

Advisory report

Play behavior and environmental enrichment in pigs

*Concretizing principle-based regulation Article 2.22, paragraph 1 from
The Animal Keepers Decree to improve pig welfare*



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Picture on cover: Myra Ekkelboom, taken at Organic Farm Van Leeuwen

Executive Summary

The Dutch Animal Act, developed to protect the welfare of animals in the Netherlands, contains 'open norms', internationally known as principle-based regulations. These principle-based regulations have been developed to improve farmers' management on their farm, and thereby the welfare of their animals. But, according to the Dutch Animal Welfare Organization 'Pigs in Peril' (VIN), these principle-based regulations are perceived as an 'obstruction' during the inspections of the Dutch food and consumer product safety authority (NVWA). According to VIN, these principle-based regulations are too suggestive and therefore they would like them to become more concrete. This project aims to concretize one principle-based regulation, namely: Article 2.22, §1, which is intended to improve environmental enrichment and pig welfare. The main question is therefore whether it is feasible to concretize principle-based regulation 2.22, §1. In addition, we analyzed previously concretized principle-based regulation Article 2.5, §4 about air quality, as a reference to identify problems that might have occurred during its implementation and lessons to learn for future concretization of principle-based regulations. In order to solve the main questions, a literature study and interviews with different stakeholders were conducted to have a better understanding of Article 2.22, §1. Stakeholders that were contacted include pig farmers, NVWA, POV, IKB and scientists.

In the literature review, it became clear that pigs have an intrinsic need to explore, even when enough feed is provided. In addition, play behavior is a very important social aspect, especially in young pigs, to gain social skills. Therefore, environmental enrichment is considered very important for pigs to fulfil their needs and demands for exploration and play. Other kinds of enrichment that can be provided to enhance the pigs' welfare are social, physical or even cognitive enrichment. Harmful consequences could occur when there is a lack of enrichment, for example, tail biting, ear biting, or aggressive behavior.

The interview results support these findings. But, even though enrichment is such an important factor in improving pigs' welfare, and therefore crucial to maintain, we can conclude from the interviews that it is important not to change the principle-based regulation into a rule-based regulation. This, to give farmers some freedom in their farm management, to promote innovativeness, and leave some room for inspectors of the NVWA to make judgements based on experience. Therefore, we will provide a tentative protocol that can serve as a guideline instead of a strict rule. So, with this report, we present a list of animal- and non-animal-related indicators that can be consulted by farmers and inspection agencies to check if they meet the minimum welfare requirements regarding enrichment. We believe that, for pigs to be able to perform their natural behavior, there should always be a minimum amount of enrichment materials available, regardless if the pigs seem unharmed and happy. We created a ranking of animal-related indicators, arranged in an order from more to less alarming, that provides a good overview of signs that show further inspection is needed. To exclude the lack of enrichment material as an instigator of the animal-related indicators, the sufficiency of the enrichment material in the farm must be investigated and if needed, more or different materials need to be provided to diminish the issues. This can be checked by looking at non-animal-related indicators with the use of an observation checklist and a short tentative list of enrichment materials. In addition, further research is needed to validate the tentative protocol and to create a more complete list of different kinds of environmental enrichment and to check what pigs themselves would like to be provided with.

For long-term solutions regarding enrichment, there are, in our opinion, some interesting ideas for possible research, such as enhancing environmental enrichment by mixing it with other enrichment materials or combining environmental enrichment with cognitive enrichment. We also advise developing an online platform for farmers and other stakeholders that might diminish the knowledge gap between farmers and research and might directly provide them with new developments and advanced legislations concerning pig welfare.

Table of Contents

Executive Summary	iii
Introduction	1
Methods	3
Interviewed stakeholders	3
Literature review	5
Exploratory behavior	5
<i>Background</i>	5
<i>Play behavior</i>	5
<i>Intrinsic need</i>	6
<i>Time</i>	6
<i>Space</i>	8
Enrichment	9
<i>Background</i>	9
<i>Enrichment materials</i>	11
<i>Cognitive enrichment</i>	15
<i>Developments on indicators for enrichment</i>	16
Consequences of insufficient enrichment	17
<i>Importance at all ages</i>	18
<i>Tail biting</i>	19
Air Quality	20
Results	23
Conventional pig farm	23
Dr. ir. Liesbeth Bolhuis	23
Dr. Inonge Reimert	26
IKB	28
NVWA	29
Organic pig farm	31
POV	32
Discussion	35
Conclusion	39
Tentative protocol	39
<i>Animal-related indicators</i>	40
<i>Non-animal-related indicators</i>	40
Observations checklist	41
<i>Validation and further research</i>	43
Further advice	43
<i>Combining enrichments</i>	43
Enhancing the environmental enrichment	43
Cognitive enrichment	44
<i>Information platform</i>	44
References	46
Appendix A	52
Appendix A1: Interview Questions	52
Appendix A2: Signed consent forms and validation of the summaries	56

Introduction

In 2013, The Dutch Animal Act has been developed to protect the welfare of animals in the Netherlands. Within this Act, a certain amount of ‘open norms’, internationally known as ‘principle-based regulations’, are included. These principle-based regulations are very broadly stated regulations that create ambiguity among farmers and inspecting agencies. Various principle-based regulations were developed, on the one hand, to provide farmers with more freedom to manage their farm, and on the other hand, to give inspection agencies, such as the NVWA, the opportunity to judge farms on the basis of experience, instead of following a set of strict rules.

The Dutch Animal Welfare Organization ‘Pigs in Peril’ (Varkens in Nood; VIN) noticed that it is difficult for the Dutch food and consumer product safety authority (Nederlandse Voedsel- en Waren Autoriteit; NVWA) to enforce parts of the Dutch Animal Act, since there are no strict limits available (VIN, 2014). VIN, therefore, perceives the principle-based regulations as an ‘obstruction’ for the NVWA (De Jonge, 2018), and thus would like to have the principle-based regulations concretized, in a way that the NVWA can maintain them better, and advice their on-farm inspectors. According to VIN, this will give the NVWA the opportunity to specifically check and enforce these regulations and, when needed, to bring farmers that fail to meet the protocols, to court. Also, it will provide farmers with tools to optimize pig husbandry conditions (VIN, 2014).

We decided to focus on one specific principle-based regulation because of its importance to VIN, and our expertise, namely:

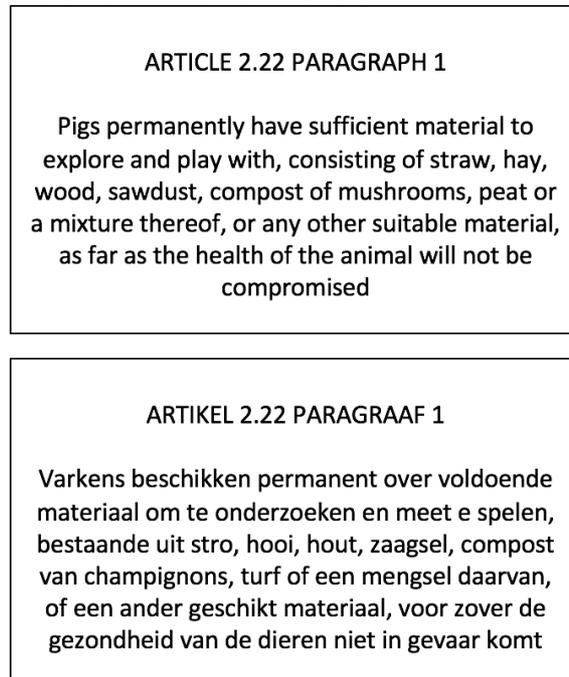


Figure 1: Article 2.22, §1, The Animal Keepers Decree (Wet Dieren, 2011).

One of VIN’s main goals is creating more space and distraction in pig farms. Next to that, our expertise in enrichment and welfare of pigs makes concretizing this principle-based regulation most feasible. Principle-based regulation Article 2.22, §1 (Figure 1) lacks indicators that clarify specific requirements,

which can be used to measure if the regulation is being maintained by pig farmers. Implementation of new indicators within the regulations will make it easier for inspectors to check if farmers meet the enrichment requirements, and, for farmers to maintain a certain level of welfare for the pigs.

The goal of this project is to give an advice on how to set up a feasible protocol for principle-based regulation Article 2.22, §1 of the Animal Act, with a clear list of indicators, that is usable for farmers, the NVWA and other stakeholders. Within this report, scientific information on the background of this principle-based regulation and an advice on making a concretized, feasible protocol will be given. Also, previously concretized principle-based regulation Article 2.5, §4 (Vermeer & Hopster, 2017) will be analyzed to identify steps taken and problems occurred while implementing the indicators, to take into account while developing a new protocol. To reach our goal, the following research questions are formulated:

The main research questions:

1. Is it feasible to concretize principle-based regulation Article 2.22, §1?
2. What can be gained from the concretized principle-based regulation Article 2.5, §4, as a reference?

Principle-based regulation Article 2.22, §1 will be regarded as a conceptual framework to implement further principle-based regulations, whereas the concretized principle-based regulation Article 2.5, §4, is used to identify obstacles for concretizing and implementing principle-based regulations in the Animal Welfare Act.

Sub-questions:

1. What is the concrete definition of principle-based regulation Article 2.22, §1?
2. What are possible indicators to be implemented in principle-based regulation Article 2.22, §1?
3. What do the stakeholders consider to be feasible indicators for principle-based regulation Article 2.22, §1?
4. Is the previous concretized principle-based regulation (Article 2.5, §4, (climate)) workable?

Methods

The research questions of this paper were examined with the help of literature and interviews with different stakeholders. A literature review was performed to provide background information on exploratory behavior and enrichment, to give more insight into the definition of principle-based regulation Article 2.22, §1 and in possible indicators. Interviews with scientists of the WUR gave information on the feasibility of the indicators found by the literature review. The interviews were conducted with scientists dr. ir. Liesbeth Bolhuis and dr. Inonge Reimert.

In addition, other stakeholders were interviewed to get more information about their view on enrichments and concretizing principle-based regulation Article 2.22, §1. The interviews were conducted with the following stakeholders: the NVWA (René Gosselink), the POV (Pig Producers Organization, *Producenten Organisatie Varkenshouderij*, Henk Boelrijk), a conventional pig farmer (Partnership Verhoijesen-Verstappen, John and Truus Verhoijesen and Wil Thiessen) and an organic pig farmer (Van Leeuwen, Bio Varkens, Peter van Leeuwen).

Lastly, a literature review based on the article by Vermeer and Hopster (2017) was conducted to gain more information about the feasibility of the previously concretized principle-based regulation Article 2.5, §4. Besides, the interviews that were conducted gave an overview of the stakeholders' outlook on the feasibility of this regulation.

For the literature reviews, the following databases were used: Google Scholar and WUR Library Search. The interview procedures can be found in Appendix A, with the questions and signed consent forms. The validated summaries can be found in chapter 'Results'.

Interviewed stakeholders

Conventional pig farm

6 June 2018

Partnership Verhoijesen-Verstappen is a commercial pig farm located in Beringe (Limburg, the Netherlands) with 1260 sows and 6500 fattening pigs. John and Truus lead the farm together with their daughters and farm manager Wil Thiessen.

Dr. ir. Liesbeth Bolhuis

7 June 2018

Liesbeth Bolhuis obtained her MSc degree on Animal Science at Wageningen University, and she did a PhD on personalities in pigs combining ethology and physiology. Besides studying, she also educates now, as the leader of the Behavioral Physiology research and supervising 10 PhD students and more than 80 MSc students. Furthermore, she has written and taken part in writing 90 peer-reviewed scientific papers and 4 book chapters (WUR, 2018a).

dr. Inonge Reimert

8 June 2018

Inonge Reimert obtained her MSc degree in Behavioural Cognitive Neurosciences at the University of Groningen. After graduating, she started with a PhD at the Wageningen University & Research. With her PhD, she investigated the growth of the pen mates of pig divergently selected for indirect genetic effects. Furthermore, emotional states in pigs were studied by Reimert and emotional contagion in pigs was firstly discovered by her. Nowadays, she works as a researcher at the Adaptation Physiology Group at the Wageningen University & Research. Besides, she is a teacher and supervises students with their thesis (WUR, 2018b).

IKB

12 June 2018

'IKB Varken' represents a chain quality system for the pig production sector. Everyone in the pig production chain, from farmer to butcher, can apply for the IKB certificate. IKB Varken checks farms to see if the farmer meets IKB's requirements considering animal welfare, food safety, and animal health. Demands are also made for feed suppliers, veterinarians, and other service providers. The interviewees of this company were Floortje Herder and Paul Oomen.

NVWA

13 June 2018

The NVWA maintains the safety of food and consumer products, animal health, health of plants, animal welfare and nature legislation (NVWA, 2018a). A part of this is to check pig farms. The pig farms are inspected by the NVWA to see if the pig farmers follow the rules about animal welfare, animal health and public health. The pigs are inspected alive and after slaughter. The pig farms are inspected based on the Animal Act and Article 2.22, §1 from The Animal Keepers Decree (NVWA, 2018b). The interviewee of the NVWA was René Gosselink, he is a controller himself.

Organic pig farm

14 June 2018

Van Leeuwen, Bio Varkens is an organic pig farm with 270 sows and 1400 fattening pig at Buren, Gelderland. All pigs are fed with organic feed, have spacious pens with straw and are not tail docked. The sows are housed in spacious farrowing pens and have the choice to be either inside or outside. The fattening pigs also have a housing inside and outside. Pregnant sows are allowed to enter a pasture with a mud pool from April till the end of October (Van Leeuwen, 2018). The interviewee of the organic pig farm was Peter van Leeuwen, the owner of the farm.

POV

15 June 2018

The POV is established by pig farmers. Pig farmers are represented by the POV and the direction within the POV is set by those pig farmers. Besides, the POV tries to strengthen the market position of the pig farmers, fight for better revenue models and for better cooperation within the chain (POV, 2018). Henk Boelrijk, the interviewee, has been active as a policy officer in pig husbandry for 20 years. In January 2018, he started working at the POV as a senior policy officer. He coordinates all incoming files of the POV and for some files, regarding animal welfare and health, he directly works on the policy-based aspects.

Literature review

Exploratory behavior

Background

Exploratory behavior has been studied for a long time in the area of animal behavior and is related to animal welfare especially in an intensive domestic environment (Wood-Gush & Vestergaard, 1989; Gonyou, 1994). Berlyne (1960) categorized the concept as extrinsic exploratory behavior and intrinsic exploratory behavior. The former refers to behaviors that are triggered by acute needs such as food or an attractive place to lie down (Wood-Gush & Vestergaard, 1989; Studnitz et al., 2007). It is thus synonymous with appetitive behavior. Intrinsic exploration is defined as exploration directed at stimuli that have little biological significance; animals' investigation of a novel object in their surroundings is suggestive of this categorization. Furthermore, inspective exploration and inquisitive exploration differ on whether to react on an environmental change or to try to make changes happen. Generally, the motivation for animals to express exploratory behaviors is about food, curiosity and boredom (Studnitz et al. 2007).

Even though domestication of *Sus scrofa* (*wild boar*) has occurred since 10,000 B.C. and domestic pigs in confined environments are not worried about food, water and nesting, they still show these natural behaviors regarding the search for food, by exploring their surroundings, i.e. rooting with their nose and mouth (Lekagul & McNeely, 1977). Research by Stolba and Wood-Gush (1980) also indicated that pigs, as omnivorous animals, are highly exploratory. For domestic pigs, well-studied exploratory behavior elements include: rooting, nosing, sniffing and chewing (on feed, but also vacuum chewing). The explored objects are normally the floor, substrates, map, chains, straw, etc. presented in the pens (Wemelsfelder et al., 2000; Bolhuis et al., 2006; Kittawornrat & Zimmerman, 2011).

Play behavior

Play behavior of pigs has been studied by looking at their cognitive and social abilities and is evolved during neonatal development (Fagen, 1981; Špinka et al., 2001). Play-related categories involve locomotor behavior, social behavior and play directed towards objects, but play also depends on age and sex (Martin et al., 2015; Donaldson et al., 2002; Newberry et al., 1988).

