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Using Evolutionary Operation technique to evaluate different management initiatives at herd level

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ABSTRACT

The purpose of this project was to exemplify the use of Evolutionary Operation (EVOP) technique at herd level to test the effect of change in the herd's normal management procedure. As pigs are day active animals, it is assumed that an increase in the activity level during the night will indicate that the pigs are forced to change their normal diurnal rhythm to adapt to the conditions. Thus change in the diurnal pattern of drinking was used as a potential indicator of stress/resource limitations in the pen. A three way factorial experiment with 714 crossbred pigs (34.3 ± 4.1 kg) was carried out. The variables were: stocking density (14 or 18 pigs per pen), number of straw allocations (one allocation of 140 g straw per pig/day or four daily allocations of 35 g straw per pig) and allocation of pigs to pens (randomly or by size). The pigs were fed a libitum. Water consumption and temperature at pen level were continually measured during the experimental period (29 days). The day was divided into two 12-h periods: "day" (from 0700 h to 1859 h) and "night" (from 1900 h to 0659 h), and the proportion of the water consumption during the night of the total water consumption was calculated at pen level. Data were analysed using a linear mixed effect model. The average daily water consumption was 4.52 ± 0.24 l per pig per day. On average, 26.0% of the total amount of water was consumed during the night. An increasing stocking density increased the proportion of water consumed during the night by 2.0 percentage points ($P=0.01$). A random distribution of the pigs instead of sorting them by size at pen level reduced the proportion of water consumed during the night by 2.3 percentage points ($P=0.03$), while no significant effect of the number of straw distributions ($P=0.36$) or interactions was found. Looking at the daily water consumption, no effect of stocking density ($P=0.32$), straw allocation ($P=0.85$) or sorting the pigs (Randomly versus sorted by size, $P=0.11$) was found. Groups with small pigs had a lower water intake compared with groups with large or randomly sorted pigs ($P<0.01$). The results show that the use of an EVOP design at herd level using change in the diurnal rhythm as response variable can be used to give a fast indication of the optimal combination of production factors within the herd.

1. Introduction

Nearly every existing industrial process has a potential for improving productivity. This potential arises not only from the inadequacies in the original design, but also from changes which can occur during the lifetime of a production unit (Hunter and Kittrell, 1966). Finding the optimal settings that give the desired response is of major concern, and it is well known that farmers try different management initiatives to solve problems or optimize the production at herd level. However, often more than one procedure on the farm is changed at the same time without a systematic plan, making it difficult to get an overview of the impact of the different procedures and possible interactions between them. Evolutionary Operation (EVOP) is a technique for the systematic experimentation with and improvement of an ongoing full-scale production without actually interrupting it (Box et al., 1978). EVOP uses a randomized controlled trial to solve a specific problem, normally by optimizing two or three parameters at a time. The methods are developed especially to seek/track the optimum when the process is already operating near this optimum as determined during prior (experimental) experimentation (Rutten et al., 2014). EVOP consists of introducing small, but well-chosen (designed), perturbations in the process to gain information about the direction in which the optimum is located. The changes are not large enough to interrupt production, but are significant enough to provide valuable local knowledge about what the optimal plant/herd procedures are (Box et al., 1978). Once the optimal direction is defined, a new series of small perturbations is performed at a location defined by this direction, and the procedure is then repeated until the stopping criterion is reached (Rutten et al., 2014).

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EVOP is used in other areas including biological processes, but has not, to our knowledge, been used in animal production. One of the challenges using EVOP at farm level is that, normally, the event in focus would be used as indicator of the impact of a changed procedure. The risk of this approach is that the event may easily be overlooked by the farmer or registered incorrectly or since the idea of EVOP is to introduce small changes that not interrupt the production, the change will not be large enough to affect the event itself. Besides that, only observing the event does not provide information about whether we are just below the threshold for an event to occur or moving away from the threshold. Therefore an early indicator of the underlying problem that finally may result in the event to occur and there can be collected automatically, is needed.

Behavioural and physiological responses are earlier and more sensitive indicators of adaptation to the environment than productivity (Meunier-Salaun et al., 1987). Pigs have a stable diurnal rhythm (Villagra et al., 2007), but the pattern changes when they are ill or affected by a stressor; for example, increased group size increases the proportion of feed visits at night (Nielsen et al., 1995), reduces the diurnal variation in feed visits (Hyun and Ellis, 2002), and increases the proportion of water consumed at the end of the day and at night (Andersen et al., 2014) as well pigs housed in intensive systems without straw spend more time standing during night hours compared with pigs housed in intensive systems with straw (Lyons et al., 1995).

