Exploration of animal-based parameters (activity level and respiratory health status) collected by sensors to monitor pig welfare on farm

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Abstract

Using sensor technology to support monitoring the environment and animal welfare on farm is becoming a common practice. An EU-funded project, ClearFarm, aims to use the data collected by PLF (Precision Livestock Farming) sensors to build an algorithm to assess animal welfare continuously across the value chain, with the focus on pig and dairy cattle farming. To achieve this, parameters collected by PLF sensors should first be contrasted with reference indicators reflecting the welfare status of the animals. The objective of the present study was to investigate the potential of animal-based parameters (in pigs) measured by PLF sensors, by contrasting them against aggression-related lesions and physiological biomarkers. The study was conducted in two Spanish commercial pig farms, one nursery farm and one fattening farm. Two commercial PLF sensors were used on both farms: Peek Analytics (Copeeks SAS, France) and SoundTalks (SoundTalks NV, Belgium). Peek Analytics collected environmental (temperature, humidity, NH_3, and CO_2) and animal-based data (activity level and number of active/inactive animals). SoundTalks collected environmental (temperature) and animal-based data index on respiratory health (ReHS: respiratory health status). Activity level was calculated by tracking the movement of each pig per unit of time. ReHS is a score from 0 to 100: <40 indicates high risk of respiratory health problems; 40-60 indicates potential respiratory health problems; and >60 indicates healthy animals. Sixty males and females (30+30) of each farm were randomly selected for skin lesion scoring (ear, head to fore legs, and trunk) and saliva sampling. There were two sampling points (beginning and end of the stage) in the nursery farm, and three (beginning, middle, and end of the stage) in the fattening farm. Stress- (cortisol, sAA: salivary α-amylase, BChE: butyrylcholinesterase, and oxytocin), inflammatory- (Hp: haptoglobin), and immune system-related biomarkers (ADA: adenosine deaminase) were analysed from the saliva samples. Preliminary results showed that when temperature increased, and humidity or NH_3 decreased, pigs increased their activity ($P<0.05$). On the other hand, ReHS was higher when humidity decreased, or when CO_2 increased ($P<0.05$). The increase of activity was linked to the increase of ear lesion counts ($P<0.05$), total lesion counts ($P<0.07$), Hp ($P<0.05$) and BChE ($P<0.05$), and the decrease of oxytocin ($P<0.05$). ReHS was positively associated with Hp ($P<0.05$) and sAA ($P=0.06$). Overall, the change of activity or ReHS may reflect the change of the environmental conditions, which can affect the aggression level and the physiological status of the pigs. In conclusion, continuously recording animal-based parameters collected by PLF sensors, such as activity level and ReHS, may be useful to monitor

animal welfare. Nonetheless, exploring more relevant animal-based parameters by sensor technology, especially covering parameters reflecting other welfare domains, will provide a better picture of the real-time welfare status of the animals.

Keywords: activity, animal welfare, pig, Precision Livestock Farming, respiratory health, salivary biomarker, sensor.

Introduction

An increasing herd size with minimum labour input has become common lately in the last few decades in modern livestock farming. Exploiting sensor technology together with artificial intelligence may facilitate producers for rapid decision-making to optimize herd management in an objective way. To replace in-person animal welfare assessment, which is time- and labour-consuming, an EU-funded project, ClearFarm, aims to build a platform to monitor animal welfare in real-time and continuously along the production chain through sensor technology. The foundation of this project relies on the selection of relevant welfare parameters collected from the sensors, in order to be built in the platform algorithm. To achieve this goal, it is fundamental to first contrast these parameters with reference indicators which can reflect animal welfare status and are collected by humans. The objective of the present study is therefore to investigate the potential of animal-based parameters measured by the sensor, by contrasting them against two reference indicators, which are aggression-related skin lesions and salivary biomarkers.

Material and methods

Animals and housings

The study was conducted in two commercial pig farms in the Region of Murcia (Spain), one was a nursery farm and the other one was a fattening farm. Two pens of the nursery farm and four pens of the fattening farm were followed. There were 100 weaners in each nursery pen and 13 fatteners in each fattening pen. The nursery pen size was 2.5 m x 10.5 m, and the fattening pen size was 2.5 m x 4 m, providing the stocking density of 0.26 and 0.77 m^2/pig, respectively. Both farms raised commercial crossbred pigs, which were (Piétrain x Duroc) x Danbred in the nursery farm, and (Danbred x Duroc) x Danbred in the fattening farm. It was 100% of fully slatted floor in the nursery pen, and 50% of slatted and 50% of concrete floor in the fattening pen. The study period of the nursery farm was between 29/September and 22/November 2022, and that of the fattening farm was between 26/October 2022 and 12/January 2023.