The research of Wood-Gush & Vestergaard in 1991 showed that play behavior is motivationally related to exploratory behavior. Play may have some interactive function with exploration. Already a few decades ago, several researchers speculated that play is related to exploration (e.g. Newberry et al., 1988). When exploring a novel object, play can appear by a stimulation from a sudden change in stimuli or novelty, which suggests that fear is involved as well with play behavior. It seems that when a piglet is exploring a novelty, it can be a bit fearful sometimes, but to overcome this, they can show play behavior as well, such as biting the novel object or scampering. Scampering can be defined as both a fear, but also a play response, since it mostly means that the piglet is running around with quick light steps through fear and/or excitement, often joined with barking. Play behavior has as an important function in learning, so, play must be linked to exploration, as the learning abilities how to explore is gained through playing with novel objects (e.g. Wood-Gush et al., 1990; Wood-Gush & Vestergaard, 1991).

Intrinsic need

In their natural environment, pigs have the need to express exploratory behavior, because they need to explore the environment and search for food (Machado, et al., 2017). Pigs will still show rooting behavior even when there is enough food for them (Beattie & O'Connell, 2002). In a barren environment, pigs' need for rooting is compromised, which might cause frustration leading to an increase in aggressive behavior and harmful social behavior.

To ensure pigs' welfare, 'Rich Pig' (Bracke, 2008) was constructed to support the Dutch Ministry of Agriculture with the further implementation of the minimum standards of the pig pens (EC Directive 2001/93/EC). The model was intended, more specifically, to generate operational assessment criteria that determine the enrichment value of toys and substrates for intensively-housed pigs. Rich Pig is a semantic model that can be used to calculate enrichment scores (1 to 10) for different materials that can be used in intensively-housed weaners and fattening pigs. The model encloses 30 assessment criteria with different weighting factors, based on scientific information collected from databases.

The feedback loops in Figure 2 indicate that the welfare of the animals is good when the enrichment fulfills the pigs' needs to explore, forage and play. When the enrichment is insufficient, the pigs will redirect their behavior (e.g. Wallgren et al., 2016). This framework highlights that the pigs' needs and requirements for enrichments are affected by their evolutionary history. Pigs in the wild are used to rooting in forest soil, so mainly floor-directed behavior (e.g. Bracke, 2017). So, pigs are not built to reach up or twist their heads towards straw racks or wooden logs. Rearing on straw is similar to their 'wild' life, it might enhance their natural behaviors (Munsterhjelm et al., 2009). Furthermore, in barren environments, experiencing tail biting might even further increase the need for exploration. So, once pigs get a taste of it, it could increase the likelihood of tail biting outbreaks to escalate (Fraser, 1987). The main advantage of the Rich Pig model is that it is only based on scientific information, that it is transparent, robust and upgradeable, which is also the major scope of this model (Bracke, 2008). Rich pig is primarily designed to support further research and possible concretization of the principle-based regulation concerning pig enrichment.

Time

To satisfy the intrinsic need of pigs to express exploratory behaviors in confined environments, minimum time is considered to be one of the significant factors. But for now, only limited research

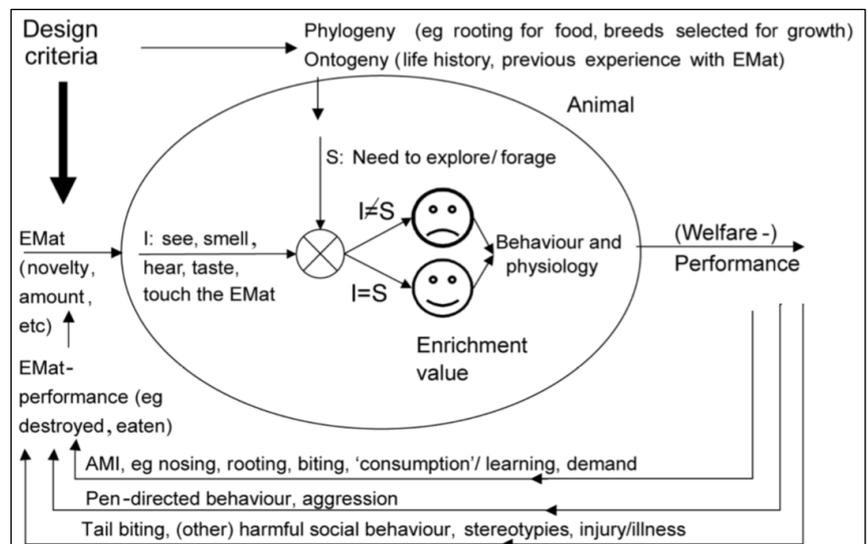


Figure 2: Schematic representation of the conceptual framework for assessing environmental enrichment for pigs (Rich Pig). EMat: enrichment material; AMI: animal-material interactions; I: Istwert, the environment as perceived by the animal; S: Sollwert, setpoint or norm of the animal (from Bracke, 2008).

showed data concerning this topic. An experiment conducted by Stangel and Jensen in 1991 investigated the time farrowing sows and piglets spent expressing behaviors in the first 10 days postpartum. Their results can imply something on the time that pigs need for exploratory behavior. During the experiment, sows received a full ration of commercial pig feed every morning in order to meet their nutritional demands. Therefore, if pigs still show exploratory behavior such as foraging, it means that pigs need to express exploratory behavior, not because of the hunger, but they have the intrinsic motivation to do so. Sows were out foraging for 10% of the observations in the first 2 days, and the foraging frequency, as well as the frequency of walking, increased gradually in the next 8 days. At the 8th day, sows spent most of the time on foraging instead of lying, and the proportion of time spent on different behaviors became stable. As seen in Figure 3, the percentage of observations marked by the dashed line is about 47% on day 8 postpartum, therefore, it can be concluded that farrowing sows like to spend at least 47% of their time on foraging in order to satisfy their motivation to express exploratory behavior.

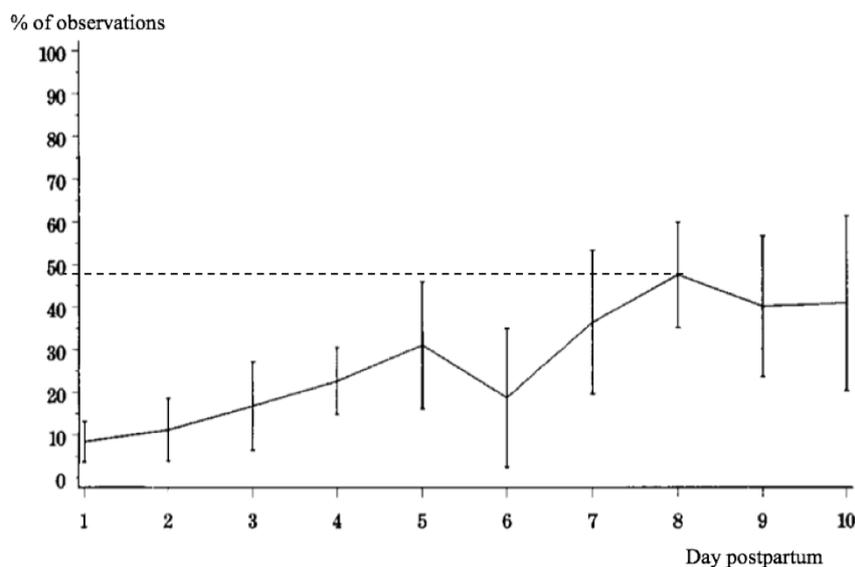


Figure 3: Average percentage of observations of foraging behavior of sows for 10 days postpartum. The dashed line marks the percentage on day 8 when the behavior frequency turned to be stable (Stangel & Jensen, 1991).

There are some researches done on the time distribution of pigs spent on different kinds of behaviors. In 2017, Machado et al. performed a research on fattening pigs to assess their behavior in an enriched environment. The results indicated that environments enriched by objects, affect the time pigs spent expressing various behaviors. The results of this research can be found in Table 1. Taking the data of the environment without enrichment as the reference, and when the NE (nuzzling or exploring the environment) and IO (interacting with the object) are considered as the exploratory behavior, pigs spend 14.52% of their time expressing explorative behavior. With the environmental enrichment, the time for exploring increases to 21.25%. On the other hand, if drinking and eating (ED) are also included in the exploratory behavior, the total time pigs spend will be 36.48% and 28.40% of the day in the environment with and without enrichment, respectively.

Table 1: The difference of time (%) pigs spend on various behaviors in the environment with and without the enrichment (Machado et al., 2017):

Behavior	% of observations		Difference ¹
	With enrichment	Without enrichment	
SL (sleeping or lying)	58,31	67,72	-9,41
ED (eating or drinking)	15,23	13,88	+1,35
SB (sexual behavior)	0,01	0,08	-0,07
AB (agonistic behavior)	0,36	0,61	-0,25
NE (nuzzling or exploring the environment)	11,56	14,52	-2,96
IO (interacting with the object)	9,69	0	+9,69
IP (interacting with another pig)	0,39	0,03	+0,36
MS (moving around or sitting)	4,45	3,16	+1,29
Total ²	100	100	0

(Behaviors marked in blue are mostly considered as the exploratory behavior)

1. Difference = % of observations with enrichment - without enrichment. '+' means the time (%) spend on the behavior increased by the enrichment, '-' means decrease.
2. Total observing time was 480 minutes per day.

As for piglets, in the first 2 days postpartum, the frequency of piglets being active started at 30% and increased with the age, meanwhile, foraging behavior and locomotion increased slightly. Piglets started to play on the second day and on the seventh day they started orientated mounting correctly (Stangel & Jensen, 1991). Another experiment conducted by Petersen in 1994 showed that in the first week, the time piglets were active rooting and grazing accounted for 40% of the observations and kept increasing significantly until week 8 (90%). The activity was up to 100% in week 17, the rooting behavior took up to 40%, and the percentage of grazing behavior was about 25%. The result showed that the litter and age had an interaction in between, and the age of the piglets had a highly significant linear effect on the frequency of expressing different behaviors.

Space

Not a lot of research has been done yet on optimal space requirements for displaying play behavior in piglets and pigs. However, some research showed that piglets reared in an enriched environment (with e.g. straw and more spacing) did show a larger repertoire in play behaviors and also developed those earlier than piglets reared in a non-enriched environment (e.g. De Jonge et al., 1996; Bolhuis et al., 2005; Oostindjer et al., 2011; Martin et al., 2015). This might indicate that more space than stated in the commercial guidelines, allows piglets to exhibit play behavior earlier and more. What again enhances their cognitive and social abilities (Špinko et al., 2001; Martin et al., 2015).

Usually, organic farming is considered to have a higher ability to meet the pigs' biological and ethological needs in many aspects. In an organic system, sows are often kept with the possibility to go outside while weaners are kept inside but with an outdoor yard where they can go outside. In 1999, the Council Regulation (EC) formalized the basic rules of organic animal agriculture, the housing condition of pigs is one of the most important regulations (Von Borell et al., 2004). The EC regulation states that pigs should be able to perform all their natural behaviors in organic housing systems; it also

specifies minimum space requirements for organic pig farms (Table 2). These rules on space are stipulated on the premise that the pig can exhibit all their natural behaviors.

Table 2: The minimum space requirements on the organic pig farm based on the EC regulations (Von Borell et al., 2004):

Group of animals	Indoor space (m ² /animal)	Outdoor yard space (m ² /animal)
Boars	6.0	8.8
Lactating sows	7.5	2.5
Gestation sows	2.5	1.9
Weaners 40 days -30kg	0.6	0.4
Fattening pigs 30-50 kg	0.8	0.6
Fattening pigs 50-85 kg	1.1	0.8
Fattening pigs 85-110 kg	1.3	1.0

Enrichment

Background

In the commercial pig husbandry, stressful conditions, such as unfamiliar social and physical environments, are known to affect the pig's behaviors and welfare (e.g. Beattie et al., 1995; Janczak et al., 2002; Bolhuis et al., 2005; Van Dixhoorn et al., 2016). It has been shown that providing suitable substrates, such as straw and wood-shavings, preferably in combination with more space per animal as environmental enrichment, improves the welfare of pigs by meeting their behavioral requirements better (e.g. Bolhuis et al., 2006; Van Dixhoorn et al., 2016).

Environmental enrichment is of major importance for animal welfare and is even taken up in the Five Freedoms (Farm Animal Welfare Council, 1992): that an animal should have "freedom to express normal behavior". This freedom should be achieved by providing sufficient space, proper facilities, and company of the animal's own kind. Thus, by providing enrichment in a certain way.

The idea of environmental enrichment can be described as an advantageous change in the environment of a captive animal, resulting in behavioral opportunities which originate from the enrichment or that the opportunities are further intensified (Shepherdson, 1994; Young, 2013). Environmental enrichment can be characterized as a dynamic procedure where changes to management and housing are made with the goal to enhance the natural behavior of the animals, thereby increasing animal welfare (Young, 2013).

There are 5 types of enrichment that can be distinguished (Bloomsmith et al., 1991; Young, 2013): (1) Social enrichment, which can be divided in contact, with either conspecific or allospecific animals, and in a non-contact form; (2) occupational enrichment, what could be psychological like some sort of puzzle, or plain exercise; (3) physical, with, for example enclosure or accessories, e.g. toys inside their cage/pen; (4) sensory, e.g. visual by movies or images, auditory by music or other stimuli like olfactory or tactile; and (5) nutritional, which can be divided in the way that food is delivered to the animal, and the type of feed.

To enrich an animal's environment, two different strategies can be used (e.g. Wormell and Brayshaw, 2000; Young, 2013). On the one hand, there is a more naturalistic approach, where the 'wild'/natural environment of an animal is recreated to provide stimulation. On the other hand, behavioral engineering can be applied, i.e. cognitive enrichment. Devices or machines are provided that can be manipulated, or sometimes even operated by the animal, where it receives some kind of reward (mostly food). However, normally in the livestock sector, the first strategy is carried out, as there has not been enough research yet on latter strategy in pigs. It has been shown that providing suitable substrates, such as straw and wood-shavings, preferably in combination with more space per animal as environmental enrichment, improves the welfare of pigs by meeting their behavioral requirements better (e.g. Bolhuis et al., 2006; Van Dixhoorn et al., 2016). With this type of environmental enrichment, the pigs have more freedom to exhibit natural behaviors, such as rooting.

When the environment is enriched in a proper manner, the incidences of abnormal behaviors can be decreased and the performance of 'natural', species-specific behaviors, such as exploration, foraging, positive social interaction and play, can be increased (e.g. Van de Weerd and Day, 2009). Moreover, it has been shown that environmental enrichment in pigs has another positive effect since it reduces stress and could positively affect immune responses (e.g. Bolhuis et al., 2003; Luo et al., 2017). Nonetheless, substrates used as environmental enrichment are often negatively associated with extra costs, labor, and hygiene, and are unsuitable for pens with partially slatted floors, since it will clog the manure systems (Tuytens, 2005; Van Dixhoorn et al., 2016). So, pigs kept in conventional systems are therefore often reared under barren environmental conditions, without any kind of actual stimulation, and as a consequence, manipulative behaviors such as tail biting occur regularly in these pigs (e.g. Beattie et al., 2000a; Taylor et al., 2010).

Nonetheless, since January 2003, providing appropriate environmental enrichment to pigs of all ages has been mandatory across the EU (Directives 2001/88/EC and 2001/93/EC). It is stated that: *"To enable proper investigation and manipulation activities, all pigs must have permanent access to a sufficient quantity of material such as straw, hay, wood, sawdust, mushroom compost, peat or a mixture of such which does not adversely affect the health of the animals"*. Even though the EC Directive itself does not mention a metal chain, this is still the most provided 'enrichment' across pig farmers. However, it has become more and more clear that enriching the pigs with only a metal chain is not sufficient. So, in the last two decades, scientists have been looking for solutions to this enrichment problem by conducting different projects, as shown in Table 3. Here it is shown that already back in the 90's, concerns were there regarding pig enrichment, however, it took until 2003 to really implement legislations on enrichment in the law. Soon after, the Rich Pig project started, what showed that other values should be weighed in as well. In 2007, tail docking became a 'hot topic', so from then on, lots of research has been done on that to reduce tail biting and thus, tail docking. In the same time span, it became clear that only a chain was insufficient as enrichment and that new regulations implemented that chains should be upgraded with e.g. ball or pipe, what already in 2010 turned out to be even more insufficient, as a ball at the end reduces the use of the chain for more pigs at the same time. Nonetheless, a chain with ball or pipe is still the most standard enrichment type that is used in most conventional farms, and for that reason, there is still a lot of ongoing research on suitable enrichment materials (Bracke, 2017).

