Geostatistical Techniques of Comparing Swine Noise Levels From an Automated Acquisition System.

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Abstract: With the evolution of research related with animal welfare and thermal comfort, studies comparing the animal response of the animal by a noise or vocalization, when exposed to intensive production environments are still scarce in the academic field. The methodologies described in the literature does not provide sufficient details that can be used in further studies of noise levels of animals in confined environment. Due to the lack of information from studies related to animal bioacoustics, the aim of this work is to analyze comparatively two methodologies for automatic collection of noise levels emitted by pigs in the nursery phase. The experiment was conducted in a 4.10 m wide and 9.8 m long nurse room , where a smooth wire mesh was installed dividing the carport in ten quarters identical to the installation of decibelimeters in the geometric centre of each quadrant. Daily data of noise temperature and humidity inside the room during the winter of 2007 were collected. Two provisions from decibelimeters were tested: 1st – Data collection with 10 equipments filling all the installed quarters and 2nd - Data collection with 5 equipments arranged in "zigzag" form, with the purpose of compare what is the most ideal for the collection of noise emitted by pig using the geostatistics analysis, to verify the existence of the spatial dependence among the collected points inside the room. It can be concluded by the joint descriptive analysis and kriging survey of the data that, the configuration 2, with 5 decibelimeters in zigzag form, was enough to feed the model prediction data for the entire room where animals are confined.

KEYWORDS: sound pressure, nursery pigs, decibelimeters, bioacoustics.

Introduction

For better evaluation of the animal production environment, studies have been performed with the aid of advanced technologies, non-invasive tools for assessment and control of animal welfare in confined environment. Among the various mechanisms for evaluation, emerge as innovative technology to identify behavior the records and noise studies emitted by a group of animals. The use of a data collection methodology for data noises becomes essential for an accurate analysis of the data.

The study of noise animals is characterized by the sounds emitted by a group of animals in the same environment and animal vocalization is being used by researchers in the field as an attempt to establish some standards of sounds emitted in order to characterize any situation, like cough that can identify some respiratory disease (Van Hirtum and Berckmans), behavior (Jensen and Algers, 1983; Weary et al., 1999), milk release (Illmann et al., 1999; Risi et al., 2007) and pain (Marx et al., 2003). All these works seek an animal answer with the purpose to use the animal like a "biosensor", using the own animal to control its environment, since feed until comfortable thermal sensations or not, may activate mechanisms by the level of noise or emission of vocalizations.

This study suggest a methodology for automatic collection of noise levels from animals that meets the needs to extract the animals noise, as a response to environmental conditions in which they are inserted. In this paper, it was proposed a comparative analysis of two designs of equipments to measure sound pressure in order to obtain information with regard to the best configuration to be adopted and to assure a right way to employ a right number of decibelimeters without compromising the quality of information to be acquired. This way, it has been two settings of decibelimeters placed in the confined animal's hall. The first configuration presents 5 decibelimeters distributed in "zigzag form" for the collection of noises; the second configuration contains 10 decibelimeters arranged in a symmetrical way across the room. The aim of this study is to compare the kriging maps submitted by the two settings and to check the equivalence or not of prediction of the data based on models suitable to the problem.

Material and Methods

A trial was carried through a commercial pig farm production (Granja Mamy) located in Monte Mor city, São Paulo State, Brazil; located at 22.33S and 47.11WGr and average altitude of 560 m, with the predominance of climate Cwa according to Köppen's classification.

During the period of 10 days, two methodologies were tested for the collection of piglets' noise levels, in order to verify the existence of a spatial dependence among the collection points from decibelimeters in a room of nurse carport. This carport room had its internal area split in 10 identical quarters from 2.05 m wide and 1.96 m in length and each decibelimeters was prepared in the geometric center of each quadrant with a minimum distance of 1 meter from any surfaces such as walls, ceiling and floors (ABNT, 2000).

