and red (high risk) in the area of developing biting behavior, as if it were a traffic light. The fourth option is: "not applicable/not known/not measured". In Microsoft Excel the values are coded as, 1, 2, 3 and NA (Not Available) respectively. For the limit value for an orange colored risk for feed-related subjects, the scientific team has chosen to use the standard value from the CVB Tables Book (Federation of Dutch Animal Feed Chain 2018).

Reliability and validity

The *on farm* risk-assessment-tool has been developed by the scientific team of the Project 'Roadmap Intact tail 2017-2021' (see 'Introduction' for explanation). Prior to the application of the tool within the network, the risk-assessment-tool was externally validated and calibrated on different farms, under supervision of WUR.

Furthermore, in this study, the thirteen pig farmers in the network volunteered to participate in this study. Meaning our study population is not a random sample of pig farmers in the Netherlands. This will be taken into account in the discussion and conclusion of the study.

Processing completed tools

The first step of the data analysis is the anonymization and processing of the data obtained from the 13 completed risk-assessment-tools of the network farms in Microsoft Excel™. The three age groups are each processed in a separate table. During this process, comments of the supervisors, recorded on the paper version are collected, summarized and displayed in Appendix 4. Missing data in the database are shown as NA (Not Available). This is specifically for:

- Response option 4 for ordinal scaled questions (not applicable/not known/not measured);
- Indicators where no option is checked;
- Indicators for which two answers were provided.

Statistical analysis – Quality tool

By using the tool, risk factors can be identified on farm level. Additionally, it becomes clear to which category a certain risk factor belongs (low, medium or high risk category), for both animal-related and non-animal-related indicators.

It is tested whether there are more 'orange + red' answers for animal-related indicators, if there are also more 'orange + red' answers for non-animal-related indicators. As the data concerned many indicators for few farms and also concerned much missing data the type of analysis needed to account for these limitations.

For this reason, the percentage 'orange + red' of the given non-animal-related indicators was calculated per farm (number of farms per indicator minus missing data (i.e. NA)), and similarly for animal-related indicators. The number of 'orange + red' answers is divided over the number of available indicators and converted into percentages and processed as such for the different age categories. In Appendix 3 "Tables data Excel 13 farms" the above is depicted schematically.

Next, the non-parametric Spearman rank correlation test was used to assess the correlation between the percentage of orange-red scored non-animal-related indicators and animal-related indicators using R (R Core Team, 2018). The Spearman rank correlation test fits best in this study since the data was not normally distributed and it was mostly ordinal. For testing the hypotheses, α was set at 0.05.

The following arbitrary classification of correlation coefficient (r) was used for the interpretation (based on Tilburg University, 2018):

- $0.00 < r < 0.30$: hardly any correlation
- $0.30 < r < 0.50$: low correlation
- $0.50 < r < 0.70$: moderate correlation
- $0.70 < r < 0.90$: high correlation
- $0.90 < r < 1.00$: very high correlation

Statistical analysis – 'Feed' weaned piglets

In addition to the assessment of the quality of the tool as a whole, it was investigated whether the tool is also usable and reliable for testing the correlation between separate non-animal-related and animal-related indicators.

In this analysis, there is a focus on the non-animal-related indicator for the category 'feed' in weaned piglets because there is a great quantity of scientific knowledge available about feed in pigs (often in relation to tail biting). Water quality and drinking equipment, on the other hand, are often underexposed, which also makes it interesting and relevant. In addition to the data analysis, a literature study on nutrition in pigs was written (if available specifically for weaned piglets), based on the most recent literature in relation to the EFSA report on tail biting (2007). Results are depicted in Appendix 2 "Literature analysis on nutrition for weaned piglets" and serves as a reference work for the expert group.

The feed-category consisted of 22 non-animal-related feed-related indicators and 18 animal-related indicators for weaned piglets. In this study only four non-animal-related indicators and only the animal-related indicator 'tail intact end of rearing' were included, as this study is focused on tail biting. The non-animal-related indicators were selected based on the availability of the data. An answer of at least 10 of the 12 farms was required for inclusion in the analysis. This requirement was met for 10 of the 22 indicators. Next, to enhance statistical power, indicators with less than two answers were excluded, i.e. at least two response options per indicators should have been given.

Four of the 22 non-animal-related indicators (ND) that remained were tested, namely:

- ND9: Digestible Lysine day 3-7 after weaning (10 answers);
- ND27: Number of piglets per drinking place (12 answers);
- ND28: Accessibility of feed and water (12 answers);
- ND30: Water yield per minute from nipple (12 answers).

Next, 2x2 contingency tables for the individual sub-hypotheses were generated. These 2x2 tables were analyzed with a Fisher's exact test. This test fits best since the data set is quite limited. The step-by-step plan is executed separately for suckling piglets, weaned piglets, and finishing pigs/rearing gilts. No p-values are used to answer these hypotheses, but 95% confidence intervals for the odds ratio, to make statements about significance.

Finally, in the fourth analysis (ND30 in relation to 'tail intact end of rearing' (=D69)), the analysis of the data showed that a value of 'zero' appeared in the 2x2 table. Since no association measure can be calculated with a zero-value in a cell, it has been decided to add +1 to each of the four cells to enable calculation of an association measure.

Results

Results analysis - Quality tool

The Spearman rank correlation test was assessed for each age group. First, the primary hypothesis (H_0) per age group is given and thereafter the results obtained from the Spearman correlation. Appendix 3 contains the tables with crude data from the three age groups.

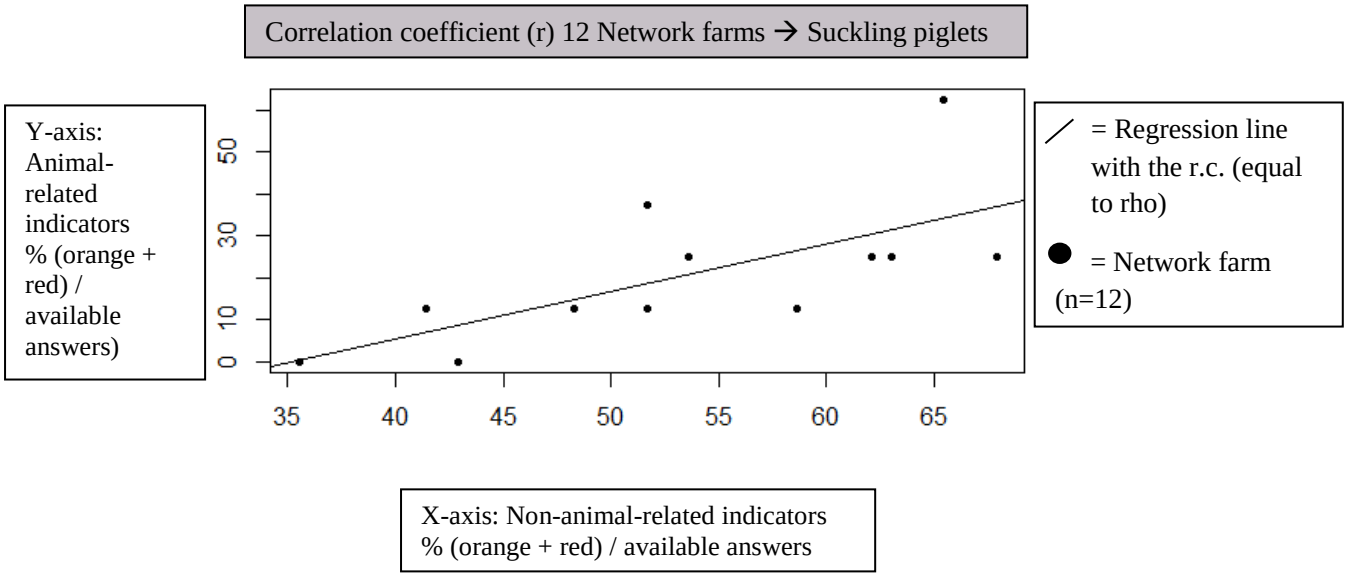
Suckling piglets

Primary hypothesis I:

H_0 = There is no relationship between animal-related indicators and non-animal-related indicators in suckling piglets.

Result:

- Correlation coefficient rho (r) = 0.74
- p-value = 0.006



Explanation:

There is a strong, significant positive association between the percentage deviating non-animal-related indicators and animal-related indicators in the age group of suckling piglets. This means that the more 'orange + red' answers are scored on non-animal-related indicators, the more 'orange + red' answers were scored on animal-related indicators at the 12 network farms.