Table 3: Time points concerning legislations and projects in pig enrichment (Bracke, 2017):

Date	Event
1994	Dutch legislation on pig enrichment (Barren pen no longer allowed; short chain is ok; Anonymous, 1994)
Aug. 2001	EC Directive issued on proper pig enrichment (EC, 2001)
Jan. 2003	EC Directive ought to have been implemented (EC, 2001)
2003	NGO calls on Dutch Ministry of agriculture to enforce 1994 legislation to provide a chain (Bleijenberg, 2003)
Aug. 2003	Start of RICHPIG project (3yr; Verburg, 2007)
May 2006	Alarm letter of pig sector to ministry about enrichment (Ten Have-Mellema and van Gemert, 2006)
2006	End of RICHPIG project
2007	Project initiated by pig sector to weigh in other values (esp. economics; Zonderland, 2007)
July 2007	Dutch guidelines specified (Short chain is no longer sufficient; chain with ball or pipe is ok; LNV, 2007).
2008-2011	Project 'Ending tail docking'/'Responsible tail management'
2008	Farmer survey (De Lauwere et al., 2009)
2010-2011	Information and tool box for farmers to deal with tail biting; prize contest (www.hokverrijking.nl)
Sept. 2010	Dutch pig sector was informed about welfare deficit of ball/pipe and promising alternative (branched chain; Bracke, 2010a)
2011	Farmers optimistic about pig enrichment (Questionnaire Livestock Fair) in relation to Better Life RICHPIG calculations balls/pipe implementation in NL implied saving about 71 million euros at a loss of 376 million enrichment-value life-points compared to softwood over the period 2003-2011.
2013-2016	FareWellDock project (www.farewelldock.eu)
2015	Enrichment (chain+ball/pipe) mostly implemented in NL (NVWA, 2015a, 2015b)
March 2016	New EC guidelines/recommendations on enrichment and tail docking (EC, 2016, 2016b)
2016	Pig expert questionnaire confirms value of branched chain design (Bracke, Submitted)

Enrichment materials

Optimal environmental enrichment should not only provide proper manipulation activities to the pigs so that they are no longer bored, but it also should support the transition towards rearing pigs with intact tails. Currently, the use of metal chains is the most common form of environmental enrichment used in conventional systems. However, it is stated that metal chains are not recommended for long-term use, as the novelty factor diminishes quickly (Bracke et al., 2007).

Already in 2006, Bracke et al. reviewed that metal chains showed only very few significances in welfare benefits. Rubber, rope, wood, roughage and substrates, however, already had a lot more benefits for the welfare of the pigs, but it seemed that straw and compound objects overall scored best. Compound objects can be classified as, e.g. a straw rack with chains and a wood beam; straw combined with peat; two chains and two rubber hoses; straw and branches; etc., so a combination of materials used as environmental enrichment (Bracke et al., 2006).

Additionally, Studnitz et al. (2007) reviewed suitable rooting materials and concluded showed that straw has positive effects on behavior, because when the more straw is available, the more exploratory behavior is exhibited by pigs towards straw. But, minimum amounts are hard to establish. Even if straw is allocated in various ways, peat, mushroom compost, sand, sawdust, wood shavings, branches, beets, and silage rank above straw. Typical characteristics of these enrichment types are that all exist out of small, chewable, and often even eatable, pieces. The ranking below straw shows that pigs prefer ropes,

In 2007, Zonderland wrote a report on 10 different kinds of environmental enrichment that are currently used in pig husbandry (Table 5). Several scores were given to the materials, based on animal welfare, animal health, material costs, risk for housing systems, workability/availability of the materials, hygiene, labor time and human health risks. For welfare, a score of '3' seems low, but it was all compared with straw. Therefore, it seems that a wooden log or a rope is not good for the welfare but compared to straw it just scores much lower.

Table 5: Scores per aspect for the different enrichments (Zonderland, 2007):

		None	Straw bedding	Roughage	Straw rack	Wooden log	Rope	Rubber toy	Clapper	Plastic ball	Metal chain
<i>Animals</i>	Welfare	1	7	7	6	3	3	3	3	2	2
	Health risks	0	0	-	0	0	0	0	+	0	+
<i>Material</i>	Costs €	0	7.50	4.60	4.50	0.45	0.75	2.90	3.70	0.30	0.25
	Risks housing systems	+	0	-	0	0	0	0	+	+	+
	Workability/availability	+	0	-	-	+	+	0	+	+	+
	Hygiene	+	-	-	0	0	0	0	0	-	+
<i>Humans</i>	Labor (min)	0	123	105	10	2	8	1	10	<1	<1
	Health risks	+	-	0	0	+	+	+	+	+	+

Orange = negative effect; Green = positive effect; White = no/neutral effect - Several scores were given to the materials, based on animal welfare, animal health, material costs, risk for housing systems, workability/availability of the materials, hygiene, labor time and human health risks. Welfare scores were all compared with straw. All factors in the table were scored with 'ranking points', but costs and labor. The material costs were not scored since the cost per object is just given in Euros (€) and labor is shown in the minutes needed to provide a certain enrichment type.

The following 5 points were concluded in the report by Zonderland (2007): (1) That straw and roughages both had much higher scores regarding pig welfare than the other enrichment materials, such as rubber toys, but that substrates do lack practical aspects; (2) In scientific research so far, the main research was on welfare aspects, but relatively little research is done yet on the practical aspects of the materials, such as labor and costs; (3) Providing several kinds of enrichment at the same time, with different characteristics, could enhance the pig welfare. But providing more of identical kinds, it only improves welfare very little; (4) Providing feed via interactive mechanisms, such as a clapper in the feeder, whereby a pig has to put in more effort to get the feed, could be an improvement for welfare as well, since the feed will then be seen as a reward. However, not a lot of research has been done on these kinds of mechanisms for pigs yet; and lastly, (5) Providing enrichment material in the pen has to be done in the right place. Pigs value a distinction in places in the pen: e.g. a resting-,

defecating-, and feeding/foraging area. So, enrichment should be placed in the right area, for example, to prevent a lot of pen fouling.

Also, in 2007, Bracke et al. did some preliminary research for the Rich Pig model, to check if it is a feasible method. The Rich pig model (Bracke, 2008) has already been described in the previous chapter 'Exploratory behavior'. In this research, a long list of possible indicators has been proposed, the top 5 of this list is shown in Table 6 below (Bracke et al., 2007). The original list consisted of 64 enrichment materials and the scores were given by experts (expert score) and calculated by the Rich Pig model (model score). In 2004, a questionnaire was held among 9 pig welfare experts from five different EU countries. The experts were asked to score each treatment on a scale between 0 (worst) and 10 (best). These scores were based on their image of how much each material contributed to the pigs' need for 'proper investigation and manipulation' (EC Directive 2001/93/EC & 2008/120/EC). Other factors, such as lying comfort for the pigs, economics and environmental concerns, were not taken into account (Bracke et al., 2007).

Table 6: Ranked enrichment materials/treatments based on expert score and model score (Bracke et al., 2007):

Ranking	Elaborate treatment description	Short description	Expert score	Model score ¹
5	Whole straw mixed with maize silage provided ad lib on the pen floor once daily	Whole straw + maize silage (loose)	8.42	8.4
4	A bale of straw loose in the pen	Straw bale (loose)	9.00	9.7
3	Long straw provided once daily in a pen with two fir branches (which are renewed every month or when destroyed)	Long straw + fir branches (loose)	9.30	9.8
2	A layer of straw supplemented with concentrate feed (approximately 200 g/pig) scattered evenly over the bedded area	Strawbed + additional feed (loose)	9.50	9.9
1	A layer of straw (approximately 4 kg/pen, once daily) and bark (approximately 5 kg/pen, once daily), and two tree branches (refreshed monthly)	Straw + forest bark + 2 branches (loose)	9.50	10.0

1. Model score was calculated with the Rich Pig model (Bracke, 2008).

Furthermore, Van de Weerd (2003, 2009) developed a systematic method to analyze the interests of pigs in different kinds of enrichment. Main characteristics of the materials that were most explored by the pigs were 'ingestible', 'odorous', 'chewable', 'deformable' and 'destructible'. Which are generally associated with natural behavior of pigs, such as exploration, rooting and foraging. It seemed that the pigs mainly preferred enrichment that was 'chewable', 'deformable' and/or 'destructible'.

Recently, research has been done on manipulative materials that can be operated in commercial pig production systems. Bracke (2017) focused on enrichment that provided 'proper investigation and manipulation activities'. What should occupy the pig and reduce its boredom. Boredom in pigs can lead to frustration, what could induce to redirected, harmful behaviors, such as tail- and ear biting in weaner and fattening pigs, or bar biting in sows. With modelling work and on-farm observations,

Bracke (2017) came to some interesting conclusions that a short metal chain without any material attached to it at the end evoked more manipulative behaviors by the pigs than a chain with a ball or pipe attached to the end. Pigs mainly like to manipulate the end of the metal chains, so when a ball is attached, it inhibits this behavior. Even so, the metal chain can be upgraded, especially when the chain is branched with e.g. additional screws or wooden logs. Then more pigs at the same time have the opportunity to manipulate the branched chain. However, Bracke (2017) stated that additional research is still needed as the need for new enrichment materials is high.

Even so, it seems that straw as environmental enrichment is still very suitable, as it is widely available. It is used by pigs for playing, rooting and exploring, and is even claimed to prevent tail biting from happening in pig production systems. When pigs have no opportunity to play or explore they often turn to tail biting. But, principle-based regulation 2.22, §1 lacks guidelines in the usage of this material, how much is needed for pigs to perform their natural behavior, and how often it should be provided to the pigs (Wallgren et al., 2016). A study done by Wallgren et al. (2016) showed that most farmers were not willing to use straw because they believed it would cause blockages in their manure system. Other studies, contrarily, have shown that straw did not cause blockages in the manure system when the straw gets chopped in a length that fits the type of floor and its design (Westin et al., 2013). A study done by *Praktijkcentrum Lelystad* has proved straw to be more efficient in preventing tail biting than toys such as a chain and a rubber toy. They concluded that providing only a small amount of straw on the floor would prevent tail biting with undocked pigs. Only provisioning toys are inadequate in preventing tail biting (Zonderland & Fillerup, 2003).

Cognitive enrichment

A form of cognitive enrichment can be achieved by introducing, for example, interactive games. Other, inanimate forms of enrichment are often not interesting enough for animals and can cause a lack of interest in the enrichment material after only a couple of days. According to Manteuffel et al. (2009), environmental enrichment should lead to a reward gained through cognitive environmental processing. Effective environmental enrichment should challenge the animal but also maintain the motivation to use the enrichment over a longer period of time. The anticipation for the reward will activate arousal. Two examples of cognitive enrichment are the 'Call Feeding Station' (CFS) (Ernst et al., 2005) and 'Pig Chase' (Alfrink et al., 2012).

CFS is part of the food-rewarded learning system which integrates cognitive enrichment based on auditory conditioning into the familiar confined environment of domestic pigs (Ernst et al., 2005). After successfully mastering recognition tasks, pigs were rewarded with food and in the following specific period, the amount of food increased, as a reward. The results showed that pigs were more relaxed when fed, and after, positive emotions lasted longer. Furthermore, they expressed more exploratory behaviors in stressful conditions (Zebunke et al., 2013).

Pig Chase is a game developed by Utrecht School of Arts that was created to strengthen the pig-human relationship. To create this relationship and at the same time create cognitive enrichment, a big touch screen is placed in the barn where pigs can chase balls of light that are controlled by humans through an iPad. Even though this form of cognitive enrichment might be somewhat futuristic and costly to implement, we can only encourage the innovativeness of the game and a great example of looking at future possibilities that might increase pigs' welfare (Alfrink et al., 2012).

Developments on indicators for enrichment

Recently, the European Commission came up with a *Commissions services working document* (EC, 2016) introducing a rating method for better maintaining the legislations regarding environmental enrichment and play behavior in pigs. It is stated in the European law that “pigs must have permanent access to a sufficient quantity of material to enable proper investigation and manipulation activities, such as straw, hay, wood, sawdust, mushroom compost, peat or a mixture of such, which does not compromise the health of the animals” (Directives 2001/88/EC, 2001/93/EC & 2008/120/EC).

The European Commission would like to see that starting from 1 September 2018, all pig farmers will maintain this rating method, and keep the data, so that it is available for inspection agencies. The farmers are asked to perform this method at least once a month for at least 5 different pens (Varkens.nl, 2018). The rating system takes into account several indicators (EC, 2016), but the most important one is based on exploratory behavior of pigs: if the pigs are interested enough in the enrichment material that is provided and/or that the pigs have sufficient access to it to exhibit exploratory behavior. The EC Directive created a formula that could calculate the amount of exploration in the pen:

$$A/(A+B) * 100= X \%$$

Whereby the X value gives an indication of how much exploration behavior is performed by the pigs in a pen (Table 7). To calculate, values A and B are needed, by calculating the number of animals in a pen for 2 minutes, that:

- A: the number of pigs that are exploring the enrichment material(s), i.e. all the pigs that are touching/exploring/chewing the material with their nose and/or mouth. As long as the material (when it is roughage) is not part of the feed of the pigs.
- B: the number of pigs that are in contact with other pigs AND with other equipment in the pen, i.e. pigs that touch/manipulate with their nose/mouth other pigs, manure, the floor, or other equipment in the pen that is not meant as enrichment (such as the bars of the fence). Include pigs that perform stereotypic behavior, such as vacuum chewing, tongue rolling, trough chewing, etc.

Table 7: The formula will give a percentage that explains the X value as follows (EC, 2016):

X in %	Exploratory behavior is...	Rating/advice
0 – 18	Minimal	<i>Give another kind or more enrichment material(s)</i>
18,1 – 86,3	Moderate	
86,4 – 100	Optimal	

The following indicators are based on the recommendation of the EU commission from 8 March 2016 regarding EC directive 2008/120/EC to establish minimum regulations to decrease the need for tail docking (EC, 2016):

- Non-animal-related indicators:
 - Level of interest: is the material often refreshed/replaced?
 - Accessibility: easily accessible for all pigs?

- Sufficient amount: Are all pigs able to manipulate the enrichment material at the same time?
- Hygiene: Is the material covered in manure?
- Animal-related indicators:
 - Abnormal/redirected behavior:
 - After a while, pigs stop to show interest anymore in the material;
 - Pigs are manipulating other objects but the enrichment material, such as the bars, tails/ears from pen mates, etc.
 - Pigs are rooting and/or playing in their manure;
 - Pigs are competing or even fighting about occupying the enrichment material;
 - Sows exhibit 'foul'/mean nest-building behavior.
 - Presence of tails with bite marks;
 - Presence of (severe) skin lesions.

If the pigs have a minimal scoring for their exploratory behavior concerning the formula or exhibit abnormal behavior, farmers should give another kind of material, or more sufficient material as environmental enrichment (EC, 2016).

In addition, the European Commission would like to see that enrichment materials only consisting out of metal or solid plastics, will not be recognized as sufficient. These kinds of materials should be accompanied or even replaced with more suitable, 'natural' materials, such as straw, jute sacks, natural rope (made out of hemp or sisal) or soft/raw wood. These materials can be attached to a metal chain to keep clean. Roughages are also suitable as environmental enrichment, most ideally provided on the floor. However, in a lot of systems this is not possible (yet) (Varkens.nl, 2018; EC, 2016).

Consequences of insufficient enrichment

When housing systems are provided with no, or insufficient enrichment for pigs to manipulate, redirected behaviors, i.e. harmful social behaviors (Beattie et al., 1995) can occur in pigs. The main cause of redirected behavior could be that pigs are limited in exhibiting exploratory behavior. Already back in 1981, it has been stated that exploration is a behavioral need from the pig (Van Putten, 1981). Pigs need to explore as it is a part of their natural behavior, so they will even perform it when there is not any material to actually explore, such as the walls of the pen or the feeder (Beattie et al., 1995). However, this exploration behavior is often redirected towards pen mates as well. Persistent nosing, chewing and biting of pen mates can in some cases even lead to cannibalism, since pigs are attracted to the taste of blood (e.g. Fraser, 1987; Beattie et al., 1995; Taylor et al., 2010). An infamous redirected behavior in pigs is tail biting, but ear biting and belly nosing can also occur.