Precision Livestock Farming (PLF) devices

Features of Peek Analytics and SoundTalks devices

Two commercial PLF devices were used in the study: Peek Analytics (Copeeks SAS, France) and SoundTalks (SoundTalks NV, Belgium). Peek Analytics was a multi-sensor device which consists of two main parts, the camera and the sensor. The camera measured the activity level of the animals and the number of active/inactive animals, calculated by a built-in algorithm, whereas the sensor monitored the environment of the pen, including temperature, humidity, and CO_2 and NH_3 concentrations. It was not possible to access the raw data and the algorithm to know how Peek Analytics calculated activity level for the confidentiality reason. However, the concept of it was to track the dots of each pig when the pig moves. As it did not monitor the distance and the speed of the movement, activity level did not have a unit and was provided with a numeric value (being the minimum value of 0). The sensor measured the environmental parameters every 2 minutes from 00:00 to 23:59, whereas the camera measured the animal-based parameters every 30 minutes from 07:00 to 22:00. Due to the darkness of the night-time, the camera could not measure the animal-based parameters. As for SoundTalks, it measured the temperature of the pen and a respiratory health status (ReHS) daily, which was a score also calculated by a built-in algorithm mainly based on the coughing sounds of the pigs. It was also not possible to access the exact parameters the algorithm collected and how it calculated the ReHS score due to confidentiality reason. ReHS score had three levels and was presented in two forms: the numeric value or colour scale value, in which 0-40 (colour red) indicated a 'high risk of respiratory health problems', 40-60 (colour yellow) a 'potential respiratory health problems', and 60-100 (colour green) 'animals are healthy'.

Installation of Peek Analytics and SoundTalks devices

Two Peek Analytics and two SoundTalks were used to monitor two nursery pens (n=200). Peek Analytics monitored the same two pens, with one installed at the front and the other at the back side of the pens, approximately 2.4 m height from the floor. SoundTalks were also installed in a similar way, with one at the front and the other at the back side of the pens, approximately 1.8 m height from the floor. On the other hand, two Peek Analytics and one SoundTalks were used to monitored four fattening pens (n=52). Each Peek Analytics monitored two pens (2.5 m height) and the SoundTalks was installed in the middle of these four fattening pens (2 m height). The views taken by Peek Analytics are shown in Figure 1.

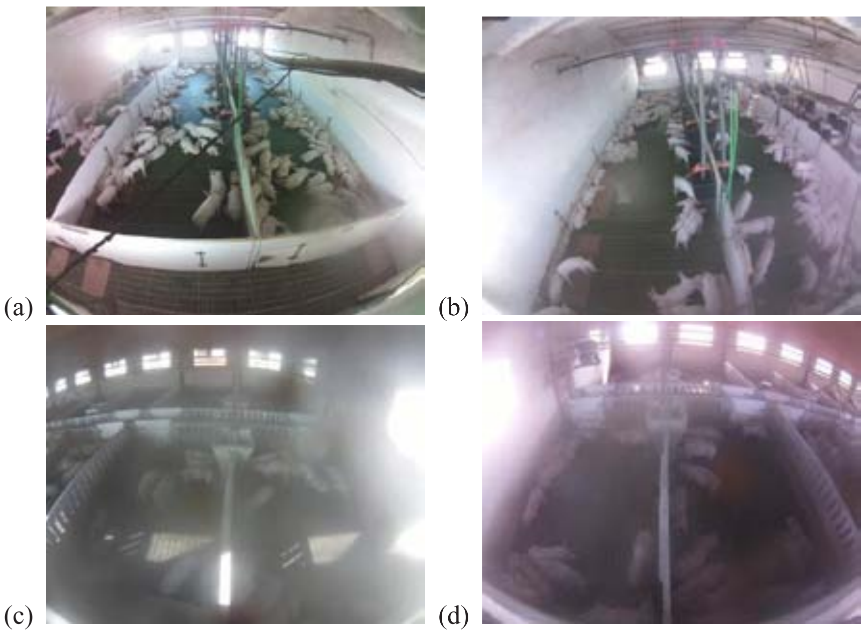

Figure 1. Pen views captured by Peek Analytics in the nursery pens (a) and (b) (at 15:01 on 28/October 2022) and in the fattening pens (c) and (d) (at 15:01 on 29/October 2022 during the study trials.