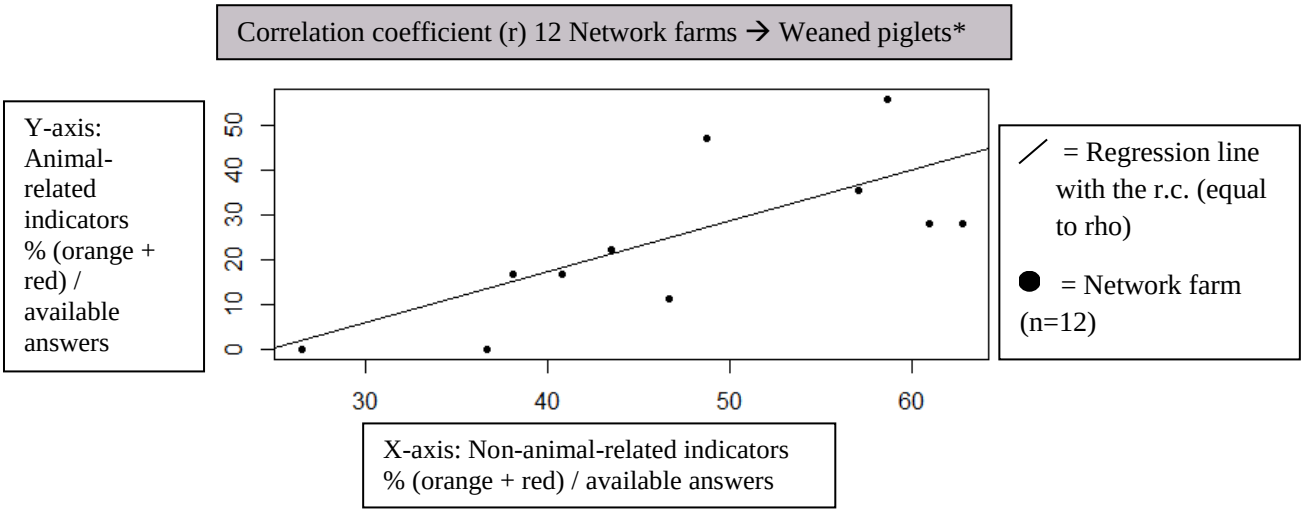
Weaned piglets

Primary hypothesis II:

H_0 = There is no relationship between animal-related indicators and non-animal-related indicators in weaned piglets.

Result:

- Correlation coefficient rho (r) = 0.76
- p-value = 0.004



* 11 points can be seen in the graph; as two farms have exactly the same percentages of animal-related (D) and non-animal-related (ND) indicators (D 47.1% and ND 48.4%) and overlying dots cannot be distinguished visually.

Explanation:

There is a strong, significant positive relationship between non-animal-related indicators and animal-related indicators in the age group weaned piglets, because r = 0.76. This means that the more 'orange + red' answers are scored on non-animal-related indicators, the more 'orange + red' answers are scored on animal-related indicators at the 12 network farms.

Finishing pigs/breeding gilts

Primary hypothesis III:

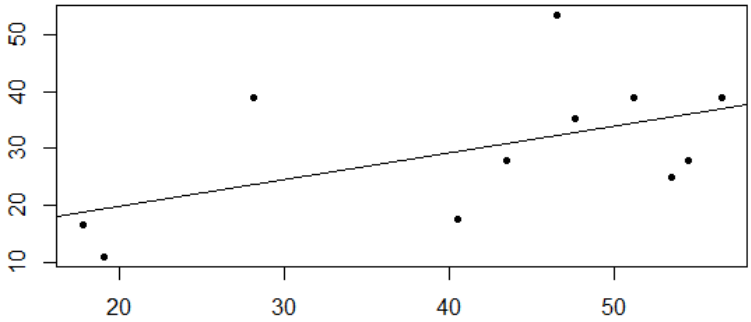
H_0 = There is no relationship between animal-related indicators and non-animal-related indicators in finishing pigs/breeding gilts.

Result:

- Correlation coefficient rho (r) = 0.47
- p-value = 0.14

Correlation coefficient (r) 11 Network farms → Finishing pigs/breeding gilts

Y-as: Animal-related indicators % (orange + red) / available answers



= Regression line with the r.c. (equal to rho)

= Network farm (n=11)

X-axis: Non-animal-related indicators % (orange + red) / available answers

Explanation:

There is a weakly positive, but insignificant, relationship between non-animal-related indicators and animal-related indicators in the finishing pigs/breeding gilts age group. This means that there is no clear correlation between the degrees of occurrence of the number of 'orange + red' responses compared to the number of non-animal-related indicators finishing pigs/breeding gilts, at the 11 network farms.

Results analysis - Feed weaned piglets

The association of the following four non-animal-related indicators with 'tail intact end of rearing' was assessed using 2x2 contingency tables and Fisher's exact test:

- ND9: Content of intestinal digestible Lysine per Energy Value 2015 (gr/EV) of the weaning feed on days 3-7 after weaning;
- ND27: Number of piglets per drinking place;
- ND28: Accessibility of feed and water for the smallest piglets at the time of entering the nursery and for the largest piglets at the end of the rearing;
- ND30: Water yield per minute from drinking nipple (ml/minute).

For each sub hypothesis two 2x2 tables are made. The first contains the results based on data from the 12 network farms with weaned piglets and the second is a supplement to part one with the 3 additional farms. A brief explanation follows after each non-animal-related indicator.

Sub hypothesis 1:

H_0: There is no relationship between animal-related indicator 'tail intact end of rearing' and non-animal-related indicator 'Digestible protein: lysine day 3-7 after weaning' in weaned piglets at 10 pig farms in the network.

Non-animal-related indicator no. 9 versus animal-related indicator no. 69

12 Network farms (-2 missing data)

		ND 9: Digestible protein: Lysine day 3-7		
		Green	Orange+red	Total
D 69 Tail intact end of rearing	Green	6	2	8
	Orange+red	1	1	2
	Total	7	3	10

Fisher's exact test:
Odds ratio: 2.64

95% confidence-interval = 0.026 – 273.2

12 Network farms (-2 missing data) + 2 extra farms

		ND 9: Digestible protein: Lysine day 3-7		
		Green	Orange+red	Total
D 69 Tail intact end of rearing	Green	6	2	8
	Orange+red	3	1	4
	Total	9	3	12

Fisher's exact test:
Odds ratio: 1.0

95% confidence-interval = 0.013 – 27.9

Explanation:

Based on these results, there seems to be a positive association between 'Digestible protein: lysine day 3-7 after weaning' versus 'tail intact end of rearing', executed at the 10 network farms, after all the odds ratio is larger than 1 (analysis 12 network farms). This is different within second analysis (12 + 2 farms), where the odds ratio is 1 and there is no association.

Sub hypothesis 2:

H_0: There is no relationship between animal-related indicator 'tail intact end of rearing' and non-animal-related indicator 'number of piglets per drinking place' in weaned piglets at 12 pig farms in the network.

Non-animal-related indicator no. 27 versus animal-related indicator no. 69

12 Network farms

D 69 Tail intact end of rearing	ND 27 Number of piglets/drinking place: Green	Orange+red	Total
Green	5	5	10
Orange+red	1	1	2
Total	6	6	12

Fisher's exact test:
Odds ratio: 1.0

95% confidence-interval = 0.01 – 94.0

12 Network farms + 3 extra farms

D 69 Tail intact end of rearing	ND 27 Number of piglets/drinking place: Green	Orange+red	Total
Green	5	5	10
Orange+red	4	1	5
Total	9	6	15

Fisher's exact test:
Odds ratio: 0.27

95% confidence-interval = 0.004 – 4.25

Explanation:

Based on these results, there appears to be no association between 'number of piglets per drinking place' versus 'tail intact end of rearing', executed at the 12 network farms, the odds ratio being equal to 1 (analysis 12 network farms). This is different within second analysis (12 + 3 farms), where the odds ratio is less than 1 and there is a negative association.

Sub hypothesis 3:

H_0: There is no relationship between animal-related indicator 'tail intact end of rearing' and non-animal-related indicator 'accessibility of feed and water' in weaned piglets at 12 pig farms in the network.

Non-animal-related indicator no. 28 versus animal-related indicator no. 69

12 Network farms

D 69 Tail intact end of rearing	ND 28 accessibility of feed and water: Green	Orange+red	Total
Green	8	2	10
Orange+red	1	1	2
Total	9	3	12

Fisher's exact test:
Odds ratio: 3.46

95% confidence-interval = 0.034 – 351.0

12 Network farms + 3 extra farms

D 69 Tail intact end of rearing	ND 28 accessibility of feed and water: Green	Orange+red	Total
Green	8	2	10
Orange+red	3	2	5
Total	11	4	15

Fisher's exact test:
Odds-ratio: 2.48

95% confidence-interval = 0.13– 50.83

Explanation:

Based on these results, there appears to be a positive association between 'accessibility of feed and water' versus 'tail intact end of rearing', executed at the 12 network farms, the odds ratio being greater than 1 (analysis 12 network farms). This is also the case in the second analysis (12 + 3 farms).

Sub hypothesis 4:

H_0: There is no relationship between animal-related indicator 'tail intact end of rearing' and non-animal-related indicator 'water yield per minute from drinking nipple' in weaned piglets at the 12 pig farms in the network.

Non-animal - related indicator no. 30 versus animal-related indicator no. 69

12 Network farms

		ND 30 water yield per minute from drinking nipple		
D 69 Tail intact end of rearing		Green	Orange+red	Total
	Green	8	4	12
	Orange+red	3	1	4
	Total	11	5	16

Fisher's exact test:
Odds ratio: 0.55

95% confidence-interval = 0.008 – 9.4

12 Network farms + 3 extra farms

		ND 30 water yield per minute from drinking nipple		
D 69 Tail intact end of rearing		Green	Orange+red	Total
	Green	7	3	10
	Orange+red	4	1	5
	Total	11	4	15

Fisher's exact test:
Odds ratio: 0.60

95% confidence-interval = 0.009 – 11.1

Explanation:

Based on these results, there appears to be a negative association between ND30 and D69 executed on the 12 network farms, since the odds ratio is less than 1 (analysis of 12 network farms). This is also the case in the second analysis (12 + 3 farms).