Pigs in barren housing will also show less diverse behaviors (Wemelsfelder et al., 2000), are less active (Wemelsfelder et al., 2000; Bolhuis et al., 2005) and more aggressive (De Jonge et al., 1996; O'Connell & Beattie, 1999) compared to pigs in enriched housing. In addition to the abnormal behaviors, barren housed pigs were found to be fearful and suffered from chronic stress (Beattie et al., 2000b; De Jong et al., 2000; Wemelsfelder et al., 2000). The chronic stress could also be linked to a psychological state of depression (van de Weerd & Day, 2009). Furthermore, pigs housed in a barren environment were found to be pessimistic (Douglas et al., 2012). In addition, play behavior could be less or even absent.

Play behavior, or locomotory behavior is also a very important activity in pigs, especially in piglets and weaners. However, play behavior is known as a 'luxury' behavior, that is mainly only shown when all other factors are sufficient, such as welfare, health, and access to feed and water (Beattie et al., 1995). An absence of play behavior, and then mainly in the younger pigs, could be an indicator that the enrichment is not sufficient, as this compromises their welfare.

A pig interacting with an object used as environmental enrichment might influence other pigs in the pen to also become (more) interested in exploring the object, as a result of 'social facilitation' or synchronization of behavior (Gonyou, 2001; Scott et al., 2007). If there is an insufficient amount of material though, social competition could arise. Whereby some pigs are prevented from using the enrichment at the same time, what could lead to frustration and even aggression (Hansen et al., 1982; Scott et al., 2007).

Apart from behavioral consequences of insufficient enrichment, meat quality has a tendency to be decreased as well, when the enrichment is not appropriate. Lactate formation and drip loss could significantly be lowered when proper environmental enrichment is provided (Klont et al., 2001).

Importance at all ages

Piglets start expressing rooting behavior in the first week after birth, so because the conditions in early postpartum have long-term effects on the development of piglets, it is necessary to offer some enrichment materials at the early stages of their life in the pen (Telkänranta et al., 2012). Furthermore, their behavioral and physiological development can be enhanced by expressing rooting and exploring behaviors. More accessibility to enrichment materials can decrease aggressive behavior from weaning period to fattening stage (Chaloupková et al., 2007), it can also help piglets to develop a more biologically normal cortisol rhythm (De Jong et al., 2000). The lack of manipulable material can increase the risk of ear biting and tail biting when the piglets grow up (Moinard et al., 2003; Telkänranta et al., 2014). Pigs that are able to show some exploratory behavior during the piglet stage could also have a better-developed eating behavior (Oostindjer et al., 2011).

Exploratory and possible foraging behaviors are the natural habit of weaner and rearing pigs, there are some reasons which could lead to the frustration of pigs' motivation to express these behaviors. When there is a lack of the manipulation materials, pigs cannot get satisfied by expressing exploratory behaviors, it will cause a bunch of problems: the increase of ear biting, tail biting and skin lesions (Schouten, 1986; Fraser et al., 1991; Beattie et al., 1995; De Jong et al., 1998; Sneddon et al., 2001; Van de Weerd et al., 2005), the reduction of play behavior, furthermore, the cognitive bias of weaner and rearing pigs will be affected, they will perceive fuzzy stimuli in a more pessimistic way (Douglas et al., 2012). Limited time, inadequate play material and inappropriate location of the play material will reduce the accessibility of the manipulation materials, which will also frustrate pigs to play and reduce animal welfare. Besides, less accessibility may increase agonistic behavior, asynchrony of behavior and reduce resting behavior (Hansen et al., 1982).

In addition, farrowing sows have a very special and important need to concentrate on the enrichment material: the establishment of a farrowing nest, which is strongly determined by hormones. Farrowing sows also have the motivation to express their exploratory behavior such as foraging and exploring behavior. When exhibiting exploratory behavior is compromised, sows will have a higher probability

to express stereotypic behavior (EFSA, 2007). Farrowing sows in an environment without enrichments have a lower oxytocin level than in an enriched environment (Oliviero et al., 2008). The changes in stress levels and parallel endocrine levels have some negative effects on the welfare and production of sows and piglets, such as an increased farrowing period, thereby an increase in the number of stillbirths (Oliviero et al., 2010); reduced premature milk and colostrum transfer which reduced the immunity for piglets; reduced body weight gain in piglets, and reduced maternal reactivity and good maternal characteristics (Herskin et al., 1998; Yun et al., 2013).

Pregnant sows and boars are restricted to feeding high-energy feed, so these pigs have less time spent on eating. Therefore, the exploring and foraging time associated with ingestion of food is very limited, and due to the low filling of the gut, pigs are still not satisfied after eating, causing a high motivation for foraging, which can lead to abnormal behavior if there is no suitable enrichment material (EFAS, 2014). The abnormal behavior in pregnant sow can be recognized as stereotypies, restlessness and aggression (van Putten and van de Burgwal, 1990; Terlouw and Lawrence, 1993; Durrell et al., 1997; Whittaker et al., 1998). For fed-restricted sows, gilts and boars, the lack of bulky or high-fiber foods can lead to long periods of depression and pain caused by gastric ulcers (Meunier-Salaün et al., 2001). Therefore, in order to maintain the welfare at a high level, it is essential to offer proper amounts of fibers for pigs, which could be a manipulable substrate. However, in some cases, the presence of straw may contribute to an increased incidence of vulvar bites or attacks, the reason could be the confusing feeding system, such as spreading feed on the floor (Whittaker et al., 1999).

Tail biting

There are three types of tail biting are described in literature. First, the 'two-stage' tail biting, which is the most common type of tail biting. This type consists of a 'pre-damage stage' and a 'damaging stage'. During the pre-damage stage, one pig manipulates the tail of another gently without causing damage or discomfort (Fraser & Broom, 1990). This behavior is seen as natural foraging and exploring behavior and has no aggressive motivation (Taylor et al., 2010). When, by accident, the skin breaks during this pre-damage stage the transition to the damaging stage is made (Schrøder-Petersen et al., 2003). In this stage, the problem can escalate very quickly as the other pigs are attracted by the bleeding tail (e.g. Fraser, 1987; Taylor et al., 2010). The second type of tail biting is 'sudden-forceful'. When a pig performs this type of behavior it forcefully bites or yanks another pig's tail, mostly out of competition or frustration over a desired resource, like feeders (Morrison et al., 2007). The motivation behind this type of tail biting is aggressive in contrast to the two-stage tail biting (Widowski, 2002). Finally, the third type of tail biting is 'obsessive' tail biting. This is a chronic form of tail biting, where a pig is fixated on tail biting and damages tails of other pigs severely by biting and yanking forcefully. Opposed to the sudden-forceful type that stops when the desired resource is provided sufficiently, obsessive tail biters do not stop. One possible motivation behind obsessive tail biters is that the tail biting became a consummatory behavior (Taylor et al., 2010).

Tail biting can be caused by a numerous amount of different factors, and mostly by combinations of these factors. Tail biting can be seen as redirected behavior caused by stress factors. The most reviewed factors that could encourage tail biting behavior are: feed, enrichment, climate/air quality; stocking density; age; flooring; health status; gender; genetics; and teething (Schrøder-Petersen & Simonsen, 2001; Sonoda et al., 2013; Taylor et al., 2010).

One of the main causes of two-stage tail biting is the lack of materials to explore and manipulate. The motivational background is natural foraging and exploring behavior. When no suitable material is present to perform this behavior on, pigs may start tail biting (Taylor et al., 2010). Providing enrichment for the piglets from birth to weaning can cause the pigs to perform less tail biting later in life and thereby prevents severe damage to the tails of the other pigs (Oostindjer et al., 2011; Telkänranta et al., 2014). Materials that are most suitable for reducing tail biting in pigs are jute sacks, straw and rope (Ursinus et al., 2014; Telkänranta et al., 2014). Also providing the pigs with raw materials like corn silage or alfalfa hay during rearing can lower the occurrence of tail biting during their life, though it does not eliminate it (Veit et al., 2016). Because of this clear relation between providing enrichment in pens and the lower occurrence of tail biting, the EU Commission Directive 2001/93/EC states that: “pigs must have permanent access to a sufficient quantity of material such as straw, hay, wood, sawdust, mushroom compost or peat to enable proper investigation and manipulation activities”. In practice, most farmers use metal chains or a rubber hose as environmental enrichment because it is cheap and easy in maintenance, but this type of enrichment has a much lower effect on tail biting than for instance straw or rope where an open end and the ability to destroy the material are very important factors to make the enrichment interesting for the pigs (Feddes and Fraser, 1994).

Nonetheless, in a recent study, it was concluded that victims of tail biting were more likely to manipulate environmental enrichment, such as chains and ropes, more frequently (Bracke & Ettema, 2014). It has been shown that pigs in barren pens have an increased interest in ‘novel objects’, i.e. environmental enrichment (Bracke & Spoolder, 2008). Thus, pigs that experience injurious behavior might experience their environment as even more barren, and hence could be more interested in the enrichment materials. The alternative to this is that these harmful behaviors themselves are known to have a tendency to escalate, what might increase destructive behavior in general, including redirected manipulations towards pen mates, but also more rope/chain manipulation. Thus, showing (more) manipulation behavior towards chains or ropes could either be related to a difference in cause or in effect of abnormal biting behaviors. This manipulative behavior could be resolved by providing more optimal materials as enrichment, feasibly not only as prevention of tail biting but also as treatment, as pigs in such pens tend to have higher demands for enrichment (Bracke & Ettema, 2014).

When severe, tail biting can lead to the development of chronic lesions and even infections so severe that subjected pigs sometimes are euthanized prior to slaughter dates. Tail biting is a serious form of reduced welfare, not only in the bitten but definitely also in the pig that is biting, partly due to insufficient materials that do not fulfill their behavioral exploratory/foraging needs, i.e. ‘natural’ behavior (Walggren et al., 2016). However, tail biting is a multifactorial problem, so it has to be kept in mind that (lack of) enrichment is definitely not the only cause.

Air Quality

An example of a principle-based regulation in the Animal Act that has previously been concretized is the following:

“The air circulation, the dust content of the air, the temperature, the relative humidity of the air and the gas concentrations in the environment of the animal, are not harmful to the animal”.

– Article 2.5, §4, *The Animal Keepers Decree (Wet Dieren, 2011)*

This principle-based regulation, as all principle-based regulations in the Animal Act, lacked indicators to measure if pig farmers maintained a level of care that made sure the welfare of the pigs at the farm met the right requirements. Even though this omitting of indicators within the law gave farmers the space to create innovations, which would be harder with stricter rules, it also created ambiguity among farmers and the task of maintaining these principle-based regulations by controllers of the NVWA became too difficult.

This is why the Ministry of Economic Affairs, in close collaboration with the NVWA, asked Wageningen Livestock Research to provide data related to the climate of weaning and fattening pig barns and with that information create workable indicators. The ministry of Economic Affairs did not request to close the principle-based regulation but to give the controllers of the NVWA the right tools to maintain the principle-based regulation and if necessary bring pig farmers to court when not meeting the requirements. With this research, Vermeer and Hopster produced five signal indicators that can be used as tools by controllers to identify those farms that fail to meet the necessary requirements to maintain a certain level of pig welfare regarding the air quality of the barn. Further research will be conducted on those farms to provide insight into the level of the violations regarding principle-based regulation Article 2.5, §4, which can lead to administrative action or criminal proceedings of NVWA. The five signal indicators are as follows (Vermeer & Hopster, 2017):

- *For weaning pigs*: level of NH₃ (ammonia) and CO₂ (carbon dioxide), degree of ear biting, degree of tail biting, and degree of redness of the eye;
- *For fattening pigs*: level of NH₃ and CO₂, degree of tail biting, degree of redness of the eye and degree of fouling.

When the NH₃ and CO₂ levels are too high in the barn, the climate of the barn might not be suitable. But to make sure these levels are not just a temporary issue, NVWA needs to check the indicators regarding the pigs, namely: degree of ear biting, tail biting, redness of the eyes and fouling (Varkens.nl, 2017). At least three violations regarding the indicators must have been measured in a single pig pen for NVWA to conclude that the welfare requirements of the pigs are not met. When such violations are measured for one out of six pig pens, the number of observed pig pens will be doubled. If again a pig pen shows 3 violations, NVWA will conclude the climate of the barn is insufficient (Vermeer & Hopster, 2017). According to Hopster, you cannot be 100% sure if the climate of a barn is insufficient on the basis of these indicators. They only measured the indicators in one season. They state that if they need to draw stronger conclusions, they need to take measurements all year long through all the different seasons and at more different barns (Varkens.nl, 2017).

The measurement of these indicators is important for the welfare of the pigs. This because the climate of the barn influences certain aspects concerning pig health, such as the growth and development of the pigs, the amount of pig and ear biting, but also the health of the workers at the farm (NVWA, 2018c,d). So, after receiving the report of Hopster and Vermeer, in January 2018 NVWA started sending out controllers to pig farms to check if the climate of the pig barns is not harming the animals according to the five indicators mentioned above. NVWA state on their website that pig farmers themselves can decide how they regulate the climate but should keep the five indicators in mind while regulating the climate. NVWA advises the pig farmers to look at certain characteristics of a good climate, which are stated in the principle-based regulation, and are as follows:

- The air circulation;
- The dust content of the air;
- The temperature;
- The relative humidity;
- The gas concentrations in the environment of the animal.

When these 5 characteristics are regulated, farmers should be able to pass the indicator test of the NVWA (NVWA, 2018c,d).

But, regulating these characteristics of the climate in the barn is not an easy process. According to Aarnink (Boerderij.nl, 2018), a researcher in Livestock environment of Wageningen University, the current climate systems of pig barns make it impossible to create a decent and healthy climate for the pigs. With the arrival of the air scrubber, a system that removes ammonia and particulates from the air in the barn before the air leaves the barn, the climate within the barn became even harder to control (Boerderij.nl, 2018). An air scrubber is only focused on the air that is leaving the barn, not the air within the barn. Investing in the air scrubber, to meet the quality requirements of the air leaving the barn, has put a huge strain on farmers, leaving little money for investments in the air quality within the barn (Wakker Dier, 2016). According to Moesker (2014), the amount of pigs with pneumonia and pleurisy has increased significantly and the worsening climate in the barn is causing an increase in tail biting (Moesker, 2014). This worsening of the climate in the barn makes checking the air quality of the barn by the above-mentioned indicators a very important task. However, further research is needed to investigate whether it is feasible for farmers to live up to these regulations with the current climate systems, and to investigate if the NVWA should focus on making the rules stricter or on closing the knowledge gap.

Results

All summaries of the following interviews are agreed upon by the interviewees (Appendix A).

Conventional pig farm

Considering play behavior and enrichment, the pigs on Partnership Verhoijesen-Verstappen are provided with chains with gummy balls, jute sacks, chains, and pieces of hose. John, Truus and Wil, think that only by observing pigs for a long time, it can be figured out if they have enough, and the right enrichment. However, they cannot come up with some specific indicators for the lack of enrichment. Partnership Verhoijesen-Verstappen gains a lot of information and knowledge from VIC Sterksel and tries, where possible, to implement this on their own farm. "New kinds of enrichments need to meet the pleasure of the animals, but it also has to be feasible considering labor, costs and hygiene". However, when asked what they would do when there were no economic boundaries, they did not really answer; "there are always economic boundaries and economics are just a very important issue". According to them, it is also very difficult to make changes on the farm. First of all, because for some changes you have to rebuild the whole farm, and second of all, because of the quick changes in rules and knowledge/information so you always get overtaken by events, since procedures to make changes take a long time.

Tail biting only occurs occasionally at partnership Verhoijesen-Verstappen. According to them, enrichment is not the only factor that affects tail biting. The change in weather and the time of the year where new wheat is used in the feed are of more importance. Furthermore, pigs are just like humans, there are always more aggressive or more submissive animals, according to John. "When we notice such a tail biter, we take it out of the group to solve the problem". But also genetic lines can be of influence.

When asked how they would like to see the maintaining of rules, they said they like to get more advice where they can work with instead of a stricter law. "There are already rules enough. We want to work on innovation and improvement regarding enrichment, but this needs to be created together with the pig production sector instead of by governmental organizations".