As pigs are able to adapt to an environmental or social challenge by changing the diurnal rhythm, there is a risk of overlooking adjustments made by the animals to adapt to the condition when looking only at data averaged over 24 h (Nielsen et al., 1995, Andersen et al., 2014). As pigs are day active animals, it is assumed an increase in the activity level during the night will indicate that the pigs have been forced to change their normal diurnal rhythm to adapt to the conditions. Changes in the animals' diurnal rhythm will thus indicate whether changes in management routines have a positive or negative effect on the animals. It seems as if there is a relation between the diurnal rhythm of the pigs when it comes to drinking behaviour, eating behaviour and activity level (Villagra et al., 2007). Thus, besides describing changes in the drinking pattern as such, drinking behaviour can also be used as an indirect measure of changes in activity level in the pen (Aparna et al., 2014), which may precede serious events caused by stress such as tail biting (Ursinus et al., 2014).

In this paper, we exemplify the use of EVOP in a pig herd, using the diurnal pattern of drinking behaviour as a potential indicator of stress/resource limitations in the pen. It is expected, but not yet known, that changes in the diurnal drinking pattern can serve as an early indicator of stress that may eventually result in other serious production problems such as tail biting, aggression and diseases. Therefore, using EVOP to indicate production changes that have the potential to change the drinking pattern could eventually serve as a way to gradually steer the production in a direction with a low risk of e.g. tail biting.

The aim of this paper was to use an EVOP design in a herd to observe how three minor changes in management procedures affected the pigs' diurnal rhythm of water intake.

2. Material and methods

2.1. Animals and housing

In all, 714 crossbred pigs (Landrace × Yorkshire × Duroc) were bought from one commercial Danish herd and transported to the experimental farm at the Department of Animal Science, Aarhus University, AU-FOULUM, Denmark. The experimental unit consists of one house with four identical rooms, equipped with 16 pens each. On arrival, the pigs were randomly distributed to groups of 32 pigs per pen and housed in one of the rooms. A week after arrival, each pen was divided into one group of 14 and one group of 18 pigs, which were moved to two neighbouring pens in one of the three rooms used for the experiment. All the pens in each experimental room were filled at the same time. One pen in each room was left empty due to practical reasons. To calculate the daily weight gain, the pigs were individually weighed at the start (34.3 ± 4.1 kg) and at the end of the experimental period. Data were collected in May and June 2012 from the start of the experiment and the following 29 days.

The pens measured 5.48 m × 2.48 m of which 0.5 m^2 was occupied by a feeder. The floor was concrete and consisted of one third solid floor, one third drained floor and one third slatted floor. Each pen was equipped with two drinking bowls located over the slatted floor – one on either side of the pen – and a feeder with three feeding spaces located next to one of the drinking bowls and over the drained floor. Throughout the experimental period, the pigs were fed a commercial dry feed for growing/finishing pigs for ad libitum intake. The feed dispensers were filled automatically three times a day (at 03.00, 10.00 and 19.00 h). There was free access to water. The water consumption at pen level was continually measured during the experimental period by a flow metre (RS 257–149; RS Components A/S, Copenhagen, Denmark; flow range 0.25–6.5 l/min, ± 1.0%) attached to the supply of each drinking bowl. The flow metres were calibrated at the start of the experimental period. The water consumption was logged every second and transferred to a PC. Inflow of natural light through windows was blocked and the artificial light was turned on between 06:00 and 22:00 h. The indoor climate was regulated by negative pressure ventilation with the room temperature gradually decreasing from 21 °C, when the pigs were introduced to the pens, to 17 °C when the pigs approached slaughter weight. The temperature at pen level was continually measured during the experimental period by two temperature sensors (VE10A temperature sensor, VengSystem A/S, Roslev, Denmark; range −10 to 65 °C ± 1.25 °C) attached to the side wall of each pen 0.5 m above floor level (animal level).The first few days after insertion the measured pen temperature at animal level (mean ± SD) were 23.6 ± 0.5 °C. The temperature was gradually reduced over the following two weeks (according to the pigs' age), after which it reached a temperature level at 21.2 ± 0.7 °C. The measured pen temperature at animal level was higher than the set point temperature, due to the temperature sensor for the climate control was located ~2 m above floor level.

2.2. Experimental design

Since the idea with EVOP is to track the local production optimum on the particular farm, assuming the process is already operating near this optimum, the EVOP design was based on the herd's normal standard and compared with a setup where slight changes were made in specific operation conditions. One of the advantages of EVOP is it can be used for either quantitative or qualitative factors (Rutten et al., 2014). In general it is impractical to investigate the effect of more than three variables in an industrial process (Smart, 2003) as increasing the number of factors (k) will increase the number of measurements in each EVOP phase to 2^k (Rutten et al., 2014). To illustrate the first phase of the EVOP method a 2^3 factorial design with the following variables were chosen: stocking density, straw allocations and sorting of the pigs at insertion. The variables were selected based on previous experiments indicating that they had an impact on the animal's well-being. The factor step for the two quantitative factors was set to 4 for density and 3 for the straw allocations; the factor step