Discussion

Summary of results in relation to aim of the study

The aim of this study was first of all to assess the quality of the *on farm* risk-assessment-tool, based on completed tools from thirteen network farms. In addition, it was also examined whether it is feasible to make a reliable statement about an association between a separate non-animal-related indicator and the animal-related indicator 'tail intact end of rearing' for some variables within the category ‘feed’ in weaned piglets. As the tool is based on scientific literature, it can be assumed that the individual components are reliable in themselves to identify risk factors for the development of tail biting. The quality of the tool was assessed by looking at coherence within the tool as a whole.

The results show that the tool is sufficiently reliable in terms of usability, identification of risk factors in suckling piglets and weaned piglets, and the determination whether and to which extent tail biting occurs. The tool appears to be reliable for these two age groups, given the significant positive relationship between percentage of non-animal-related indicators and animal-related indicators in both groups. This means that the more ‘orange + red’ answers are scored in the tool for non-animal-related indicators, the more ‘orange + red’ answers are scored for animal-related indicators.

A weak positive but not significant association was found between animal-related and non-animal-related indicators in finishing pigs/breeding gilts, whereas this association was significant in suckling piglets and weaned piglets. During processing and analyzing the data, no specific indications were discovered which could explain this difference. Remarkable is the fact that for both suckling and weaned piglets on two out of twelve farms a score of 'green' was achieved on all animal-related indicators. This is in contrast with the finishing pigs/breeding gilts, where there were no farms with a 100% ‘green’ score (the lowest score was 11 percent; i.e. ((orange + red) / available answers in %). This may make the regression line less steep. Nevertheless, the number of farms (twelve farms with both suckling and weaned piglets and eleven with finishing pigs/breeding gilts) is limited so this may be due to coincidence. The percentages regarding the non-animal-related indicators were relatively comparable. Furthermore, reduced intra-assessor reliability due to the long time it takes to complete the tool on one day may play a role. Finishing pigs/breeding gilts were consistently assessed as the third and last age group. Although the tool is designed in such a way that it can be completed in about three hours, it is likely that the assessor is less concentrated and possibly fatigued at the end and therefore records observations less accurate.

The second part of the study, regarding an association between a non-animal-related indicator and the animal-related ‘tail intact end of rearing’ indicator, was carried out for a few variables within the ‘feed’ category for weaned piglets. The expectation was that a data set of twelve farms was too limited to make a reliable statement. This proved to be true even when using the Fisher's exact test which should fit well with data sets where more than 20% of the cells in the 2x2 table have an expected frequency of less than five values (Kim, 2017). Indeed, there is no trend in the odds ratios, with the confidence interval being wide to very broad, which also indicates a lower reliability of individual risk indicators for damaging behavior.

Power

Another limiting factor with regard to the statistical power in the data set is the design of the risk-assessment-tool. The tool for suckling piglets, weaned piglets, and finishing pigs/breeding gilts consists of respectively 39, 78 and 72 indicators. With data available for only 11 or 12 farms per age group, there are only a few observations per indicator. Therefore, a reliable association between a single non-animal-related indicator and an animal-related ‘tail intact end to end rearing’ indicator could not be assessed within this dataset.

Selection bias

As described in Material & Method, the 13 network farms are not randomly selected. This selection bias may limit the external validity, since the farmers in the network may be more motivated than the average pig farmer in the Netherlands. In addition, it could be hypothesized that these farms have more green answers on average than the average Dutch pig farm; or farms with an average higher standard.

Judgement bias

On the other hand, it is a strong point that the network support team did follow training prior to complete the risk-assessment-tool (including the development of the same reference standard regarding animal- and non-animal-related indicators). As a result, it is likely that the supervisors can judge sufficiently objectively and standardized. Although this inter-observer agreement has not actually been determined, it has been assumed for the time being that the inter-observer agreement is sufficiently high since many parameters in the tool are objective, in addition to some more subjective parameters.

Response bias/missing data

The analysis takes into account the so-called "missing data". For suckling piglets, 6.4% of the possible answers appeared to be missing in the dataset. This is 20.0% for weaned piglets and 15.9% for finishing pigs/breeding gilts. It has to be mentioned that the missing data partly consisted of questions that logically cannot be answered at some farms. For example, a question for weaned piglets is: "When eating at the same time several times a day (long trough) [...]". In the case of such a question, however, a farm that has ad libitum feed will answer this with the option "Not Available" (i.e. missing data). In other cases, however, this does not apply, namely: in the case of weaned piglets, the category of non-animal-related indicators 'thermal comfort/air quality' consists of, among others, measuring NH_3, CO_2 and relative humidity (RH), each as well 'one week after weaning' as 'end of rearing'. At the 12 farms where weaned piglets are kept, these six measured values were incomplete in 40.3% of the possible answers. Regardless of the reason for these 'missing data' (such as perhaps the lack of measuring equipment), it is recommended that in particular the subject of climate (category 'thermal comfort/air quality') deserves more attention, in the sense of acquiring more knowledge or about making sure that necessary climate measuring equipment is available. For other missing data there seems to be no clear trend that one specific category has relatively more ‘missing data’.

According to literature, previous research on risk factors related to tail biting in pigs regarding animal-related indicators is lacking. The BioCheck™ from Ugent (Belgium), a tool focused on biosecurity (Gelaude et al., 2014), seems comparable in terms of design and development. This risk-based, quantitative tool examines the relative status of biosecurity on a livestock farm in a standardized and reproducible manner (animal-specific: pigs, poultry or cattle). Similar between this tool and the *on farm* risk-assessment-tool is the classification per parameter in categories where there is a high (medium) or low risk classification. However, the way in which this classification was established is different. The Biocheck™ is composed by a panel consisting of 16 experts (epidemiologists, veterinarians, microbiologists and hygiene specialists), whereby they each assign a weighting to the individual risk factors (Gelaude et al., 2014). In contrast, for the *on farm* risk-assessment-tool, scientific literature has been used to classify the classification into low, medium, and high risk per parameter. This is more objective than the average opinion of 16 experts, as is the case with the Biocheck™. However, the *on farm* risk-assessment-tool has the limitation that it is not suitable for assigning a weighting to a separate indicator/risk factor, which is possible with the BioCheck™. Perhaps that may proof possible for this tool in the future, when the dataset is supplemented with data from more farms. This may aid in prioritization for improving the non-animal-related indicators on farms.

External validity

As mentioned, the network of thirteen pig farmers is not randomly selected. In addition, it is very likely that these participants in the network are more motivated than the average pig farmer in the Netherlands.

Furthermore, the tool is a 'snapshot', it gives information about a certain moment in time. The tool was implemented on all network farms in the summer of 2018. It is therefore recommended to execute the tool at different moments per year, to account for possible influences due to season and other factors.

Usability tool in practice

The tool has been developed within the project 'Roadmap Intact Tail 2017-2021'. Nowadays, the tool seems only suitable for application within this project, namely the identification of risks at farm level and to determine to which extent biting behavior is present. The next step in the use of the tool could also take place within the project, by implementing the tool at other farms where a problem with (tail) biting behavior exists. By a larger, perhaps more diverse, dataset, the second part of the research discussed here, namely whether there is a positive association between a separate non-animal-related indicator in relation to animal-related 'tail intact' indicator, may be executed with more power. It may even be possible to prioritize risks. This is speculative for now, but could be of great value for practical applications. Ideally, a weighting can be assigned to a separate non-animal-related indicator, so that the reduction of risk factors at farm level can be tackled in a more targeted manner. In this way, the interpretation of the so-called 'bucket' filled with risk factors per farm can be made insightful.

In addition, as already discussed above, the tool says something about risks at a certain moment. In practical terms, this means that the tool is not yet suitable for use by livestock farmers and veterinarians, but with this initial research a solid step has been made in making the tool applicable in practice.

Conclusion

As the results show, the tool is a reliable way to identify risk factors in suckling piglets and weaned piglets at farm level. A limitation is that the tool is only reliable when used as a whole. It is not possible to make reliable statements about the weighting of individual (non-)animal-related indicators. In a follow-up study, or before the tool will be introduced in daily practice on farms or by veterinarians, the dataset of completed tools must be expanded so that the weighting of the individual indicators can also be determined.

Conclusion

The conclusion of this study is that it is feasible to use the *on farm* risk-assessment-tool to reliable identify risk factors for tail biting at farm level for suckling piglets and weaned piglets, as well as determining to which extent tail biting occurs. It is recommended to further expand the dataset with farms where the tool is implemented, so that a potential trend in individual animal- and non-animal-related indicators can be clarified.

References

Bracke, M., Vermeer, H., Bokma, M., Van der Peet, C., Bolhuis, L., & Leeijen, J. (2012). Checklist Aanpak staartbijten bij (biologische) varkens. Wageningen UR, Lelystad, The Netherlands.

CVB Veevoedertabel 2018, Chemische samenstellingen en nutritionele waarden van voedermiddelen. Federatie Nederlandse Diervoederketen 2018, www.cvbdiervoeding.nl, assessed at 17 December 2018.

De Lange, C. F. M., Pluske, J., Gong, J., & Nyachoti, C. M. (2010). Strategic use of feed ingredients and feed additives to stimulate gut health and development in young pigs. *Livestock Science*, *134*(1-3), 124-134.

D'Eath, R. B., Arnott, G., Turner, S. P., Jensen, T., Lahrmann, H. P., Busch, M. E., ... & Sandøe, P. (2014). Injurious tail biting in pigs: how can it be controlled in existing systems without tail docking?. *Animal*, *8*(9), 1479-1497.