John had heard of the concretized air quality regulation; however, he was not contacted by the NVWA. The communication with the NVWA is not sufficient. "They just come to your farm to act like the police. It would be way better if they came to help you and give you a push in the right direction instead of fine you straight away. They should start with giving advice and cooperating to improve things instead of starting with maintaining".

Overall, John and Truus want to work on improvements and innovations as long as it is created together with the pig production sector, without stricter rules, and with more supervision and feedback instead of enforcement from the NVWA.

Dr. ir. Liesbeth Bolhuis

According to Liesbeth, exploration behavior is the investigation of the environment and foraging is an important part of it. From an evolutionary point of view, this behavior is so important for pigs that they still have the need to do this, even if they are housed in an environment where food and shelter are

available and where no enemies are present. There are many studies suggesting that the execution of exploratory behavior may actually be somehow rewarding for the pigs because in nature they have to continuously explore and forage because otherwise, they do not find food. Play behavior may resemble adult behavior, but in a very playful way. It is important for the development of their brain and their social skills. Besides, the execution of play behavior likely also has a rewarding effect on pigs. Also, play behavior is relatively more shown when the pigs are in a good shape, good health and have a good welfare. It becomes less when their mood and health is not optimal. However, it is a difficult welfare indicator as play behavior is mostly observed when the pigs are 2-8 weeks of age. Play behavior can be observed in older fattening pigs, but not as frequently.

The biggest lack, when pigs are housed in barren pens, in terms of natural behavior is the absence of foraging material. Besides, to exhibit their natural behavior pigs should be able to feed at the same time, as they like synchronization. However, if there is only limited space there will be some competition and their feeding time will be sub-optimal, i.e. not within their normal activity pattern. "The more feeding places, the fewer aggression pigs will show, and it would allow them to show more synchronization". It would be nice if pigs had some more space. However, Liesbeth can imagine that there are some boundaries for farmers as well, for example how much they are able to do. Although, when pigs are housed together with for example 25 pigs at 25 m², more can be done with the space they are living in, compared to four pigs that are housed together on 4 m². There will, for example, be more opportunities to make different functioning areas in the pen, like a foraging and exploration area, a defecation area and a resting area. In very small pens it is harder to make such different functioning areas.

There are different examples of good enrichment materials. Pieces of wood, even wooden beams and fresh branches are a couple of those materials. Besides, rooting materials like sawdust and short, chopped or long straw are good enrichment materials as well. Furthermore, pigs also like jute sacs, ropes and roughage or alfalfa combined with a straw bedding. Roughage and alfalfa are nice for the pigs as they can root for it in the straw and they can eat it. Moreover, aspects that are really important for enrichment are the synchronizing aspect, destructibility of the material and permanent enrichment with a novelty aspect. However, the optimality of enrichment materials really depends on the details, "The devil is in the details". The wood used as enrichment has to be soft, so the pigs can chew on it. Also, if you give them a bedding of straw and never refresh it, it is not suitable anymore for foraging or enrichment. What is also important for pigs are aspects of novelty, for instance, you can give them some extra fresh straw twice a day. This would give them something new to explore. When chains are used as enrichment, it is really important how it is hanging. Sometimes the chain is hanging too high and therefore a pig will not use it that much. One of the worst examples of enrichment is the chain with the ball. "The ball was added to the chain to have two toys, but I think it ruins the chain as they cannot chew on the chain anymore because of the ball".

Liesbeth thinks there is a lack of knowledge about how useful enrichment can be for some farmers. She thinks a proportion of the farmers thinks it is just a rule from the government, without having benefits for them or the pigs. In some countries, there is some sort of compromise with the farmers of not using straw bedding but giving the pigs some hands full of straw. She thinks, compared to other countries, the farmers in the Netherlands are very reluctant to do this because they are afraid the slatted floor gets obstructed, that it cannot be managed by the slurry system and that it will block the

system. The word 'straw' in general is a bit of a taboo for some farmers and they see it as old-fashioned. Some farmers like to buy fancy looking enrichment materials of plastic. It is easily manageable, and they do not have to replace it as it is undestroyable. However, pigs like destroyable things. A good compromise would be to give the pigs some hands full of straw every day.

Liesbeth agrees with concretizing principle-based regulation 2.22, §1. She thinks the rules have to become stricter and that a kind of ranking system has to be created. Based on scientists' and farmers' opinions, as it will always be a compromise between the two, a ranking can be created for the suitability of enrichment materials. Farmers could earn points if they use, for instance, a chain and two hands full of straw as enrichment. It would give them a certain score and if they have other kinds of enrichment they receive another score. So, there will be sort of a minimum standard. However, it is going to be very difficult, as again the details are very important.

For farmers, according to Liesbeth, there are some indicators that could tell them something about the enrichment they use, like if it is enough they provide their pigs. One really good indicator could be that the pigs use the enrichment and that multiple pigs can use it at the same time. However, it is a bit tricky to use this indicator as pigs also will use the enrichment a lot if there is something wrong in the pen, like tail and/or ear biting. Besides, the human-animal relationship would be a nice indicator. If the farmer would add a hand full of straw to the pen every morning, for instance, the farmer would see that the pigs would actually use it and would see that it improves the relationship between them. Also, the absence of tail- and ear biting would be a good indicator. Furthermore, it would be important for the farmers to look beyond the period of arousal of the pigs after the farmer enters the room where the pigs are housed. It would also be good to look at the behaviors of the pigs when they are calm again. However, Liesbeth can imagine that farmers do not have enough time to do this. Other indicators, not just only for farmers, could be the amount of tail- and ear wounds even though it is multifactorial, but enrichment is a big risk factor. An early indicator of tail biting, before the wounds appear, is a hanging tail between the legs of the pigs. Apart from this indicator, it is much more difficult, as for instance observing play behavior itself is too time-consuming.

Liesbeth's impression about the NVWA is that she can imagine that they have too little time to check things. Also, it seems that they do not have enough people working at the NVWA. However, this is based on information from the media. For the NVWA she thinks it would be useful to score both the animal and the environment to make a good evaluation of the enrichment. They should not only check for tail- and ear biting, but also look at what is available for the pigs and they should have some knowledge if it is enough or not. For instance, they have to check how the enrichment is offered, if it is offered in the right part of the pen and if it is not dirty as pigs will not use it then. Furthermore, there is a Welfare Quality Protocol for pigs. This protocol is animal-based and tells something about the welfare of the pigs. According to Liesbeth, enrichment should also be a part of this protocol.

Liesbeth's reaction to the indicators from the EU is that she really agrees with the animal-related- and the non-animal-related indicators, but that the formula to calculate exploratory behavior is a bit tricky. Since checking a pen for only 2 minutes is not a lot, pigs need some time to adjust, and will always be a bit distracted by humans. Also, the B value in the formula is not really concrete. In the formula, they indicate pig to pig contact, with, for example, their noses, as negative, but this can also happen in a

'friendly' way. So Liesbeth thinks this should be changed to only a negative aspect, such as biting/nibbling other pigs or (equipments in) the pen.

Dr. Inonge Reimert

According to Inonge, play behavior is mostly seen in young animals. It is especially seen in a form of locomotion, like running really fast, turning on the spot or running in circles. Besides, they can also play with substrates, like shaking straw, or throwing it in the air, or shaking a chain. Play behavior is exhibited when all other requirements, e.g. not hungry, not thirsty, no predators around, are met. However, play behavior is also shown when pigs try to handle a stressful situation. So, then not all other requirements are met. Furthermore, the importance of play behavior is that pigs can learn things in a non-serious way that can help later in life. Exploration behavior is a basic/intrinsic need for pigs. It is their way to find feed. "So, if they will not perform this behavior, then in nature they would starve to death. Apparently, if you give them feed, they still want to search for it. So, I think that is why it is really important that pigs should show this behavior. You should make it possible that pigs can show this behavior".

For enrichment, generally substrate enrichment, farmers give extra things to pigs such as a chain, a huge layer of straw, sand or branches. Furthermore, social enrichment means animals have access to more animals or animals of different ages, or even contact with humans. When relating enrichment with welfare improvement, temperature is also important.

When welfare is good, pigs are healthy and have enough enrichment. Inonge agrees with us that play behavior might be an indicator at the young age, but it is difficult. Apparently, piglets with the sow in quite barren pens (though it is not a good way to keep animals) are still playing. So, animals will play independently of the environment where they are, as it is an intrinsic behavior, especially in young piglets. Also, older animals do not play much but it does not mean that they are not fine, it is just that they do not show play behavior at that time.

According to Inonge, the basic needs for pigs to express natural behavior such as play and exploration is enough space and substrates. If they are in a very small pen, they cannot walk and play, since play is normally done over distances. For most pigs, rooting on a chain is not enough, their interest in chains might last for a week but in the long term, they need new materials to dig in.

According to Inonge, chains can be improved. For pigs, it would be nice when it is on the floor since pigs focus more downwards than upwards. They probably will play with a jute sac hanging above, but if it is too high, they will not jump. Even though soils from nature would be the optimal enrichment, for hygienic reasons it is not the best. Also, it dries quickly and then makes a lot of dust. Straw is still a very good option since it stays interesting. Different straws with different lengths can be given to the pigs. Pigs can chew on it, bite on it, go through it, and root it, especially when it is on the floor. But, farmers can also provide it in a bucket, this could work for some pigs as well if farmers do not forget to fill it. Furthermore, straw should be refreshed frequently but it is time-consuming. The more practical way for farmers is to give pigs a layer that pigs will eat up completely in a day, then the layers will not become higher and higher. But she is not sure about the health effect of excrement in the straw. It is also difficult to say exactly how much and when it should be refreshed, but at least once a week. For the amount of straw, she argues that definitely straw is helpful, and pigs really enjoy it. Also,

there are cognitive forms of enrichment, i.e. pigs can turn a wheel; farmers can give the pigs a name and when they respond to their name they get a treat. Pigs also like human interaction, it would be nice if farmers come in the pen and stroke them, play with them, that is also really distracting and helpful as an enrichment source. So, Inonge advocates combining different types of enrichment, she thinks not just objects or substrates, but also cognitive or social enrichment. A combination of objects or substrates with cognitive or social enrichment would be better. Inonge argues that there is not much difference in the type of enrichment that weaners and fattening pigs need. Straw is helpful during every stage of a pig's life, but there could be a difference in amount.

According to Inonge the minimum amount of space pigs might be enough in the beginning. After weaning (25kg) the pen size stays the same until the pigs reach their slaughter weight, which is 1 m². For the last stage/weeks, it is not enough anymore, especially if they are all lying down. This would mean that the whole pen is filled with pigs and if one pig wants to go somewhere it cannot. Pigs have to step over each other and it can induce a lot of unrest. It might be really nice if the pens can grow/become bigger as the pig become bigger, but it will be practically impossible.

The possible consequences for pigs when they cannot express their natural behavior are tail biting and social stress. Tail biting is way less in enriched pens, but still not zero. So, apparently, there are still other problems that pigs encounter which lead to a tail bite outbreak. It is hard to say tail biting is caused by not enough enrichment. Social stress according to Inonge means pigs are more agitated with each other. There is no space to escape so they might express more aggressive behavior such as pushing each other away, what may lead to social tension. There are other physiological consequences, for example, they may eat less. The main thing is coming down to more frustration, then pigs get aggressive and will bite each other's ears or tails. But she is not sure about to what extent these factors and behaviors are related to each other.

According to Inonge, it depends on farmers to say whether they have enough knowledge to recognize the problems regarding play or exploratory behavior. Some farmers really know their pigs well and can act quickly when a pig is not feeling well or comfortable. There are other farmers that probably do not know a lot about the animals they care for. There are huge differences between farmers and the ways they handle their animals. Some farmers take really good care of the pigs, even without any kind of enrichment, so she thinks it also depends on the management the farmers have. They can recognize the problems, but it takes time. One problem is that they do not have much time. Farmers come in the pen and the pigs react intensively for a while before they return to their normal behaviors. That is the time farmers probably do not have. She thinks farmers find it difficult to do anything about it, only if they have more people on the farm to check. However, there is probably no money for that.

When asking the question about whether straw would lead to clogging problems of the manure system, Inonge said that she is not sure about it. It probably depends on the systems, the type of manure and straw, and the following process of manure. But one thing is for sure, this needs further investigation about how the manure system actually works. A possible solution might be to have a beam in between (straw in the front of pen and slatted floor in the back) or use very long straw, then the straw cannot really go into the manure system. She thinks less than 1% of straw, in the end, will go through the slatted floor since the pigs might eat everything if not given too much. In this way, straw might not be a problem while processing the manure.

She agrees that in one way the principle-based regulation regarding enrichment and play behavior should be concretized. Because it is now more suggestive, and the farmers can choose the easiest way for them. However, she is not sure about going for specific amounts of enrichment. The minimum amount might be enough for some pigs while for others not. But the farmers will probably go with the minimum since it is less costly and less time-consuming for them. Another thing is that different pigs might prefer different types of enrichment. So, she thinks the principle-based regulation now should be less suggestive or vague: pigs need this type of enrichment, which is visible, but the amount of enrichment depends on the pigs and also on the farmers' management.

To come up with indicators as what has been done for the air quality principle-based regulation, Inonge argues that tail- and ear score are probably useful. But about fouling, she feels that pigs are cleaner when they have a huge layer of substrates, but whether they care about being dirty or clean is not clear. However, there will be detrimental health effect on pigs when they get covered in faeces and urine. Also, the limitation of using fouling as an indicator is that pigs might do it because of a high temperature in the barn, or because they defecate in inappropriate places. It is difficult to come with a clear list of indicators since pigs might express their discomfort regarding a lack of enrichment in different ways.

About the image of NVWA, she did not know much about how they work, but she thinks it is good to visit unannounced to check the farms in their normal conditions. Her suggestion for NVWA is to check more often and keep it unannounced. Furthermore, they should remain independent so that can say everything they want. When something is wrong there should be an improvement based on their institutional power. As for the inspection, considering the limited time they have, at least check the feed and water (such as feeders and water nipples), the number of animals in a pen and the temperature in the pens. If they can spend more time on the inspection, they should go into the pen, when the pigs are not scared anymore, the pigs will come to you and have some interaction. Also, it is quite important for them to have knowledge about pigs, for example, what are different kinds of behaviors of pigs.

Inonge's reaction to the new indicators from the EU is that she really agrees with the animal-related- and the non-animal-related indicators, but that the formula to calculate exploratory behavior is not sufficient according to her. The formula is not concrete enough and checking only 5 pens, once a month is not sufficient. Also, the B value in the formula is not really concrete according to Inonge. "In the formula, they indicate pig to pig contact in a negative way, however, this can also be positive. Therefore, the B value should be explained better". Besides, she thinks that the different categories of the X value are unclear. It is not clear to her how these values are established.

IKB

IKB tries to check every farm in the same way to keep the quality high. However, principle-based regulations can make this difficult. Therefore, IKB often has team meetings with their inspectors to inform them about how to check these principle-based regulations and to make sure that all inspectors check them in the same way. Even though these principle-based regulations are challenging to check for IKB, they do not think it is the best solution to completely concretize them, because it is important to give farmers freedom in their work. "Enrichment innovations are ever-developing, so we should give

farmers space to innovate. But it is also important to not let them get away too easily when they fill in the principle-based regulation by doing the bare minimum make sure that they comply with the law and the IKB requirements.”

“Regarding the enrichment regulation, it is very difficult to make it more concrete, because every barn is different and not every kind of enrichment works in every barn”. IKB inspects the indicators ear- and tail biting in barns, however, this is multifactorial, which means it is hard to use it as a specific indicator to check the sufficiency of the enrichment. When it comes to the air quality regulation, IKB tells us it is still quite difficult to check the NH₃ and CO₂ values of the barn. Especially for farmers themselves, it is hard to measure these values to see if they meet the regulation, such a system is quite an investment.

NVWA

René Gosselink of NVWA is a controller himself and tells us that there are different types of inspections. Before visiting a farm for an animal welfare inspection, the NVWA looks at certain information, such as the history of the farm, how often they have been there and the results of the inspections. While at the farm, he states that the inspectors check all the facets of the Animal Keepers Decree. When we inform him about the open norms in the Animal Act he says he believes there are not many open norms when it comes to pig farms, compared to dairy farms. We informed him that there are quite a couple, gave him information about open norm 2.22, § 1, and asked him his opinion on this open norm.