Reference indicators: Salivary sampling and skin lesion assessment

Accumulation of skin lesions and salivary biomarkers were selected to be the reference welfare indicators for this study. Accumulation of skin lesions can be an indicator of aggression at group level in pigs (Turner *et al.*, 2006) and salivary biomarkers are suggested to adequately reflect the physiological status of a pig (Cerón *et al.*, 2022). A subgroup of pigs was selected for saliva sampling and skin lesion assessment: 60 weaners (30 males and 30 females) and 60 fatteners (30 males and 30 females). Aggression-related skin lesions were counted when the lesions were fresh, red, and linear (Turner *et al.*, 2006). The body of a pig was divided into six parts: ear, head to fore legs, and trunk, of left and right sides. As for saliva sampling, there were two sampling points in the nursery farm (i.e., the beginning and the end of the nursery stage) and three in the fattening farm (i.e., the beginning, the middle, and the end of the fattening stage). Stress (i.e., cortisol, sAA: salivary α-amylase, BChE: butyrylcholinesterase, and oxytocin), inflammatory (i.e., Hp: haptoglobin), and immune function (i.e., ADA: adenosine deaminase) biomarkers were analysed from the saliva samples, following the procedures of sampling and determination of these biomarkers mentioned in Ortín-Bustillo *et al.* (2022).

Statistical analysis

Statistical analysis was performed in RStudio ver 2023.03.1+386. Pearson correlation tests were conducted: environmental parameters of the PLF devices (i.e., temperature, humidity, CO2, and NH3) vs. animal-based parameters of the PLF devices (i.e., activity level, number of active/inactive animals, and ReHS score). Additionally, generalized linear models were conducted, having animal-based parameters/skin lesions/salivary biomarkers as response variable, date, sex, and environmental parameters as fixed factors. Statistical significance was set at $P \leq 0.05$, whereas the tendency was considered when $0.05 < P \leq 0.10$.

Results

The preliminary results of the correlation tests between the environmental parameters and animal-based parameters are presented in Table 1. Activity level and number of active animals followed similar correlations with the environmental parameters. When temperature increased, the activity of the animals increased (P<0.05), whereas when humidity and NH_3 increased, the activity of the animals decreased (P<0.05). On the other hand, when temperature increased, ReHS decreased (P<0.05), and when CO_2 and NH_3 increased, ReHS increased (P<0.05). In general, temperature showed a

Table 1. Pearson's correlation coefficients (r) between the environmental parameter and animal-based parameter collected by the PLF devices (Peek Analytics and SoundTalks) in the nursery and fattening pigs. The correlation coefficients with no specified P-values indicate P<0.05. The correlation coefficients that are not available indicate the insignificant results.

	Temperature	Humidity	CO_2	NH_3
Activity level	0.52	-0.30	-0.20 (P=0.06)	-0.39
Number of active animals	0.52	-0.32	-0.18 (P=0.08)	-0.24
Number of inactive animals	0.21	-0.36	-	-0.33
ReHS[1]	-0.50	-	0.44	0.22

[1] ReHS: Respiratory health status.

rather stronger correlation with the animal-based parameters (especially activity level, number of active animals, and ReHS), compared to other environmental parameters.

In terms of the association of skin lesion counts and salivary biomarkers with the parameters collected by PLF devices, the increase of activity was linked to the increase of ear lesion counts (P=0.02), total lesion counts (P=0.08), Hp (P<0.01) and BChE (P<0.01), and the decrease of oxytocin (P<0.01). On the other hand, ReHS was positively associated with Hp (P<0.01) and sAA (P=0.06).

Discussion and Conclusion

In the present study, activity level of pigs increased when the environmental condition was better (i.e., higher temperature, and lower humidity and CO_2 concentration in this case). On the other hand, the ReHS score was higher (i.e., healthier pigs in terms of respiratory) during lower humidity but higher concentration of CO_2 and NH_3. Positive correlations between activity level with skin lesion counts and some salivary biomarkers may indicate that a higher activity level can be interpreted as higher agonistic interactions within the group, which therefore caused higher aggression-related skin lesion counts, higher concentrations of biomarkers related to inflammation (i.e., Hp) and stress in pain or discomfort (i.e., BChE), lower concentration of biomarker related to positive emotions (i.e., oxytocin) (Cerón *et al*., 2022). In addition, a higher ReHS score was found to correlate with higher concentrations of biomarkers related to stress (i.e., sAA) and inflammation (i.e., Hp). However, a higher level of sAA was known to be associated with the activation autonomous nervous system (Cerón *et al*., 2022), which is the system that also regulates the respiratory system, and this may be the reason for this positive correlation between ReHS and sAA. A deeper look on the data for each parameter and their associations are needed and are the current work of this project. To conclude, the change of the animal-based parameters collected from PLF sensors, such as activity level and ReHS score, may reflect the change of the environment, which can affect the aggression level and the physiological status of the pigs. There is potential to use these two animal-based parameters as an animal welfare indicator for continuous monitoring, but further confirmation and validation such as using farm or veterinary records as a ‘ground truth’ for another reference is necessary.

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