European Food Safety Authority (EFSA). (2007). The risks associated with tail biting in pigs and possible means to reduce the need for tail docking considering the different housing and husbandry systems-Scientific Opinion of the Panel on Animal Health and Welfare. *EFSA Journal*, *5*(12), 611.

Ettle, T., & Roth, F. X. (2009). Dietary selection for lysine by piglets at differing feeding regimen. *Livestock Science*, *122*(2-3), 259-263.

Gelaude, P., Schlepers, M., Verlinden, M., Laanen, M., & Dewulf, J. (2014). Biocheck. UGent: A quantitative tool to measure biosecurity at broiler farms and the relationship with technical performances and antimicrobial use. *Poultry science*, *93*(11), 2740-2751.

Kim, H. Y. (2017). Statistical notes for clinical researchers: chi-squared test and Fisher's exact test. *Restorative dentistry & endodontics*, *42*(2), 152-155.

Le Floc'h, N., Gondret, F., Matte, J. J., & Quesnel, H. (2012). Towards amino acid recommendations for specific physiological and patho-physiological states in pigs. *Proceedings of the Nutrition Society*, *71*(3), 425-432.

Martínez-Trejo, G., Ortega-Cerrilla, M. E., Rodarte-Covarrubias, L. F., Herrera-Haro, J. G., Figueroa-Velasco, J. L., Galindo-Maldonado, F., ... & Lara-Bueno, A. (2009). Aggressiveness and productive performance of piglets supplemented with tryptophan. *J Anim Vet Adv*, *8*(4), 608-611.

Nannoni, E., Valsami, T., Sardi, L., & Martelli, G. (2014). Tail docking in pigs: a review on its short-and long-term consequences and effectiveness in preventing tail biting. *Italian Journal of Animal Science*, *13*(1), 3095.

van der Peet-Schwering, C., Dirx, N., Kluivers-Poodt, M., Binnendijk, G., Bolhuis, L., & van der Peet, G. (2017). *Effect van voersamenstelling op bijtgedrag bij varkens* (No. 1008). Wageningen Livestock Research.

van der Peet, G. F. V., Kluivers-Poodt, M., Dirx-Kuijken, N. C. P. M. M., van der Peet-Schwering, C. M. C., Binnendijk, G. P., Ursinus, W. W., & Bolhuis, J. E. (2016). *Houden van varkens met een intacte staart* (No. 939). Wageningen UR Livestock Research.

R Core Team (2018). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Taylor, N. R., Main, D. C., Mendl, M., & Edwards, S. A. (2010). Tail-biting: a new perspective. *The Veterinary Journal*, *186*(2), 137-147.

Tilburg University, Indeling correlatie-coefficient https://www.tilburguniversity.edu/nl/studenten/studie/colleges/spsshelpdesk/edesk/correlat/ Assessed at 17 December 2018.

Valros, A., & Heinonen, M. (2015). Save the pig tail. *Porcine Health Management*, *1*(1), 2.

Van Der Meer, Y., Gerrits, W. J., Jansman, A. J., Kemp, B., & Bolhuis, J. E. (2017). A link between damaging behavior in pigs, sanitary conditions, and dietary protein and amino acid supply. *PloS one*, *12*(5), e0174688.

Appendices

Appendix 1: Summary Audit & Recommendations FVO

Appendix 2: Literature research on ‘feed’ for weaned piglets

Appendix 3: Tables Excel data 13 farms

Appendix 4: Recommendations fine-tuning the *on farm* risk-assessment-tool

Appendix 1: Summary Audit & Recommendations FVO

Below is the summary and the audit recommendations made by the FVO in the Netherlands, from 7 May to 12 May 2018. The entire document "Audit no.: 2017-6125 Animal Welfare - tail docking of pigs" can be found online at http://ec.europa.eu/food/audits-analysis/audit_reports/details.cfm?rep_id=3908.

Executive summary (quoted literally)

The report describes the outcome of an audit in the Netherlands from 8 to 12 May 2017. This audit is part of a Commission project aimed at improving the implementation and enforcement of Directive 2008/120/EC which lays down minimum standards for the protection of pigs in the EU.

The objective of the audit was to evaluate the suitability and effectiveness of the measures in place to prevent tail-biting and to avoid routine tail-docking of pigs.

The report concludes that the Dutch authorities do not enforce the provisions of the pig Directive to stop routine tail-docking of pigs as they are of the view that it is a complex, multifactorial issue that needs a national strategy based on working in partnership with pig farmers (declaration of Dalfsen) to ensure implementation of Commission Recommendation (EU) 2016/336, and thus reduce the routine tail-docking of pigs.

Although to date this has not rendered any results in decreasing the number of farms that routinely tail-dock piglets, the pig sector has committed to start work on the design of farm risk assessments before the end of 2017. The Ministry of Economy intends to announce, in May 2019, a date to stop routine tail-docking in the country, which if done, will indicate a serious commitment to progress in the effective implementation of the pig Directive.

European and national financial measures are not used effectively to reduce tail-biting and avoid routine tail-docking of pigs and there is little incentive to farmers to reduce levels of tail biting in the current farming and quality assurance systems in the Netherlands.

There is on-going work, including with the sector, to deliver a usable benchmarking inspection tool to address the insufficient instructions and guidance to inspectors in order to reach a harmonized understanding of what constitutes a breach regarding sufficient and suitable enrichment material.

The data on past non-compliances obtained from farm inspections and the ones on tail-damage obtained at slaughterhouse level provide opportunities for the competent authority for improving its system (e.g. risk selection of farms, set intervention levels and measuring progress in reducing occurrence of tail-biting) and for using its resources more effectively to reach the objective of reducing systematic tail-docking of pigs.

The report contains recommendations to the Dutch authorities to address the shortcomings identified.

See next page for recommendations FVO.

Recommendations

Nr.	Recommendation
1	The competent authority should review the transposition of the requirements for enrichment material in the Law on Decision holders of animals (Dutch law: Besluit houders van dieren) to ensure they reflect clearly the intent of the original language text of Council Directive 2008/120/EC. Conclusion 25; Findings 2, 3.
2	The competent authority should provide inspectors with suitable instructions and guidance to enable them to effectively enforce the provision on the prevention of tail-biting and avoidance of routine tail-docking, as laid down in the second paragraph of point 8 of Chapter I of Annex I of Council Directive 2008/120/EC, including how they should assess evidence of tail and ear lesions on farm and what constitutes sufficient measures by farmers to change inadequate environmental conditions or management systems before resorting to tail-docking of pigs, including the situation where tail-docked pigs are purchased from rearing farms which have shown no evidence of tail-biting. Conclusions 27, 28. Findings 5 to 13. Conclusion 53. Findings 42, 43, 47
3	The competent authority should provide instructions and guidance for inspectors to enable them to assess if the requirements on the provision of enrichment material as laid down in point 4 of Chapter I of Annex I of Directive 2008/120/EC regarding the suitability ("proper manipulation and investigation activities") and sufficiency ("permanent access to a sufficient quantity of material") of enrichment materials have been fulfilled on farms. Assessment methods for checking access to enrichment materials should include checks based on the guidance given in point 7 of Commission Recommendation (EU) 2016/336 and/or other suitable best practice. Conclusion 53. Findings 44, 45, 47.
4	The competent authority should ensure that high levels of non-compliances, in this case regarding enrichment materials, are taken into account in the setting of future inspection priorities as required by Articles 3 and 43(1) (b) of Regulation (EC) No 882/2004 and in their strategy to avoid the routine tail-docking of pigs. Conclusion 54. Finding 46
5	The competent authority should ensure that the levels of tail-damage in slaughterhouses is monitored and that high levels of non-compliances trigger actions on the respective farms, as required in Article 5 of Regulation (EC) No 854/2004. Conclusion 55. Findings 49, 50 and 51
6	As required in Article 4.2 (a) of Regulation (EC) No 882/2004, the competent authority should assess that there is recorded evidence of the incidence of tail biting on farm and the effectiveness of improvement measures taken to combat this and their impact, as required in point 8 of Chapter I, of Annex I to Directive 2008/120/EC, including when piglets are going to be sent to rearing farms for further fattening, and not rely on veterinary statements instead of official controls to 'ensure' the requirements of the Directive are implemented effectively. Conclusion 29. Findings 22 and 23.
7	The competent authority could consider integrating the existing pig sector training proposals with the new proposal for farmer training for the risk assessment exercise in 2017 and include veterinarians in the specific training focusing on tail biting as an indicator of welfare. Conclusion 30. Findings 11, 12 and 21.
8	The competent authority could consider liaising with other Government Agencies responsible for funding new buildings and renovating existing ones to ensure that such facilities are suitable to enable the rearing of pigs with intact tails e.g. slurry systems that can handle optimal enrichment materials, different temperature zones, suitable flooring, feeding, space allowances etc. Conclusion 39. Findings and 31, 32 and 33.

Appendix 2: Literature research on 'feed' for weaned piglets

As mentioned in Material & Methods, the non-animal-related category 'feed' will be discussed separately here. The starting point was the EFSA report from 2007, here supplemented with the most recent literature (since 2007). Because the 'feed' category is specifically investigated in this study, it is discussed separately here.