René tells us much has changed over the years, when it comes to enrichment. There used to be no enrichment at all and that slowly changed to the usage of a chain and later a chain that included another material, such as a ball. But, he says, a chain with a ball does not cover all the aspects of enrichment as stated in the law. “Livestock farmers want to do as little as possible to create as much enrichment for the pigs as possible. I think when it comes to enrichment material, a lot will change in the coming 5 years. But for now, when a farmer only has a chain, without any other material, they will get a fine”. When we ask him what he rather sees as playing material, he advises willow wood, straw or hay. But the best material, according to René, would be straw or something alike, which pigs can play with. The inspectors of NVWA do not have specific standards/measures when checking this open norm but they are aware that one chain with a ball, for example, would never be enough for 40 pigs, so they try to look at the enrichment issue from their own experience.

According to René there are countries, such as Germany, where certain rules within farms are more specific, such as the number of water nipples needed for a certain amount of pigs, if you have just one more pig than stated in the rule, you have to get another water nipple. When we ask why specific rules like this are lacking in the Netherlands he lets us know that some things are just too hard to measure. He does think that checking if the right toys are used, can, for example, be measured by checking if they are destroyable, chewable and digestible. “At some farms, pigs can look great, no tail biting, no ear biting, really great, but then there is no enrichment material at the farm, and the farmer might say we do not think they need it, pigs want to lay down, drink, eat and lay down again, that is their natural behavior. It seemed to work well since the pigs look great, but if the pigs are happy... who can tell?”.

When we get back to closing open norms, René says closing the norms does not make an inspection easier. “Sometimes a pen might be too small according to the law but then there is such a little pig in

it that I think 'well if we looked at it with an open norm it would have been fine, but a closed norm would mean we'd have to fine him'. A really big sow might actually not have enough space in this same pen but then we would not have to fine the farmer since he is following the rule. So, you could say we have to measure and count, but sometimes it is better to observe". But, it seems that these open norms can also make an inspection more difficult, according to René. This because inspectors can all give a different definition to the open norm. "When a farmer wants an inspector to quickly look at the farm and does not treat him or her nicely, or a farmer invites the inspector for coffee first and then leads him or her through the farm, an inspector will look at a farm differently. It is hard to not look at this social aspect, unless you make a really specific, concretized norm. We do have teams based on animal categories such as the 'pig team'. We have meetings with these inspectors together, to discuss which issues they have faced and the decisions they have made, to keep each other sharp and keep the norm uniform".

We ask him if he thinks the differences between inspectors and their decisions might cause opposition from the farmers. René states that if we want to show foreign countries that our meat is controlled by a governmental organization and they make sure the meat is produced by really good systems, everyone should appreciate a controlling agency. Another question we ask is if NVWA would rather be an advising organization instead of a controlling organization. René states that earlier, this would not have been possible, farmers would not have listened, but these days, farmers seem to listen more to the NVWA when they give advice, but mainly when it comes to a benefit in expenses and income. "I do not think we can be an advising organization. For advice, a farmer can go to the feed supplier and other organizations. That is just not the task of the NVWA, I think we should remain a controlling organization. I'm not sure if it is necessary to give fines very quickly, we rather focus on administrative law where you first tell farmers what needs to be adjusted and if that does not happen in a certain amount of time they get a rather large fine, 20.000, 50.000, 100.000 euros. Which is better than advising, what if you advise a farmer to do something, they invest a lot of money and then it does not work out, you need to be careful with that". When we ask him again where farmers should get their advice he states the feed suppliers and expert journals are a great source of information. "A lot of farmers get the most important information during meetings with other pig farmers, etc".

Another subject we introduce is about the new indicators that concretized the open norm of the climate in the barn. He lets us know there are NH₃ and CO₂ meters that they use these days that are set to a certain norm, exceeding this norm causes an alarm to go off, which actually happens quite often. But according to René this is a good thing, to show farmers that the levels of NH₃ or CO₂ are too high while farmers are working in this environment most of their days. Next to that, when he sees teary eyes, red eyes, or tail biting in the pigs, he can let the farmer know that something in the farm is not right and could be improved. The inspectors have not fined any farmer yet on only these indicators, but, René says when he sees faults regarding these indicators and a lot of other issues, then he might be stricter. "Pig farmers just really need to start working on certain issues, there basically should be a big ventilator in the farm that pulls in outside air and the air should be heated when it gets too cold. But farmers find this too expensive. Therefore, they choose not to ventilate the air which eventually causes a bad climate, it is that simple".

"The best instrument we have is 'improvement', when there are issues in a farm, we will raise them, tell farmers how to improve this and let them know that if it has not improved the next time NVWA

visits, they get a fine. Threatening the farmers with high fines they might get in the end, does work". We ask him if the indicators of the climate made their work easier. René states that it is easy to control NH₃ and CO₂, but, red eyes, tail biting and fouling are harder to judge because they are multifactorial. After this, we asked René what he thinks about the new indicators of the European Commission on enrichment, and if he thinks these are feasible for usage in the Netherlands. "As I said before, the next couple of years a lot will change regarding playing material. The most important thing is getting through to farmers that playing material is only playing material when you have to replace it once in a while. Farmers rather not replace playing material, since it is expensive. But, how can you call it playing material when it does not get destroyed after a while?".

Next, we want to know who comes up with the rules within these norms, new insights into what is needed. René responded that mainly NGO's, Wageningen University and the pig farmers come up with these things. "We really liked working together on the open norm on the climate, we tried new indicators, we observed, we included some of the indicators in the norm, all this together makes it more feasible for inspectors to check the open norm".

Another important aspect in enrichment, according to René, is straw. But, straw is really difficult to introduce as barns nowadays are not built to be compatible with straw. Farmers also see it as too costly and labor-intensive. It might work if some kind of reward system can be introduced, if the use of straw (or another kind of substrate) would give the farmer more profit, they might be less reluctant to it.

Organic pig farm

At Van Leeuwen, Bio Varkens, pigs have a lot of space, three times as much compared to a conventional farm. Besides the extra space, pigs can choose between being inside or outside, get natural daylight, receive straw and roughage as enrichment and sometimes a chain and/or a rope. Additionally, pregnant sows have access to pasture with mud pools, where they can root and bathe in the mud. According to Peter van Leeuwen, their pigs can express their natural behavior well, as all the pigs are housed with straw.

Straw still seems one of the optimal enrichment materials for pigs, however, most conventional farmers do not want to work with straw as it is problematic, not only with the manure draining systems but also with higher costs and more labor. Van Leeuwen does not really encounter these problems. Even though, his cost price is twice as high since he has more employees, uses expensive, organic feed and has a more expensive housing system, due to straw. As long as the income is also twice as high, he is doing fine. Besides, his manure system is compatible with straw, he is able to mix straw in the manure in most of his manure pits.

Van Leeuwen does not experience a lot of problems with tail- and ear biting, but it sometimes still happens, even though his environmental enrichment is more than sufficient. Tail biting is a redirected behavior that is a multifactorial problem. So, tail biting is not only due to the (lack of) enrichment in the housing systems but also due to health. When a pig is not feeling well, or when their basic requirements, such as ad libitum water supply, sufficient, satisfying feed, or enough space per animal, are not met, pigs can exhibit redirected behavior as well. His advice is to always try to keep on top of the situation since tail biting is a huge problem if you have an outbreak.

His tips to other (conventional) farmers regarding environmental enrichment is that straw still seems to be the best way to enrich the housing of pigs and that nowadays lots of information on environmental enrichment can be found in the trade magazines or can be obtained during special learning sessions, organized by Varkens.nl. Furthermore, he thinks that enrichment, such as toys or balls, should not be given loose in the pen, pigs will only play with it for a little while, as after some time, the enrichment will be covered in manure and then it is not interesting to the pigs anymore. Other kinds of materials he mentioned were chains attached to the fence or a spiral attached to the fence that the pigs can move up and down with their head. He was not really fond of rope, as it will get mixed into the manure system, and the manure processors will not be too happy with that. For natural ropes, such as hemp rope, he saw that pigs just eat them all, so you keep replacing the ropes several times a day. Sometimes, he uses rope made out of straw, but only during a tail biting outbreak, but not usable for a lot of conventional farmers as the straw could get mixed into the manure again. Another option he mentioned was the use of wood, such as branches, but still, this could clog the manure system.

Normally, the NVWA does not inspect organic farms, as there is another organization for that, Skal. Skal generally inspects once a year with an announced visit to check all administration, but once in a while, Skal inspects unannounced. But Van Leeuwen has never had any problems with these inspections. IKB also inspects once a year, and they especially check the organic aspects, but the use of medicines and antibiotics is also checked a lot. The slaughterhouse, de Groene Weg, whereby Van Leeuwen delivers, has some additional demands, which are also checked. De Groene Weg started the 'Eko Code', whereby farmers can score extra points, that will give them extra money. These points include, for example, use of solar panels, employ disabled staff, provide extra enrichment to the pigs, etc.

POV

The five indicators to concretize the principle-based regulation concerning the climate and air quality in barns were set up with help of the POV. Recently, this protocol has been evaluated in a pilot study in agreement with POV. The outcome of this evaluation pilot was overall pretty positive, as the collaboration between the different stakeholders was pretty good. Also, the companies that were visited for inspection cooperated fine, but it did lead to some discussion points. The major point was that, yes, you are able to measure things, such as the amount of tail biting, but that will never give a direct relation with the climate in the barn. Additionally, the measurements are a 'snapshot', they only show what is happening in the barn at that exact moment the inspecting agency is visiting. This is also one of the major problems the inspectors themselves have problems with. As the moment of inspection can be influenced by a lot of other factors. It could be that the gas concentrations during inspection are too high, but this can be due to the fact that the outside temperature is high. So, there are always influences from the climate that is currently outside the barns.

Henk Boelrijk mentions that climate is also indirectly related to enrichment. As the climate is a very complex subject and is influenced by several different factors. The conclusion of the evaluation pilot is, therefore, according to him, that inspectors cannot check only with the use of objective measures, such as the gas concentration, but they have to compose a general image of the possible problems at that farm that is being inspected. You really have to be a good inspector to get the right image of the farm with only the indicators 'red eyes' and 'ear- and tail biting'. Still, the inspectors of NVWA actually

all need to be at that level, as they are the ones that are allowed to give farmers a fine. However, as the outcome of the evaluation pilot shows, it is not that simple yet.

On all levels, the POV has policy-based contact with the NVWA. Henk's opinion is that the NVWA is always short on time, especially to get a general overview of the conditions of a farm. If the regulation is strict, for example with an exact square meter per pig, then it is just measuring if it is right. If not, the NVWA can give a fine to the farmer. But the principle-based regulations are much harder to check since it is mainly related to more complex factors.

So, these principle-based regulations are quite difficult for the NVWA to deal with, because their general function is to inspect farms and to check if farmers maintain the law. The NVWA is not there to give farmers advice on how to improve a principle-based regulation. Thus, the new indicators set for the climate are very nice for the NVWA as it makes inspections somewhat easier. Their inspections can be more structured and more uniform, as they now have some entry points to check on.

Currently, Henk thinks that the inspectors at NVWA sometimes differ quite a lot in their opinion, because it is impossible to be completely objective during a farm inspection. Therefore, new indicators for principle-based regulations can be a way to make inspections more uniform. To check enrichment at a farm, the inspector needs a lot of experience and some criteria, based on indicators, that can be checked objectively. Still, subjectivity will still be needed a little, because the inspector should be convinced himself that the enrichment is sufficient, so his own opinion on that is important as well.

Henk's opinion about straw used as environmental enrichment is that it is really difficult to implement as an indicator, as at the moment, it is not possible to make straw mandatory. Regarding the search for new indicators for the enrichment regulation, Henk believes that it will be nearly impossible to concretize it, as enrichment is way too complex. It is impossible to be completely objective when checking if enrichment is sufficient. He again thinks that climate plays a big role in this and that there will be an overlap with what the NVWA is now using for checking the climate and air quality. In addition, the indicators have to work policy-based as it has to fit in research programs to improve the animals' health and welfare, which are related to a lot of other factors.

Furthermore, the climate has to be good for the farmer himself as well, another important factor that gets checked by the labor inspectorate. This inspection agency mainly checks for danger, e.g. feeders attached to the walls directly, etc., but it also checks the climate, if it is not compromising the farmer's health. However, also with these inspections, climate is an important factor. So, it seems that there is an overlapping part between these inspections, the inspection of the NVWA, and also this project on enrichment. And with that overlap, it might be possible to come up with indicators, according to Henk.

But there are several different inspecting agencies, that all inspect and inform farmers in a slightly different way, especially concerning the climate and air quality in the barn. Which could lead to frustration among the farmers. So, the POV made a start with inventing a 'farm of the future'. Wherein the climate will be optimally maintained, and emissions will be diminished. This is one of POV's policy-based ideas of future farming, but NVWA will still need to maintain their inspections, as legislations are still needed, in particular regarding animal welfare.

Henk's impression of how to tackle our problem is mostly with an integral approach towards it. Additionally, if we come up with indicators, these can still be used in a positive way, definitely also by the farmers. Since these indicators can provide the farmers with some starting points to start working from and improving their current enrichment. Furthermore, he thinks an important recommendation could be that the goal of the NVWA needs to switch from mainly giving fines to farmers, to improving/guiding farmers and farms. However, the NVWA needs the right instruments for that, and the same for the farmers, they will also need some kind of entry points, but these have to be economically feasible. Moreover, NVWA could give the farmer advice on who/which organization to contact if they have certain problems, with e.g. the feed or the climate. More collaboration between the different cooperating organizations is needed to improve this overall (welfare) case, whereby POV definitely can play a role as well.

Henk's belief on the new indicators that were recently introduced by the EU is that the formula is way too complicated for most farmers to carry out and he has a lot of doubt whether it is workable for the NVWA to check. His first, overall impression is that it is way too complicated to start working with these kinds of formulas.

Discussion

Within the Dutch Animal Act, principle-based regulations are included that create ambiguity among farmers and inspectors of the NVWA. VIN noticed that it is difficult for the farmers and the NVWA to maintain these principle-based regulations because they are not concrete and lack strict rules regarding their implementation (VIN, 2014). To increase the feasibility of a principle-based regulation, a list of workable indicators is needed. With this project, we focused on one principle-based regulation, namely Article 2.22, §1, “pigs permanently have sufficient material to explore and play with, consisting of straw, hay, wood, sawdust, compost of mushrooms, peat or a mixture thereof, or any other suitable material as far as the health of the animal will not be compromised”. Because of time limitations, it is not possible to create a concrete, feasible list of indicators. Therefore, we will provide a tentative protocol that needs further development and validation.

To create a tentative protocol that can be used for further research into concretizing principle-based regulation Article 2.22, §1, interviews have been conducted with several stakeholders of the pig farm industry. According to Verhoijesen of conventional pig farm Maatschap Verhoijesen-Verstappen, advice on maintaining this principle-based regulation is welcomed at his farm, but, a stricter law would restrict him from creating his own management. “There are rules enough already. We want to work on innovation and improvement regarding enrichment, but this needs to be created together with the pig production sector instead of by governmental organizations”. Boelrijk of POV does not believe NVWA should perform an advising role. When asked of his opinion on the previously concretized principle-based regulation on air quality, he stated “the new indicators set for the climate are very nice for the NVWA as it makes inspections somewhat easier. Their inspections can be more structured and more uniform, as they now have some entry points to check on.” He thinks that the inspectors at NVWA sometimes differ quite a lot in their opinion because it is impossible to be completely objective during a farm inspection. Therefore, new indicators for principle-based regulations can be a way to make inspections more uniform. So, regarding the implementation of possible new indicators for principle-based regulation Article 2.22, §1, Boelrijk said: “if we come up with indicators, these can still be used in a positive way, definitely also by the farmers. Since these indicators can provide the farmers with some starting points to start working from and to improve their current enrichment”. Furthermore, he thinks an important recommendation could be that the goal of the NVWA needs to switch from mainly giving fines to farmers, to guiding farmers. However, the NVWA needs the right instruments for that. And, the same for the farmers, they will need some kind of entry points, but these have to be economically feasible. Moreover, NVWA could give the farmer advice on which organization to contact if they have certain problems concerning e.g. the feed or the climate. More collaboration between the different cooperating organizations is needed to improve this overall (welfare) case, whereby POV thinks they can definitely play a role as well.

Gosselink of the NVWA is an inspector himself and believes concretizing principle-based regulations does not make an inspection easier. “Sometimes a pen might be too small according to the law but then there is such a little pig in it that I think ‘well if we looked at it with a principle-based regulation it would have been fine, but a closed regulation would mean we would have to fine him. A really big sow might actually not have enough space in this same pen but then we would not have to fine the farmer since he is following the rule’. So, you could say we have to measure and count, but sometimes it is better to observe”. But, he believes principle-based regulations are not easy to work with either.

This because inspectors can all give a different definition of the principle-based regulation. When asked if NVWA should work as an advising organization, Gosselink answers “I do not think we can be an advising organization. For advice, a farmer can go to the feed supplier and other organizations. That is just not the task of the NVWA, I think we should remain a controlling organization”. “The best instrument we have is ‘improvement’, when there are issues in a farm, we will raise them, tell farmers how to improve this and let them know that if it has not improved the next time NVWA visits, they get a fine. Threatening the farmers with high fines they might get in the end, does work”. Gosselink stated that the NVWA really liked working on concretizing the principle-based regulation on the air quality, together with Wageningen University. “We tried new indicators, we observed, we included some of the indicators in the regulations, and all this together makes it more feasible for inspectors to check the principle-based regulation”.

Integrale Keten Beheersing Varken (IKB Varken), is an organization that farmers can turn towards if they would like to receive a certification that states they conform to the quality standards of IKB Varken. Different from the NVWA inspections, the inspections of IKB Varken are by appointment. But, IKB Varken also checks pig farms on the principle-based regulations. Herder and Oomen of IKB Varken stated that it is challenging to check these principle-based regulations. IKB Varken often has team meetings with their inspectors to inform them about how to check these principle-based regulations and to make sure that all inspectors check them in the same way. Herder and Oomen do not think it is the best solution to completely concretize the regulations, because it is important to give farmers freedom in their work. “Enrichment innovations are ever-developing, so we should give farmers space to innovate. But it is also important to make sure that they comply with the law and the IKB requirements”. When looking at enrichment they believe it is hard to use e.g. ear- and tail biting as specific indicators to check the sufficiency of the enrichment materials, since they are multifactorial.

Scientist dr. ir. Bolhuis is positive about concretizing principle-based regulation Article 2.22, §1. But, she also believes there is a lack of knowledge about how useful enrichment can be for farmers themselves. She believes a proportion of farmers thinks it is just a rule from the government, and these rules will not benefit the farmer or the pigs. Bolhuis thinks it is helpful to create a ranking system. This ranking system should consist of a list of enrichment materials that farmers can implement in their farming system. Farmers have to provide a minimum amount of enrichment to meet the standard, and the more enrichment a farmer provides to their animals, the higher their ranking. Scientist dr. Reimert agrees with Bolhuis on concretizing the principle-based regulation on enrichment and play behavior. Reimert believes it is important that the principle-based regulation Article 2.22, §1 indicates concrete forms of enrichment, however, the amount of enrichment depends on the pigs and on the farmer’s management.

So far, an impression of the different opinions of the stakeholders on concretizing principle-based regulation Article 2.22, §1 has been provided. Another important aspect for the concretization is the feasibility of introducing certain types of enrichments. According to the literature review and the interviews with Bolhuis and Reimert, it seemed that a suitable type of enrichment is straw, when looking at pig welfare aspects. But, as reviewed by Studnitz et al. (2007) it often seems that other rooting materials, such as peat or wood shavings, are not included in research regarding enrichment materials. When these are included in a ranking system, it is suggested that peat, mushroom compost, sand, sawdust, wood shavings, branches, beets, and silage rank above straw, because typical

characteristics of these enrichment types are that all exist out of small, chewable, and often even eatable, pieces (Studnitz et al., 2007). Nonetheless, this literature review (Studnitz et al., 2007) only focused on providing 1 type of enrichment per pen. Other studies found that when straw is enhanced with, for example, additional feed or branches (Bracke et al., 2007; De Jonge et al., 2008a), it has the highest welfare score regarding the Rich Pig model by Bracke (2007, 2008).

With straw as environmental enrichment, pigs have more freedom to exhibit natural behaviors, such as rooting (e.g. Bolhuis et al., 2006; Van Dixhoorn et al., 2016). However, according to the interviews with the farmers and the POV, straw is very difficult to introduce in current barns since the manure systems and flooring are not adjusted to this type of enrichment, and straw is often negatively associated with extra costs, labor and hygiene. The study of Westin et al. (2013) found that when straw is chopped in a specific length that fits the type of floor and its design, it actually is possible to use it.

To diminish costs and labor, conventional pig farmers mainly use metal chains as enrichment. Metal chains are easy to manage, as they are nearly indestructible and can be easily cleaned. However, research showed that chains are not sufficient enough, as these are not destructible, chewable, and/or deformable for the pigs (Van de Weerd et al., 2003, 2009). So, improvements can be made. According to the different interviews and literature, a metal chain with something attached to it is already an improvement, but only if the attached material is destructible, chewable, and/or deformable, such as wooden logs. Another way to improve the metal chain is by providing a branched chain, with longer chains that reach the floor, so that it is rootable (Bracke, 2017). These attachments make it more accessible for more pigs to explore the same time. As synchronic behavior is important for young pigs to learn from each other (e.g. Gonyou, 2001; Scott et al., 2007).

When talking about enrichment, farmers and inspection agencies mainly focus on environmental enrichment. However, social enrichment and cognitive enrichment can also be looked at. Social enrichment can be seen as not only conspecific or allospecific but also human-pig interaction. In addition, according to dr. Reimert, cognitive enrichment can play an important role in increasing the welfare of pigs. To check if pigs actually play and explore with the provided enrichment, and whether it satisfies them, behavioral observation is needed. According to the interview with Verhoijzen, it became clear that farmers do not really know how to check, and that there is not enough time to really observe the animals. Recently, the EU came with a formula to calculate the amount of exploratory behavior and some animal- and non-animal-related indicators, which might be able to show whether enough and/or the right type of enrichment is used. However, the values used in this formula still seem to need further improvements. According to the scientists interviewed, observing for only 2 minutes is not a lot at all, as pigs need time to adjust, and will always be somewhat distracted by humans. Furthermore, the B value in the formula is not really concrete. In the formula, they indicate pig to pig contact, with, for example, their noses, as negative, but this can also happen in a 'friendly' way. So, it might be better to change the B value to only a negative aspect, such as biting/nibbling other pigs or (equipments in) the pen. Nevertheless, the (non) animal-related indicators that are mentioned by the EU, can be useful for not only farmers but also inspecting agencies. These indicators are not specified in enrichment and exploratory behavior only. They have a multifunctional use, as some indicators can be used for other aspects as well. For example, tail- and ear biting are also recently introduced indicators for air quality.

To predict the feasibility of introducing strict indicators for principle-based regulation Article 2.22, §1, we reviewed the recently introduced indicators for the air quality. Gosselink of NVWA, believes it is helpful to think of indicators which can be used as a tool during the inspections. But, he also states that even though NH₃ and CO₂ are quite easy to check, red eyes, tail biting and fouling are harder to judge because they are multifactorial. Herder and Oomen of IKB Varken believe that NH₃ and CO₂ are not as easy to check either. Especially for farmers themselves, it is hard to measure these values to see if they meet the standard, such a system is quite an investment. Also, Boelrijk of the POV is not sure if the new indicators are feasible. Even though he is very positive about the collaboration between the different stakeholders in coming up with these indicators, he believes the measurements are a 'snapshot' that only shows what is happening at a farm at that exact moment and are therefore not usable to give a reflection of reality. When it comes to enrichment, all stakeholders agree that it is hard to concretize this principle-based regulation, since it is very complex. Issues that might be caused by a lack of enrichment can actually also be caused by other factors in the barn, such as the climate. Therefore, it is hard to come up with specific indicators to check the sufficiency of enrichment. But, if certain guidelines can be provided, they are welcomed.

We believe that, for farmers to be aware of developments regarding enrichment materials, communication between the different stakeholders is very important. There is a lot of information available for farmers to keep up-to-date with new information and innovations. But, it seems, there is such a huge amount of information, coming from all different angles, that farmers can get lost in this abundance of information. Verhoijzen stated that the communication between himself and the NVWA is not sufficient. "They just come to your farm to act like the police. It would be way better if they came to help you and give you a push in the right direction instead of fine you straight away. They should start with giving advice and cooperating to improve things instead of starting with maintaining".

So, when we look at the goal of this project: concretizing principle-based regulation Article 2.22, §1, we can conclude that, by looking at the gathered information, it is not yet feasible to provide a concrete list of indicators. We are, on the other hand, able to provide a tentative protocol, which needs to be further developed to put into practice. The interviews made us realize there are other interesting fields that could use further exploration. Such as, the ranking system, cognitive enrichment, and creating an information platform.

Conclusion

The importance of enrichment materials to increase the welfare of pigs is supported by both the literature and the interviews conducted. When enrichment is given in a proper manner, abnormal behaviors can decrease, and species-specific behavior can increase. Therefore, we believe it is necessary to clarify Article 2.22, §1, to promote the usage of sufficient enrichment materials. Since it is important to give farmers some freedom in their farm management, to promote innovativeness, and leave some room for inspectors of the NVWA to make judgements based on experience, we think it is important not to make it a rule-based regulation, but, merely to provide improved guidelines. So, given the knowledge we gained during this project, we will provide a tentative protocol. This tentative protocol is developed not only as a checklist for inspection agencies but also as a guide for farmers to make sure their farms and pigs meet certain minimum criteria. The protocol, nonetheless, needs further research and the feasibility has to be checked. Besides this protocol, advice will be given on combining enrichment materials, exploring cognitive enrichment, introducing a ranking system, and on creating an information platform.

Tentative protocol

Hereby, we present a list of animal- and non-animal-related indicators that can be consulted by farmers and inspection agencies to check if they meet the minimum welfare requirements regarding enrichment. During inspections, it is advisable for inspectors of the NVWA to keep in mind the differences in farm management.

According to the interviews with stakeholders and the literature review, animal-related indicators cannot solely be used to indicate whether enrichment is insufficient since they are multifactorial. But, there are some animal-related indicators that are important to keep track of when they occur, and solutions must be devised to get rid of these issues. The animal-related indicators mentioned below are important and measurable factors to indicate a pig's welfare.

In this project, it has been shown that exploratory and play behavior are important factors to observe when checking the welfare of pigs. Exploratory behavior is an intrinsic need that should be fulfilled for pigs to enact their natural behavior, and, play behavior is an important social aspect. But, these indicators are not easily measurable. Therefore, we believe that, for pigs to be able to perform this behavior, there should always be a minimum amount of enrichment materials available, regardless if the pigs seem unharmed and happy. We believe that during inspections it is most important to keep in mind that the welfare of the pigs should be judged by looking at it from the animal's perspective.

Next, we provide a ranking of visible animal-related indicators that we believe should always be checked. Following this list, we will provide an overview of the minimum requirements for the enrichment materials and how the sufficiency of the enrichment can be checked. Nowadays, metal chains with or without an attachment are often used as enrichment. We think this kind of enrichment is not sufficient for the pigs. According to our opinion, substrates are much better than metal chains, as pigs then can express their evolutionary need to root (Table 8).

Animal-related indicators

The following ranking of animal-related indicators, arranged in an order from more to less alarming, provides a good overview of signs that show further inspection is needed.

Ranking:

1. Lesions and bite marks due to abnormal behaviors:
 - a. Tail biting
 - b. Ear biting
 - c. Belly nosing
2. Stereotypic behavior (apart from tail/ear biting and belly nosing), e.g.:
 - a. When pigs do not show interest anymore in the material; they could start manipulating other objects but the enrichment material, such as the bars, tails/ears of pen mates, etc.
3. Aggressive behavior:
 - a. Towards pen mates: Pigs competing or even fighting about occupying the enrichment material
 - b. Towards humans: Sows exhibiting 'foul'/mean nest-building behavior
4. Abnormal behavior:
 - a. Pigs playing with their own manure instead of enrichment materials
 - b. Absence of play behavior (difficult indicator as play behavior decreases over time)

If any of these animal-related indicators are present, it might indicate a lack of suitable enrichment materials. To exclude the lack of enrichment material as an instigator of the animal-related indicators, the sufficiency of the enrichment materials in the farm must be investigated and if needed, more or different materials need to be provided to diminish the issues. To further check the sufficiency of the enrichment at a farm, the non-animal-related indicators, mentioned below, can be used.

Non-animal-related indicators

The non-animal-related indicators are mainly about the usability of enrichment materials. The following observation checklist (Figure 4) includes four steps to investigate the sufficiency of the enrichment provided by the farmers.

Observations checklist:



Figure 4: Step-wise approach for observing non-animal-related indicators

Table 8 provides an overview of commonly used environmental enrichment material. Focused on animal welfare, we integrated expert and model score and interview result instead of labor and cost issues, to assess the suitability of material.

Table 8: Short tentative list of enrichment materials:

Enrichment	Destructible ²	Chewable ²	Ingestible/ eatable ²	Overall suitability ²	Expert score ¹	Model score ¹	Why (in)sufficient? ²
Chain with ball	-	-	-	-	x	x	Pigs cannot chew on the chain because of the ball at the end of the chain
Metal chain	-	+	-	-	1.35	1.3	Not recommended for long-term use, as the novelty factor diminishes quickly
Branched chain (Bracke, 2017)	-	+	-	+/-	x	x	Pretty good solution for intensively housed pigs as the pigs than can root the chain and the branched chain can be used by multiple pigs. However, it is still not destructible and ingestible/eatable
Loose toys (rubber toys/jerry can)	+	+	-	+/-	1.5	2.4	Easily fouled with manure. When fouled with manure not used anymore by the pigs
Chain with a wooden log	+/-	+	+/-	+/-	2	1.4	Scoring depends on the wood type: hardwood: not chewable/destructible; softwood: more destructible so better
'Natural' rope	+	+	+/-	+	2.6	2.5	Destructible and chewable, but rope only accessible by 1 pig at a time
Jute sack	+	++	-	+	x	x	Destructible and chewable, but attached to the wall
Branches loose in the pen	+	+	+	+	4	5	Destructible and chewable
Substrates in a rack	+	++	+	+	5	5.5	Suitable, but rack often placed above 'eye' level of pigs
Substrates provided by hand (e.g. 20g/pig/day)	+	++	+	++	5.97	6	Pigs can express their explorative behavior, chewable and often ingestible
Substrates as bedding	+	+++ (also 'rootable')	+	+++	6.5	7.3	Pigs can express their explorative behavior, evolutionary need

1. Expert score and Model score retrieved from Bracke et al., 2007; For chain with ball, branched chain and jute sack, no scores were given in the research; substrates as bedding is a combined score of 3 materials: straw bale loose as bedding in pen; sawdust as bedding; and hay provided in a box in pen.

2. Based on literature review (e.g. Zonderland et al., 2007; Studnitz et al., 2007; Van de Weerd et al., 2003, 2009; Bracke et al., 2007; Bracke, 2017) and interviews.

Validation and further research

This tentative protocol can be seen as a short-term solution for the lack of clarity of the principle-based regulation Article 2.22, §1. But, validation of the feasibility is still needed. This information is solely based on the literature found and interviews conducted. We believe its feasibility can be tested in the same way as the indicators for the air quality, by checking the tentative protocol on a certain number of farms. In addition, further research is needed to create a more complete list of different kinds of environmental enrichment and to check what pigs themselves would like to be provided with. If the ranking system for enrichment materials seems feasible, it might be interesting to combine it with a rewarding system for farmers. Which might motivate them to provide enrichment materials with higher suitability scores, or to make combinations between different kinds of materials. Furthermore, a reward could also be given when pigs are delivered to the slaughterhouse in the healthiest possible way (no lesions, no gastric ulcers as sign of stress), since this could also mean the pigs' welfare has been optimal and enrichment at the farm has been sufficient.

Another example of an experiment could be conducted on selecting the optimal enrichment material. For example, pigs have access to several different areas within their pen. These areas could all be enriched with different kinds of rooting materials, such as peat, soil, straw, hay, sawdust, etc., to find out what pigs prefer to root and explore in. Even though, this not feasible as a short-term solution, it is important to start investigating this for future pig farming. We also advise keeping track of the progress regarding the Commissions services working document (EC, 2016). Since the European Commission will most likely implement a protocol evaluating the enrichment used at pig farms, from the 1st of September 2018 onwards. Also, currently Wageningen Livestock Research is working on a brochure to provide information to farmers on enrichment. To gain a broader perspective, we advise taking this brochure into account as soon as it is published.