The category feed can be split into two parts. On one hand the feed composition, which can be seen as the software. On the other hand, there are the feed and water system as the design of the pen, which can be seen as the hardware. However, topics are discussed here in the order as they were discussed in the EFSA report (2007), namely:

- Feed restriction and feed competition
- Type of feed (flour, dry feed, mash)
- Minerals
- Proteins and amino acids
- Fiber
- Specific raw materials
- Feed additives
- Feed changes
- Water supply

Feed restriction and feed competition

In the EFSA-rapport (2007) it is described that feed competition and insufficient feed intake are risk factors for tail biting. Research has shown that the better the feed is accessible, the less tail biting occurs. Taylor et al. (2010) and Valros & Heinonen (2015) confirm that competition for feed, through limited feeding or limited access to feed, causes frustration in pigs, which can lead to tail biting. However, very many feedings per day also lead to unrest and an increase in aggression and skin lesions.

The predictability of the feeding moments is also important, since pigs anticipate the moment feed comes (provided that feeding takes place at set times). EFSA-authors (2007) confirm this and describe that there are many practical stories where an outbreak of tail biting has occurred because the feed machine had broken down. Taylor et al. (2010) stated that pigs show inappropriate oral behavior when a feeding turn is left behind or delayed. In that case, pigs start to exhibit extra foraging behavior, whereby in vain foraging can result in frustration and thus more tail biting.

Type of feed

There is no convincing evidence that one form of feed is a bigger risk factor than another, such as flour, dry feed or mash, according to the EFSA-report (2007). When interpreting research about the form of feed, it is important to realize that feed form is often related to the method of feeding and housing. These confound these study results, as there is more than one different variable.

Minerals

Various minerals are mentioned in the literature as a potential risk factor. Below they are discussed per mineral:

- Salt: In the EFSA-report (2007) it is mentioned that feed often contains twice as much sodium as necessarily for optimum growth. Sometimes that is even quadrupled to try to stop an outbreak of tail biting. The report mainly discusses hypotheses, such as that a lack of salt would lead to more attraction to blood. Another hypothesis is that there is more salt excretion in case of stress. The latter theory is also discussed by Taylor et al. (2007), mentioning that stressed pigs will forage more to

look for extra salt. This extra foraging behavior can lead to tail biting. However, no convincing evidence was found in the reviewed literature. The conclusion in the EFSA-report (2007) was that insufficient sodium in feed should be seen as a risk factor.

- Magnesium: It has been shown that pigs in pens where tail biting occurs do have a lower serum magnesium (EFSA, 2007). A clear cause is unknown, but maybe, a shift from extracellular to intracellular occurs in case of physical stress (this process has been described in humans). However, adding extra magnesium to the pig diet did not result in a reduction in tail biting.
- Calcium-phosphorus-ratio: one study is mentioned in the EFSA-report (2007) in which there is a disturbed calcium-phosphorus ratio, but this finding has not been reproduced by other studies.

Proteins and amino acids

In the EFSA-report (2007) it is described that protein is often related to tail biting, especially according to practical reports, but the evidence is inconsistent. Van der Meer et al. (2017) indicate that reducing the protein content increases damaging behavior on pen mates. In addition, they suggest that the trend to reduce crude protein as much as possible in ratios leads to more biting behavior, especially in case of a suboptimal health status.

Taylor et al. (2010) indicate that an imbalance in amino acids can stimulate foraging behavior, in order to restore that balance. Research quoted by Taylor et al. (2010) also showed that pigs bite more in model tails with blood when having a low-protein ration. In a similar study, in the EFSA-report (2007) no greater attraction for blood was found.

A reduced tryptophan level can cause a greater attraction to blood. The underlying mechanism may be the link between dietary amino acids and neurotransmitters involved in aggressiveness and exploration behavior. Tryptophan is a typical example of this. Martinez-Trejo et al. (2009) state that giving extra tryptophan leads to fewer tail biting. They describe that tryptophan is the precursor of the neurotransmitter serotonin, which has sedative effects and reduces aggression (it is an inhibitory neurotransmitter of the central nervous system). However, a large excess cannot be given since tryptophan has anorexiagenic effects, thereby reducing feed intake and growth as well. Le Floc'h et al. (2012) support the above with the fact that tryptophan is involved in the regulation of the immune system, because it also acts as a precursor of antioxidants. It has an effect on the inflammatory response, as Van der Meer et al. (2017) also confirm. Taylor et al. (2010) indicate that the effect of tryptophan in pigs is not specifically known, but that it probably contributes to a reduction in foraging behavior and that it calms pigs.

Another essential amino acid is lysine. Taylor et al. (2010) describe that pigs that received a ration with increased lysine (and arginine) showed reduced stress responses to transport. In addition, another study showed that pigs fed with a constant lysine content showed more tail biting than pigs where lysine was given in phases, appropriate to the age requirements. Both results show that as well an excess as a shortage of lysine can lead to problems. Lysine also has an effect on daily feed intake and growth. These were significantly lower with low lysine content in the feed and there was a higher feed conversion (Ettle & Roth, 2009). This is not directly related to tail biting, but it does show that lysine has a great influence on the metabolism of pigs and possibly indirectly contributes as a risk factor for tail biting.

Finally, in the EFSA-report (2007) it is indicated that the source of the proteins plays a role in the development of tail biting, as animal protein leads to less biting behavior. The conclusion is that a deficiency of essential amino acids is a risk for tail biting and they point out that it has been reported in articles that biting pigs have lower serum protein than pen mates (EFSA, 2007).

Fibers

There is insufficient evidence that a too high or too low dietary fiber content is a risk factor for tail biting. However, in EFSA (2007) it is suggested that a low-fiber ration leads to a feeling of hunger, resulting in

restless pigs. Restless pigs can get frustrated, subsequently causing tail biting. However, hardly any controlled studies have been conducted in which varied fiber contents are linked to read-out parameter tail biting. One study was conducted by Van der Peet et al. (2017). They investigated whether providing extra fibers to pigs with intact tails (from a few days after birth to delivery to the slaughterhouse) leads among other things to reduced bite behavior and reduced bite damage. The conclusion of this study was that providing extra fiber in the feed did not result in less biting behavior and less tail damage in suckling and weaned piglets. In the case of finishing pigs, on the other hand, there was less tail damage in the group that received extra fiber. However, tail damage still occurred with an increased fiber content. As mentioned in the article, this is probably due to the fact that (tail) biting is multi-factorial in origin. Only increasing the fiber content in feed is not necessarily a complete solution, although it is certainly worthwhile to make the fiber content part of the solution.

Straw can contribute to the fiber supply as it is edible. However, this effect only seems to occur when there is limited feeding. De Lange et al. (2010) state about fibers that the optimum amount of fibers is related to the 'production' of the pig (i.e.: growth and development). Possible intestinal diseases also contribute to this. In addition, the need for fibers is influenced by the composition of the feed and the process by which the feed is prepared (including feed fermentation and addition of enzymes). They do not relate this directly to tail biting, but to intestinal health and the needs of the pig in general.

Specific raw materials

There is insufficient evidence that specific raw materials are a risk factor for the development of tail biting (EFSA, 2007). Furthermore, no recent studies have been found that investigate this.

Feed additives

There is limited evidence that the presence or absence of certain additives (feed additives) could reduce the risk of tail biting. Nevertheless, it has been suggested that feed additives can control subclinical bowel diseases and reduce the prevalence of tail biting (EFSA, 2007). However, a focused search in recent literature about feed additives for pigs, related to tail biting, did not provide any evidence. De Lange et al. (2010) describe in their review about feed additives in general (not specifically linked to tail biting) that there is a lot of interest in stimulating gut health and bowel development, in order to optimize growth. They describe four groups of feed additives, namely:

- Additives improving the immune response;
    - Immunoglobulins, ω-3 fatty acids, ß-glucans from yeasts;
- Additives reducing 'pathogen load';
    - Organic and inorganic acids, zinc oxide, essential oil, herbs and spices, some prebiotics, bacteriophages and antimicrobial peptides;
- Additives stimulating growth of desired gut bacteria;
    - Probiotica and several prebiotica;
- Additives stimulating the digestive function;
    - Butyric, gluconic, lactic, glutamine, threonine, cysteine and nucleotides.

The above sounds promising; further research that focuses on feed additives related to tail biting is required.

<u>Feed changes</u>

A risk for tail biting can be a sudden change in the composition of the diet, especially when switching too quickly to feed with a lower nutrient density (EFSA, 2007). In addition, in the EFSA-report (2007) it is described that the exact needs of pigs change gradually during the development and growth of pigs. This is important when an optimum ration is determined, including the transitions between certain rations. In more recent literature nothing has been found specifically focused on feed changes related to tail biting.

Water supply

In the EFSA-report (2007) it is described that there is limited scientific evidence that water supply leads to tail biting. There are, however, indications that water shortage and/or poor water quality are risk factors for tail biting in summer. Taylor et al. (2012) describe a study conducted at 65 commercial farms over a two-year period. It concludes that the availability of water and the water pressure are indeed risk factors. They recommend that there must be at least 1 drinking place for 10 pigs, that drinking places must be clean and that there must be an optimum water pressure of 1L/minute.

Discussion

In interpreting the above, it is important to consider that there is variation in the threshold value in an individual pig, to which extent a described risk factor is indeed a risk factor for the animal concerned (Valros et al., 2015). Even under clearly suboptimal situations, such as a low-stimulus environment, without straw and on a fully slatted floor, not all pigs will start tail biting (Valros & Heinonem, 2015). More research concerning feed and water needs to be done.