Further advice

For long-term solutions regarding enrichment, there are, in our opinion, some interesting ideas for possible research. Two important aspects came forward during this research. On the one hand, further research on combining enrichment is recommended. This might include enhancing environmental enrichment by mixing it with other enrichment materials or combining environmental enrichment with cognitive enrichment. On the other hand, developing a platform for farmers and other stakeholders might narrow the knowledge gap between farmers and research and might directly provide them with new developments and advanced legislations concerning pig welfare.

Combining enrichments

According to some literature and interviews, combining different kinds of enrichment, not only environmental enrichment but also cognitive enrichment, seems to improve the welfare status of pigs regarding enrichment even more.

Enhancing the environmental enrichment:

As it is known, pigs like to root and search for their feed, even when it is provided in a feeding trough, because of their intrinsic need to forage. So, a way to enhance environmental enrichment is by floor feeding. This effect is especially intensified when the pigs are already provided with substrates on the floor. Then, pigs really have to root for their feed, what can be rewarding. Another way to give the

provided enrichment extra input, is by announcing the supply of the materials, and this announcement strategy might even be further adapted until pigs are conditioned to associate music or sounds with enrichment. Therefore, we advise further experimentation on combining environmental enrichments, announcing the given enrichment and/or conditioning the pigs with e.g. music. A possible experiment could be on how feed is provided. As in most pig husbandry systems it currently might not be feasible to introduce floor feeding, the feeding troughs could be adjusted so that it is harder for the pigs to get their feed. If, in some ways, pigs have to root or explore for their feed in the trough, maybe with use of chains, it is more of a challenge for them and it might keep them occupied longer. However, the number of feeding places should be taken into consideration in these kinds of experiments.

Cognitive enrichment:

We advise to further research the possibilities of cognitive enrichment, such as creating interactive games that could reach a high level of distraction and play behavior. Pig Chase (Alfrink et al., 2012) seems to be a great example when it comes to providing cognitive challenges, but, we advise to look for cognitive games that are easier and less costly to implement. As confirmed by the literature and interviews, interactive games can enhance pigs' welfare. Computerized ways of delivering enrichment can also provide the opportunity for farmers and inspection agencies to keep track of the actual usage of the enrichment and that way prove its sufficiency.

An example could be to implement a combination of camera surveillance (that can also be used as backup proof that can show the daily conditions of the farm for when the NVWA is not content with the situation) and an application tracking the play behavior of the pigs. It could be interesting to see when certain playing materials can be developed, that somehow detect whether they are being used. An application linked to the detection material could then show to what extent and how frequently the playing material is being used. Since it will be difficult to track if the playing material is being used by different pigs, camera surveillance could provide that extra information. If the detection of the play behavior and the camera surveillance can be combined in one application, this would provide a valuable platform.

Information platform

The newly found indicators for Article 2.5, §4, are generally well received by the stakeholders involved, such as scientists, farmers and inspection agencies. Although, the conducted interviews reflected that the communication between all the different stakeholders is insufficient. Therefore, we believe this should be improved. We advise to set up an information platform to exchange information about new scientific developments and, advanced regulations. With this platform, scientists can share their latest research results on enrichment and pig welfare. Thereby, farmers can gain knowledge on improving the welfare of pigs and can consult scientists or inspectors about practical issues. Inspection agencies such as NVWA can introduce new regulations and policies related to pig farms, for example newly found indicators. In our report, POV is also considered as an important stakeholder, so organizations like POV could be a facilitator of this platform, who can reach the inspection agencies and scientists easily, but who also understand the farmer's point of view.

From our point of view, it is advisable to create an online platform where new information is easily exchanged and updated. Next to a static web page with the latest information, a forum can be provided

where stakeholders can discuss and ask for advice. Since most farmers have a smartphone nowadays it might be convenient to develop a mobile application in addition to the web page. As a supplement, an annual conference could be organized, whereby stakeholders can exchange their experiences and learn from each other, meet key representatives of the pig industry and attend presentations regarding the newest developments.

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Appendix A

Appendix A1: Interview Questions

Conventional Pig farm:

-Open norm 2.22

- We were wondering what you think about play behavior in pigs and how you can provide the material for this at your farm.
- Could you give an indicator on the pigs' welfare/health concerning enrichment?
 - What if there are no boundaries regarding costs/labour?
- Do you experience problems regarding boredom and tail biting at your farm?
 - What do you see as 'boredom'? How do you recognize it?
- Do you already have some guidelines to prevent boredom and tail biting?
- Would you like to have more guidelines to improve the welfare of the pigs when it comes to enrichment?
- Do you get inspiration/tips from other farm(er)s? Do you think what they did is feasible for your farm?

- What do you think is needed to maintain the open norm (article 2.22)?
- What would you do if the law gets stricter, for example when straw gets mandatory?
- What is your vision on changing this law?
 - Do you think it is ok like it is now?
 - What do you think will happen in the future regarding enrichment?
 - Which kind of indicators would you be willing to accept, and which definitely not?
 - Which changes would you like to see?

-Air quality

- What is your experience with the concretized open norm of the air quality?
 - Are you able to maintain the criteria?
 - If not, what do you need to maintain them? Are some indicators not feasible? How would they get feasible?

- What do you think of the communication with NVWA?
 - How often does the NVWA visit your farm?
 - What did they check?
 - Did the NVWA contact you about this?
 - Did you get sufficient information on how to maintain the criteria?
 - Would you like to get more information/help/education from NVWA?
- What would be your main advice to NVWA when it comes to concretizing the new open norm, looking back at the air quality open norm.

Scientists: Inonge Reimert and Liesbeth Bolhuis

- What, according to you, is play behavior/exploration and enrichment?
- Why do you think play behavior/exploration is so important?
- What are the basic requirements for pigs to exhibit their natural behavior? (play/explore)
- What do you think are the most optimal playing materials (enrichment)?
 - How much do you think should be provided?
 - And if possible, which combinations of different kinds of enrichment would be better?
 - Do you think there are different needs for weaners and fattening pigs?

- Minimal spacing that is required per pig is stated in the law:
 - < 15 kg: 0.2 m²
 - 15 – 30: 0.3 m²
 - 30 – 50: 0.5 m²

- 50 – 85: 0.65 m²
 - 85 – 110: 0.8 m²
 - > 110 kg: 1.0 m²
- Do you think the minimum space pigs need to exhibit their natural behavior is enough? (Do you think the minimum space requirement is enough to perform play behavior/explore? (knowledge gap?))
 - Or would you advice more space?
 - How much more do you think is better?
 - Which behavior is probably limited the most by the (limited) spacing?
- What are the consequences for pigs when they cannot exhibit their natural behavior?
 - Do you think a farmer is able to see the problems regarding play/exploration behavior?
 - Or could it be that farmers have a lack of knowledge in enrichment?
 - Are you aware of this open norm regarding enrichment and play behavior?
 - Do you agree that this open norm should be concretized with more strict legislations?
 - What do you think is needed to concretize this open norm?
 - Do you think it is possible to come up with similar kinds of indicators that could be used in the protocol to concretize the open norm about enrichment?
 - What is your image of the NVWA?
 - How do you think they currently check the enrichment in pig farms?
 - What indicators could be useful for the NVWA to inspect farms?
 - New EU indicators: do you know about the new indicators of the EC for enrichment?: <https://varkens.nl/verrijkingmateriaal-boordelen-varkenshouderij-september/> and indicators: <https://www.lne.be/beoordeling-van-het-verrijkingmateriaal-voor-varkens>
 - Are these indicators feasible?
 - Can it maybe even more concrete?
 - Do you think this will give problems?

NVWA: René Gosselink

- How does an inspection in pig husbandry work?
- Do open norms make the inspections harder? If yes, how?
- Would it be useful if the open norms become more concrete? If yes, how?

-open norm 2.22

- How do you inspect Article 2.22 currently?
- What is now sufficient during an inspection considering enough enrichment?
- How do you check if the enrichment does not harm the pigs?
- What is currently seen sufficient regarding an other suitable enrichment?
- What do you need to concretize this open norm?
 - What do you need to check this norm in a better way?
 - Where do you think are the pitfalls that make it hard to maintain this open norm?

-Air quality

- Do the new indicators for Article 2.5, §4, make it inspections easier? If yes, how?
- How do farmers react on these inspections?
- Do you think making use of indicators is enough of do you think it is better to give advice/guidance?

-communication

- How is the communication regarding new guidelines (for example air quality)?
- Do you see changes in the way of inspecting?
 - Do the indicators make it easier?
 - Do the indicators create problems with the farmers?

- What happens when a farmer does not meet the requirements?
- Did you have problems with farmers before?
 - Did farmers know what to do?
 - Did they ignore the guidelines?
- What is the attitude of farmers regarding new guidelines?

-New EU indicators

- Do you know about the new indicators of the EC for enrichment?:
<https://varkens.nl/verrijkingmateriaal-boordelen-varkenshouderij-september/> and indicators:
<https://www.lne.be/beoordeling-van-het-verrijkingmateriaal-voor-varkens>
 - Is this also being introduced in the Netherlands?
 - Are these indicators feasible for you?
 - Can it maybe even more concrete?
 - Do you think this will give problems?

Organic farm Van Leeuwen:

Introduce project

- *What is the difference between organic and a conventional pig husbandry?*
- *Does the NVWA inspect your farm and do they also check the open norms?*
- *If yes,*
 - *How does this work?*
 - *Did you ever have conflicts?*
 - *Do you like the workstyle of the NVWA? Or do you think they can improve, if yes, How?*
 - *How is the communication with the NVWA?*
- *If not,*
 - *Which organisations inspect your farm?*
 - *What do they check?*
- *How do you provide your pigs in their play/exploratory behavior? And why do you think this is important?*
- *What is your view on providing enrichments to improve play/exploratory behavior of pigs?*
- *Do you have tips for the conventional pig farm considering keeping the pigs 'happy' and what do you think needs to change in the conventional systems?*
- *How do you keep your hygiene optimal since the pigs have access to mud pools?*
- *How do you think the NVWA should approach the inspection of the open norms at conventional farms?*
- *Do you have advice for conventional farmers considering enrichment and play material?*
- *Do you have problems with tail biting? And how do you try to prevent that?*
- *Do you think it is necessary to concretize this open norm and what do you think will happen after concretizing?*

-Air quality

- *Do you know about the concretized open norm about air quality?*
 - *If not, give information → indicators*
- *Do you think such indicators are feasible for enrichment?*
 - *If yes, which indicators?*
- *Do you think it is useful to concretize these open norms? Or do you think education/communication is lacking?*

IKB:

- What is/does IKB?
- Do you know about the open norms in the Dutch Animal Act?
 - How do you check enrichment?
 - Do open norms make inspections difficult?
 - Would it be better if the open norms are concretized?
 - What do you need to check these open norms in a better way?

- Have you heard about the new guidelines of the EC for enrichments?:
<https://varkens.nl/verrijkingmateriaal-boordelen-varkenshouderij-september/> and indicators:
<https://www.lne.be/beoordeling-van-het-verrijkingmateriaal-voor-varkens> Is this feasible for you?
 Can it maybe even more concrete? Or do you think this will give problems?
- What do you consider enough enrichment?
- What would you like to see different considering enrichment in pig barns?
- Do you know about concretized open norm 2.5?
 Do you check these indicators?
 Are these indicators useful for you?

POV:

- Are you satisfied with the current enrichment that is used in pig husbandry? Or do you see improvement?
- Do you think it is useful to the sector when the open norm gets more concrete?
- Do you expect resistance from the sector?
- Do you think a lot needs to change regarding enrichment?
- Which changes would you like to see?

-Communication with NVWA

- What do you think of the NVWA? What do you hear about the NVWA from the sector?
- Are farmers satisfied with the communication with the NVWA? If not, what could be improved?

-Air quality

- Is it easier for farmers to adhere to the open norm since these indicators are introduced?
- Is it feasible for farmers to meet these indicators?
- Was it useful to concretize this open norm?
- What are the reactions on the communication with the NVWA regarding these indicators?
- Would farmers like more information/help/education from the NVWA?
- Do you think the NVWA should do things differently when concretizing an open norm?

- New guidelines EU

- Have you heard about the new guidelines from the EC regarding enrichment? See article:
<https://varkens.nl/verrijkingmateriaal-boordelen-varkenshouderij-september/> and indicators:
<https://www.lne.be/beoordeling-van-het-verrijkingmateriaal-voor-varkens>
 - Do you think this will also be introduced in the Netherlands?
 - Are these indicators useful to you?
 - Can it maybe even more concrete?
 - Do you see problems when these guidelines are introduced?

Appendix A2: Signed consent forms and validation of the summaries

Agreements upon the summaries in chapter 'Results' were given by email to Myra Ekkelboom, these are available upon request. Not all interviewees were able to sign the consent form. The organic pig farmer Van Leeuwen, IKB and POV did not sign. Van Leeuwen could not read the consent form as it was in English, and IKB and POV were interviewed via telephone.

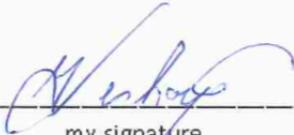
John Verhoijzen (Conventional pig farm):

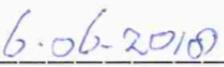
Interview consent form

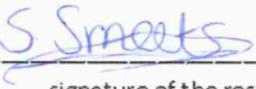
Research project title:
Play behavior and environmental enrichment in pigs: *Concretizing open norm Article 2.22, paragraph 1 from The Animal Keepers Decree to improve pig welfare*

I volunteer to participate in the above-mentioned research project. I agree to being interviewed and how the summary of the interview will be used. I understand and approve of the following:

- ✓ The interview will be recorded and a transcript will be produced that will be checked by the interviewee before being used in the report; its actual recording will be destroyed at the end of our research project (06-07-2018)
- ✓ The interviewee will be identified by name in the final report of this research project
- ✓ Direct quotations from the interview will be used in the final report after being reviewed and agreed upon by the interviewee
- ✓ The transcript of the interview will only be used for this project and the overall project of our commissioner 'The Science Shop' of Wageningen University and will not be given to any third parties
- ✓ The interview will be conducted on a voluntarily basis and the interviewee is aware he or she can stop the interview at any time
- ✓ I have been given a copy of this consent form


_____ my signature


_____ date


_____ signature of the researcher


_____ date

This research has been reviewed and approved by Wageningen University. If you have any further questions or concerns about this study, please contact our secretary: Myra Ekkelboom
Tel: 0651258694
E-mail: myra.ekkelboom@wur.nl

Liesbeth Bolhuis (WUR scientist):

Interview consent form

Research project title:

Play behavior and environmental enrichment in pigs: *Concretizing open norm Article 2.22, paragraph 1 from The Animal Keepers Decree to improve pig welfare*

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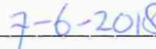
my signature



date



signature of the researcher



date

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Tel: 0651258694

E-mail: myra.ekkelboom@wur.nl

Inonge Reimert (WUR scientist:

Interview consent form

Research project title:

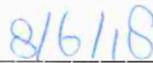
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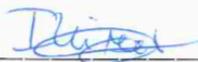
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- ✓ I have been given a copy of this consent form



my signature



date



signature of the researcher



date

This research has been reviewed and approved by Wageningen University. If you have any further questions or concerns about this study, please contact our secretary: Myra Ekkelboom

Tel: 0651258694

E-mail: myra.ekkelboom@wur.nl

René Gosselink (NVWA):

Interview consent form

Research project title:

Play behavior and environmental enrichment in pigs: *Concretizing open norm Article 2.22, paragraph 1 from The Animal Keepers Decree to improve pig welfare*

I volunteer to participate in the above-mentioned research project. I agree to being interviewed and how the summary of the interview will be used. I understand and approve of the following:

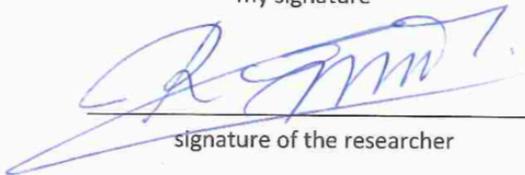
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my signature



date



signature of the researcher



date

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