Appendix 3: Tables Excel data 13 farms

Below the result of all collected data, processed in Microsoft Excel per age group, is shown. The tables are shown in Dutch, as the Excel-file will be studied further by Dutch researchers. The corresponding method is described in Material and Method. The classification of non-animal-related indicators versus animal-related indicators is displayed per age group. Next, in the suckling piglet age group, the next step in processing is described for analysis. These steps also apply to weaned piglets and finishing pigs/breeding gilts and are therefore not explained again.

Suckling piglets

- Vertical: farms are displayed by code (farm 5 has no suckling piglets);
- V1 to V31 are non-animal-related indicators;
- V32 to V39 are animal-related indicators;
- Code 1 = green, code 2 = orange and code 3 = red. NA: Not Available.

	Crit. HV voldoet aan 4	%big tegelijk expl.	Nat. Materialen	Berekbaarheid hele kraam.periode	Vervang/aanvul.	Tijdsgelimiteerd	Afh. Van 6: x uit 6	Zeug/big eten/spel	Kwaliteit drinkwater nippel = IKB	Bij bijvoer: onbeperkt	Berekb: water/bijvoer	Nippelopbrengst/min	Leefopp. Kraamh (m2)	Big rondgang zeug	Dichte vloer big gesol	m2 dichte vlr big nest	Aant.dgn zeug vast	Tocht thv. Biggennest	NH3 ppm 1 wk vr spenen	%CO2 1 wk vr spenen	%RV 1 week vr spenen	Voer/wat. Vervuild 1wws	% opp HV schoon/afd 1wws	%dicht vlr big nst vuil/afd 1wws	Laarzen/overalls handen was	Vliegenoverlast (>15/big)	DDDAf zeug/zuig big 12 mnd	%uitval zuig. Big 12 mnd	%gemengde tomen/afdeling	Krmhok inweken/rein/desinf.	Gem. Speenleeft. Dagen	%big comf. liggen/afd. 1wws	Luchtwegprob/afd 1wws	%big/afd >30% vervuild mest/urin	%big/afd wit sclera/geen tr.streep	%big/afd intct kop+oren <2cm 1wws	%big/afd 100%intact staart 1wws	%big/afd intact knie of <0,5cm 1wws	%big/afd te mager 1wws
Bedrijfscode	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15	V16	V17	V18	V19	V20	V21	V22	V23	V24	V25	V26	V27	V28	V29	V30	V31	V32	V33	V34	V35	V36	V37	V38	V39
1	3	2	2	3	3	2	NA	3	1	3	1	1	3	1	2	2	2	3	NA	NA	NA	1	1	1	2	1	1	2	2	NA	3	2	1	1	1	2	2	2	3
2	3	3	2	3	3	2	NA	3	2	3	1	1	3	1	2	3	2	1	1	1	2	1	NA	2	1	1	1	2	2	1	2	2	1	1	1	1	1	2	1
3	3	3	2	1	3	1	1	3	1	1	1	1	3	2	1	1	2	1	1	1	1	1	1	1	2	1	1	1	2	1	2	1	1	1	1	1	1	1	1
4	2	3	1	1	3	2	NA	3	1	3	1	1	3	2	1	3	2	1	1	1	NA	1	1	1	1	1	1	3	1	1	2	1	1	1	1	1	1	2	1
5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6	3	3	2	3	3	2	NA	3	1	1	1	1	3	1	1	3	2	1	1	1	1	1	NA	1	1	1	1	2	NA	1	3	1	1	1	1	1	NA	1	1
7	3	3	2	3	NA	2	NA	3	1	3	1	1	3	1	2	2	2	3	1	1	2	1	NA	1	1	1	NA	2	2	2	2	1	1	1	1	2	1	1	2
8	3	3	2	3	3	2	NA	3	1	1	1	3	3	1	1	3	2	3	1	1	NA	1	1	1	1	1	1	1	1	2	2	1	1	1	1	1	1	3	1
9	3	3	2	3	3	1	1	NA	3	3	1	1	3	1	1	1	2	3	1	1	NA	1	NA	2	2	1	1	3	2	1	2	2	1	1	1	1	1	2	1
10	2	3	2	3	3	2	NA	3	1	3	1	1	3	1	1	3	2	1	1	1	NA	1	1	1	2	1	1	2	2	1	2	1	1	1	1	1	1	2	1
11	3	3	2	1	3	2	NA	1	1	3	1	1	3	1	2	2	2	3	1	1	NA	1	1	1	2	1	1	1	3	2	3	3	1	1	1	1	1	2	3
12	3	3	2	1	3	2	NA	3	2	3	1	3	3	2	2	3	2	1	1	1	NA	1	1	1	2	1	1	2	1	1	2	1	1	1	1	1	1	2	1
13	3	3	2	3	3	2	NA	3	1	3	3	3	3	2	1	3	2	1	NA	1	2	1	NA	2	1	1	1	3	2	1	3	2	1	1	1	1	1	2	1

See next page.

Below are the non-animal-related indicators and the animal-related indicators for suckling piglets. The method of processing is described in Material and Method. The green table is the collection of the non-animal-related indicators, based on the table above. This also applies to the orange table, which is based on animal-related indicators. The last column with percentages is then plotted in Results in a graph.

NIET-DIERGEBONDEN INDICATOREN									
Aantal V	Aantal NA	Beschikbare V	Aantal pos (1)	Aantal neg (2)	Aantal neg (3)	Controle 1+2+3	Neg (2+3)	(2+3) / besch V	%
31	5	26	9	9	8	26	17	0,653846	65,4
31	2	29	11	10	8	29	18	0,62069	62,1
31	0	31	20	6	5	31	11	0,354839	35,5
31	2	29	17	5	7	29	12	0,413793	41,4
31	31	0	0	0	0	0	0	#DIV/0!	#DIV/0!
31	3	28	16	4	8	28	12	0,428571	42,9
31	4	27	10	10	7	27	17	0,62963	63,0
31	2	29	15	5	9	29	14	0,482759	48,3
31	3	28	13	6	9	28	15	0,535714	53,6
31	2	29	14	8	7	29	15	0,517241	51,7
31	2	29	14	7	8	29	15	0,517241	51,7
31	2	29	12	9	8	29	17	0,586207	58,6
31	3	28	9	7	12	28	19	0,678571	67,9

DIERGEBONDEN INDICATOREN									
Aantal V	Aantal NA	Beschikbare V	Aantal pos (1)	Aantal neg (2)	Aantal neg (3)	Controle 1+2+3	Neg (2+3)	(2+3) / besch V	%
8	0	8	3	4	1	8	5	0,625	62,5
8	0	8	6	2	0	8	2	0,25	25,0
8	0	8	8	0	0	8	0	0	0,0
8	0	8	7	1	0	8	1	0,125	12,5
8	8	0	0	0	0	0	0	#DIV/0!	#DIV/0!
8	1	7	7	0	0	7	0	0	0,0
8	0	8	6	2	0	8	2	0,25	25,0
8	0	8	7	0	1	8	1	0,125	12,5
8	0	8	6	2	0	8	2	0,25	25,0
8	0	8	7	1	0	8	1	0,125	12,5
8	0	8	5	1	2	8	3	0,375	37,5
8	0	8	7	1	0	8	1	0,125	12,5
8	0	8	6	2	0	8	2	0,25	25,0

Weaned piglets

- Vertical: farms are displayed by code (farm 5 has no weaned piglets);
- V1 to V44b are non-animal-related indicators;
- Code 1 = green, code 2 = orange and code 3 = red. NA: Not Available.

Crit. HV continu aanw. voldoet aan 4	%big tegelijk exp/spelen met HV	Nat. Materialen >heft HV	Berekbaarheid hele ronde	Vervang/aanvul. Min 1x/wk	HV deels/geheel boven lig/meststuk	Tijdsgelimiteerde HV wel/niet	Afh. Van 7: aant. Voldaan uit 6 crit. Tijdsafh.	Spn vr. DVE Lys/EW2015 (gr/EW) 3-7dns	Spn vr. verh. DVE-Lys vs DVE-tryp 3-7dns	Spn vr. %ruwe celstof 3-7dgn	Spn vr. %NSP (=OOS) 3-7dns	Spn vr. Gehlte natrium (gr/kg) 3-7dns	Opf vr. Gehalte DVE-Lys per EW2015 (gr/EW)	Opf vr. Verh. DVE-Lys vs DVE-tryp.	Opf vr. % ruwe celstof	Opf vr. %NSP (=OOS)	Opf vr. %natrium (gr/kg)	Voer lste wk vr spenen = eerste dgn na sp	Kwaliteit drinkwater nippel = IKB	Volgtijdig vreten: aant big/vreetplaats	Volgtijdig vreten: biggen onbepaekt gevoerd	Indien meerdere voerbak: >3m ertussen	Onbep.voer: >1x/wk dat >1u geen voer	Trog: alle dieren tot einde ronde tegelijk eten	Trog: voerfrequentie per dag	Aantal biggen per drinkplaats over hele ronde	Voer/water berekbr: kleinste vs grtste biggen	Water drinken zonder voer erbij mogelijk	Nippelopbrengst (ml/min) laagste v. 5 nippels	Eff. Leefopp (m2 per big) excl. Voerbak	Dichte vloeropp. Per big (m2 per big)	Indien dichte vloer, geëoleerd	Vluchtmogelijkh. Aanwez. Biggen	Ligruimte tussen eet/drink/mestplaats	Tocht thv. Biggen kan voorkomen	NH3 ppm 1 wk na spenen	NH3 ppm vlak voor einde opfok	volume%CO2 1 wk na spenen	volume%CO2 vlak voor einde opfok	%RV 1 week na spenen	%RV 1 week vlak voor einde opfok	1wns: Temp ruimte/afd 100% rooster	1wns: Temp ruimte/afd 50%rooster+vloerverw.	Einde opfok: Temp ruimte/afd 100% rooster	Eind opf. Temp ruimte/afd 50%rooster+vloerverw.
V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15	V16	V17	V18	V19	V20	V21	V22	V23	V24	V25	V26	V27	V28	V29	V30	V31	V32	V33	V34	V35	V36	V37	V38	V39	V40	V41	V42	V43a	V43b	V44a	V44b
2	2	2	3	3	NA	2	NA	NA	NA	NA	NA	NA	1	2	2	2	1	1	2	2	1	1	3	NA	NA	1	1	1	1	3	2	1	2	2	1	NA	NA	1	1	2	2	NA	1	NA	2
3	3	1	1	3	NA	2	NA	NA	NA	NA	NA	NA	1	2	2	2	1	1	1	NA	NA	NA	NA	1	3	2	1	1	3	3	3	2	2	NA	1	NA	NA	2	NA	2	2	NA	1	NA	2
2	1	1	1	2	2	2	NA	1	2	NA	NA	NA	1	2	2	1	1	1	1	2	1	1	1	NA	NA	2	1	1	1	3	1	1	2	1	NA	1	1	1	1	1	1	NA	1	NA	1
1	2	1	1	3	2	2	NA	1	2	NA	NA	NA	NA	2	2	NA	NA	1	1	2	1	1	NA	NA	NA	1	1	1	1	2	3	2	2	2	1	3	2	2	2	NA	NA	1	NA	2	NA
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	3	2	3	3	2	2	NA	1	2	NA	NA	NA	NA	2	2	NA	1	1	1	2	1	1	1	NA	NA	2	1	1	1	3	1	1	2	1	1	1	1	1	1	1	1	NA	2	NA	2
3	3	1	1	1	NA	1	1	1	2	NA	NA	NA	1	2	2	2	1	1	NA	NA	NA	NA	NA	3	3	3	1	1	1	2	1	1	2	2	1	NA	NA	1	1	2	2	NA	1	NA	1
2	2	2	1	1	1	2	NA	1	NA	NA	NA	NA	1	NA	2	NA	1	2	1	NA	NA	NA	NA	1	3	1	1	1	3	2	3	NA	2	NA	1	1	1	1	1	1	1	1	NA	2	NA
2	2	2	3	1	2	2	NA	3	NA	NA	NA	NA	1	2	1	2	1	NA	1	2	1	1	1	NA	NA	1	3	1	1	2	1	1	2	2	1	NA	NA	NA	NA	NA	NA	NA	2	NA	3
3	3	2	3	3	2	1	1	3	2	NA	NA	NA	NA	2	2	3	1	1	1	2	1	1	1	NA	NA	1	1	1	1	3	2	1	2	2	1	1	1	1	1	NA	NA	NA	1	NA	1
1	3	1	3	3	1	2	NA	1	2	NA	NA	NA	1	3	2	2	1	1	1	2	1	1	1	NA	NA	3	3	2	1	2	NA	NA	2	1	1	NA	NA	NA	NA	NA	NA	2	NA	2	NA
2	3	1	1	3	1	2	NA	3	2	NA	NA	NA	3	2	2	2	1	1	2	NA	NA	NA	NA	3	3	1	3	1	1	3	NA	NA	2	1	3	3	1	2	2	NA	NA	2	NA	2	NA
3	3	2	3	3	1	2	NA	1	2	NA	NA	NA	1	2	2	2	1	1	1	NA	NA	NA	NA	3	3	3	1	1	3	3	NA	NA	2	2	1	NA	NA	1	1	2	2	1	NA	1	NA

Continue weaned piglets

- Vertical: farms are displayed by code (farm 5 has no weaned piglets);
- V45 to V57b are non-animal-related indicators;
- V58 to V75 are animal-related indicators;
- Code 1 = green, code 2 = orange en code 3 = red. NA: Not Available.

Voer/wat. Vervuild 1w na spenen (>1plek/afd)	Voer/wat. Vervuild Einde opfok (>1plek/afd)	% opp HV schoon/afd 1w na spenen	% opp HV schoon/afd einde opfok	%dicht vlr big.nst vuil/afd 1w na spenen	%dicht vlr big.nst vuil/afd einde opfok	Dubbel	Laarzen/overall wisselen + handen was	Vliegenoverlast (>15/big)	DDDAf gespeende biggen 12 mnd	%uitval gespeende biggen 12 mnd	Afdelingen na elke ronde inweken/rein/desinf.	Gem. Speenleeft. Dagen	Biggen na spenen mengen tussen tomen	%big comf. liggen/afd. 1w na spenen	%big comf. liggen/afd. einde opfok	Luchtwegprob/afd 1w na spenen	Luchtwegprob/afd einde opfok	%big/afd >30% vervuild mest/urin 1w na spenen	%big/afd >30% vervuild mest/urin einde opfok	%big/afd wit sclera/geen tr.streep 1w na sp	%big/afd wit sclera/geen tr.streep einde opfok	%big/afd intact kop+oren <2cm 1w na spenen	%big/afd intact kop+oren <2cm einde opfok	%big/afd 100%intact staart of laesie<2cm 1w na sp	%big/afd 100%intact staart of laesie<2cm eind opfok	%big/afd intact knie of <0,5cm 1w na spenen	%big/afd intact knie of <0,5cm einde opfok	%big/afd te mager 1w na spene	%big/afd te mager einde opfok	Gem. Ademfreq./min/afd (3 bigg uit 3 hok) 1wns	Gem. Ademfreq./min/afd (3 big uit 3 hok) einde opfok
V45	V46	V47	V48	V49	V50	V51	V52	V53	V54	V55	V56	V57a	V57b	V58	V59	V60	V61	V62	V63	V64	V65	V66	V67	V68	V69	V70	V71	V72	V73	V74	V75
1	1	1	2	2	2	NA	1	1	3	2	2	3	2	1	1	1	2	1	1	2	3	2	2	1	1	2	2	2	2	1	2
1	1	3	3	NA	NA	NA	1	1	3	3	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	2	3	2
1	1	1	1	1	1	NA	2	1	1	1	NA	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	NA	1	1	1	3	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	2	1
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1	1	1	1	1	1	NA	1	1	1	1	1	3	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	2	2	1	3	NA	1	1	1	2	1	2	2	1	1	1	1	3	3	1	1	1	1	1	1	1	1	1	1	2	2
1	1	1	3	NA	NA	NA	1	1	1	2	2	2	1	1	1	1	1	1	1	1	2	1	1	2	1	1	1	1	1	2	2
1	1	1	1	1	1	NA	2	1	1	2	2	2	2	1	2	1	1	2	2	2	3	2	2	1	1	1	1	1	1	NA	3
1	1	1	1	1	1	NA	2	1	1	2	1	2	2	2	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	3	1
1	1	1	1	NA	NA	NA	2	1	1	1	2	3	2	1	1	1	1	1	2	1	2	1	3	NA	2	2	2	1	1	2	2
1	1	1	1	NA	NA	NA	2	1	1	2	2	2	2	1	1	1	1	1	1	1	1	1	2	1	1	2	2	1	1	2	2
1	1	2	2	NA	NA	NA	1	1	NA	2	1	3	2	3	NA	2	1	1	1	1	1	1	2	2	1	1	1	2	1	1	2

Finishing pigs/breeding gilts

- Vertical: farms are displayed by code (farm 8 + 9 do not have finishing pigs/breeding gilts);
- V1 to V42 are non-animal-related indicators;
- Code 1 = green, code 2 = orange en code 3 = red. NA: Not Available.

Crit. HV continu aanw. voldoet aan 4	%big tegelijk exp/spelen met HV	Nat. Materialen >helft HV	Berekbaarheid hele ronde	Vervang/aanvul. Min 1x/wk	HV deels/geheel boven lig/meststuk	Tijdsgelimiteerde HV wel/niet	Afh. Van 7: aant. Voldaan uit 6 crit. Tijdsafh.	Vleesv: DVE Lys/EW2015 (gr/EW) startvoer 23-45kg	Vleesv: DVE Lys/EW2015 (gr/EW) tussenvoer 45-70kg	Vleesv: DVE Lys/EW2015 (gr/EW) eindvoer 70kg-aflev	Opfokz: DVE Lys/EW2015 (gr/EW) 9-12 weken	Opfokz: DVE Lys/EW2015 (gr/EW) 15-22 weken	Opfokz: DVE Lys/EW2015 (gr/EW) 23 weken-eind opf	Vleesv+Opf: verhoud. DVE-Lys vs DVE-tryp	Vleesv+Opf: %ruwe celstof	Vleesv+Opf: %NSP (=OOS)	Vleesv+Opf: Gehalte natrium (gr/kg)	Kwaliteit drinkwater nippel= IKB	Aantal vakens per drinkplaats	Voer/water bereikbaar grote/kleine dieren	Water drinken zonder voer erbij mogelijk	Nippeloplbrengst (ml/min) laagste v. 5 nippels	Volgt eten: aantal vakens/vreetplaats	Volgt eten: wel/niet onbepekt gevoerd	Indien meerdere voerb: >3m ertussen	Onbepekt voeren: >1x/wk dat vakens >1u geen voer	Gelijk eten: tot einde ronde tegelijk eten aan trog	Gelijk eten: wat is voerfrequentie per dag	Eff. Leefopp (m2 per vakken) excl. Voerbak	Indien dichte vloer, geisoleerd	Vluchtmogelijkh. Aanwez. Vakens	Liguimte tussen eet/drink/mestplaats	Tocht thv. vakens kan voorkomen	NH3 ppm 4-5 weken na opleg	NH3 ppm 11-12 weken na opleg	Volume%CO2 4-5wk na opleg	Volume%CO2 11-12wk na opleg	%RV 4-5 weken na opleg	%RV 11-12 weken na opleg	Temp ruimte/afd 4-5wk na opleg	Temp ruimte/afd 11-12wk na opleg
V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15	V16	V17	V18	V19	V20	V21	V22	V23	V24	V25	V26	V27	V28	V29	V30	V31	V32	V33	V34	V35	V36	V37	V38	V39	V40	V41	V42
2	1	2	1	3	NA	2	NA	NA	NA	NA	1	3	1	2	1	1	1	1	2	1	1	3	1	1	1	3	NA	NA	1	2	2	2	1	NA	NA	1	NA	2	NA	3	2
3	1	2	1	3	NA	2	NA	NA	NA	NA	1	3	1	NA	NA	NA	NA	1	1	1	1	3	NA	NA	NA	NA	1	1	2	1	2	1	1	NA	NA	1	1	2	1	2	2
1	1	1	1	1	2	1	1	NA	NA	NA	1	1	1	3	1	1	1	1	2	1	2	1	2	1	1	1	NA	NA	2	1	2	1	1	1	1	1	1	1	NA	1	2
2	3	1	3	3	2	1	1	1	1	1	NA	NA	NA	2	2	NA	1	1	1	1	2	3	1	3	1	1	NA	NA	2	2	2	1	1	3	3	2	2	NA	NA	3	3
1	2	1	1	1	2	1	1	1	1	1	NA	NA	NA	NA	2	NA	1	1	2	1	1	3	NA	NA	NA	NA	1	1	2	1	2	1	1	NA	NA	NA	NA	NA	NA	3	3
2	2	2	1	3	1	1	1	NA	NA	NA	1	1	1	NA	NA	NA	1	1	1	1	2	1	2	1	1	1	NA	NA	2	1	2	1	1	1	1	1	1	1	1	1	1
3	3	2	1	3	NA	2	NA	1	1	1	NA	NA	NA	3	2	2	1	2	1	1	1	3	NA	NA	NA	NA	1	1	3	1	2	2	1	NA	NA	2	1	2	2	1	2
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2	3	2	1	3	2	2	NA	NA	NA	NA	1	3	3	3	2	3	1	1	1	1	2	3	1	3	1	1	NA	NA	3	1	2	2	1	3	2	1	1	NA	NA	3	3
1	3	1	3	3	2	2	NA	NA	NA	NA	1	1	1	3	1	1	1	1	1	1	2	3	2	3	1	3	NA	NA	3	1	2	2	NA	2	2	NA	NA	NA	NA	2	2
3	3	2	3	3	1	2	NA	1	1	1	NA	NA	NA	2	1	2	1	2	3	1	2	3	NA	NA	NA	NA	3	1	3	1	2	2	1	1	1	1	1	NA	NA	2	3
2	2	2	1	3	1	1	1	NA	NA	NA	3	1	1	2	2	2	1	NA	2	1	1	3	NA	NA	NA	NA	3	1	3	1	2	2	1	NA	NA	1	NA	2	2	2	2

Continue finishing pigs/breeding gilts

- Vertical: farms are displayed by code (farm 8 + 9 do not have finishing pigs/breeding gilts);
- V43 to V54 are non-animal-related indicators;
- V55 to V72 are animal-related indicators;
- Code 1 = green
  code 2 = orange
  code 3 = red
  NA: Not Available.

Voer/wat. Vervuild (>1plek/afd) op 4-5wk na opleg	Voer/wat. Vervuild (>1plek/afd) op 11-12wk na opleg	% opp HV schoon gem.alle hok/afd op 4-5wk na opleg	% opp HV schoon gem.alle hok/afd op 11-12wk na opl	Indien dicht vloer: %vuil/afd 4-5wk na opleg	Indien dicht vloer: %vuil/afd 11-12wk na opleg	Laarzen/overall wisselen + handen was	Vliegenoverlast (>15/vakken)	DDDAf vleesvakens 12 mnd (opfokz: nvt!)	%uitval vleesvakens 12 mnd	Afdelingen na elke ronde inweken/rein/desinf.	Vleesvakens bij opleg mengen	%vleesvakens comf. liggen 4-5wk na opleg	%vleesvakens comf. liggen 11-12wk na opleg	Luchtwegprob. 4-5wk na opleg	Luchtwegprob. 11-12wk na opleg	%vakens >30% vervuild mest/urin 4-5wk na opleg	%vakens >30% vervuild mest/urin 11-12wk na opleg	%vakens wit sclera/geen tr.streep 4-5wk na opleg	%vakens wit sclera/geen tr.streep 11-12wk na opleg	%vakens intact kop+oren <2cm 4-5wk na opleg	%vakens intact kop+oren <2cm 11-12wk na opleg	%vakens 100%intact staart of laesie<2cm 4-5wk na op	%vakens 100%intact staart of laesie<2cm 11-12wk na	%vakens intact knie of <0,5cm laesie 4-5wk na opleg	%vakens intact knie of <0,5cm laesie 11-12wk na ople	%vakens te mager 4-5wk na opleg	%vakens te mager 11-12wk na opleg	Gem. Ademfreq./min (3 vak uit 3 hok) 4-5wk na opl	Gem. Ademfreq./min (3 vak uit 3 hok) 11-12wk na opl
V43	V44	V45	V46	V47	V48	V49	V50	V51	V52	V53	V54	V55	V56	V57	V58	V59	V60	V61	V62	V63	V64	V65	V66	V67	V68	V69	V70	V71	V72
1	1	2	2	2	2	2	1	1	2	1	2	1	1	1	1	2	2	3	3	1	1	1	1	2	1	1	1	2	2
3	3	1	1	3	3	1	1	NA	1	1	NA	1	1	1	1	3	NA	1	1	1	1	1	1	1	1	1	1	3	3
1	1	1	1	1	1	NA	1	1	1	1	2	1	1	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	2	2	1	1	1	1	2	1	1	1	3	2
1	3	1	1	1	1	1	1	1	1	1	2	1	1	1	1	2	2	2	2	1	1	2	1	1	1	1	1	2	3
1	1	1	1	1	1	1	1	1	NA	1	1	1	1	1	1	2	1	1	1	1	1	2	2	1	1	1	1	1	1
1	1	1	2	3	3	2	2	1	1	1	2	NA	NA	1	1	2	2	1	1	1	1	1	1	1	1	1	1	2	2
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1	1	3	3	1	1	2	1	1	1	2	2	1	1	1	1	2	1	3	2	2	1	2	1	1	1	1	1	3	3
1	1	1	1	1	1	2	1	1	1	2	1	1	1	1	1	NA	1	2	2	2	2	2	2	2	2	1	1	NA	NA
1	1	1	2	3	2	2	1	1	2	2	1	1	1	1	1	2	1	1	1	1	1	1	1	2	2	1	1	2	2
1	1	1	1	3	1	1	1	1	1	2	NA	3	NA	1	1	2	1	1	2	1	1	3	1	1	1	1	1	3	3

Appendix 4: Recommendations fine-tuning the *on farm* risk-assessment-tool

General

- It is not known how many animals per pen or pens per section have been assessed: they are required for statistical analysis;
- Keep using the same concept of the tool because of different questions that may influence each other.

Advise: add an additional questionnaire

- How many weeks-system;
- Which member of the support team does support which farmer;
- Teeth grinding yes/no;
- Castration yes/no;
- Mixing groups after weaning yes/no or after entering finishing barn yes/no;
- Boars/gilts/castrated boars separated per gender yes/no;
- Genetics piglets/pigs;
- Weather conditions: suitable for season / stormy / very hot / very cold.

Suckling piglets

- The starting point of the tool is the Holders of Animals Decree, which states that pen enrichment is mandatory. This is mentioned in the tool, although it is not specifically mentioned that this means that pen enrichment is mandatory. Looking at the answers in the tool, this is confusing.
    - V1-V7: Option missing: there is pen enrichment (yes/no). Some support team members/farmers have written this on the tool themselves;
    - V6: Now it states: "in addition to the continuously available pen enrichment, time-limited enrichment is also given". This means that only the combination may occur and the option "only time-limited" does not exist;
    - V23: NA if no pen enrichment is present;
- V8: Why eat/play together as a combination? What is the definition of playing together? Now the added value of eating together that is mentioned in at least one farm is missing (farm 7: piglets can eat with their mother). The importance of ‘learning to eat’ is thus lost.

Weaned piglets

- V6: 3 out of 12 support member team/farmers have not understood this question (is it about whether continuous enrichment for pens is wholly or partly above or at the actual lying or manure location of the animals) The advice is to add a definition of this;
- V9-V14 relatively often as missing data. This implies that there is no separate weaning feed;
- V32: <10% closed floor area implies that it is completely slatted? Same with V49 and V50: the question is: "if solid floor is present, then ....";
- V43 + V57: double; now a) and b). Not practical for processing data.

Finishing pigs/breeding gilts

- The unit is missing from all animal-related indicators, for example ‘per section.