Nursery house characteristics

The characteristics of the nursery rooms in tropical conditions in Brazil are:

- 9.80 meters length and 4.10 meters width measured internally;
- Eaves height of the installation: 4 meters in center of the installation;
- Roof wood structured and tiles of asbestos cement coverage (without lining);
- It has four 1m wide and 1m long metal windows;
- It has a 0.85 m wide and 2.10 m high metal door;
- Each room has four suspended stalls with height of 0.60 m from the floor of the room. The stall's floor is concrete with a part of slated floor of plastic material and has still a part of the floor with water slide across the length of the room;
- The stalls have dimensions of 3m width by 2.45m length;
- The separation of stalls with metal bars is 0.65 m high;
- Has a 1.10 m wide hallway for employee's movement through the entire length of the room;

The noise data were collected for a period of 20 days, with 10 days for each type of equipment arrangement. Two types of methodology have been described and implemented in accordance with the pre-defined sketches (Figure 1):

Installation of 10 decibelimeters inside a carport room (Configuration 1);

Installation of 5 decibelimeters in the same room in zigzag disposition (Configuration 2).

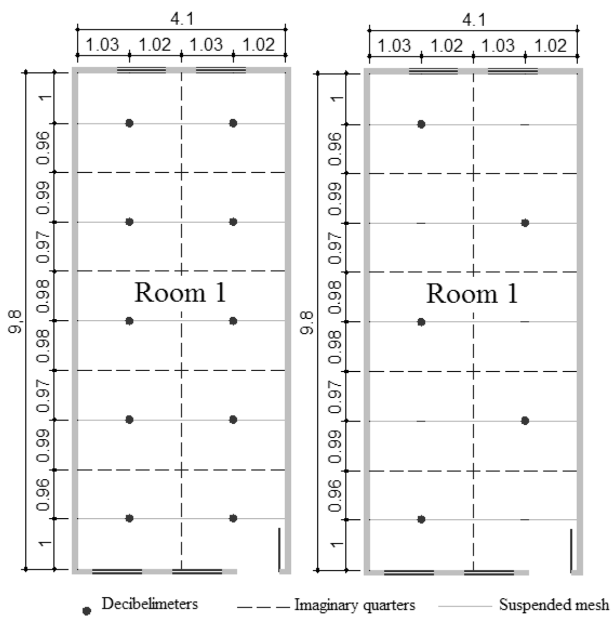

Figure 1. Layout of decibelimeters installed in nursery houses. Configurations 1 and 2 respectively.

Geostatistical analysis

A geostatistical survey was used for search information about the spatial dependence of the data resulting from the two settings of decibelimeters arranged in rooms. The data collected, or rather, the random attribute is the noise level in decibels (dB) stored inside the decibelimeters. Data were collected for 10 decibelimeters (Configuration 1) and subsequently by 5 decibelimeters (configuration 2). It is a punctual data collection of over time, in pre-established coordinated as shown in Figure 1.

The geostatistics models present, as reported by Diggle and Ribeiro (2006), a subjacent spatial process S(x) and response variable Yi where the random variable should be n-dimensional (Y_1... Y_n). It can be reported that S(x) represents the measures made by the random attribute Y (x), which in this particular case is the level of noise in each decibelimeters.

For the data analysis the statistical software R version 2.3.1 (R Development Core Team, 2006) and *geoR* package was used, enabling the data processing and adoption of techniques for geostatistical analysis. First, it was needed to transform data in geodata to make the reading by geoR. Thus, it was possible to know the data in the matrix that shows the x and y coordinates (*coords*) and the interest data (*data*). Edges of the R script were entered like measures of the room that was showed previously in Figure 1.

With the *summary* command it was possible to know the descriptive statistics of the set data. The semivariograms, as a descriptive resource for data analysis, can help in viewing data behavior and also their level of differences between the Euclidian's distances data from the command variog.

After all these steps, some models have been adjusted to the function of the semi variance by Log Likelihood method, which calculates the parameters in the Gaussian model by a estimated way, which are: Φ (1 / 3 of the variance with the curve from semivariogram stabilized), σ^2 (variance) and ζ^2 (noise variance), by the function likfit. Thus it is possible to verify the best model, which represents the presence of spatial dependence of the variables under study. The models were chosen as the data behavior, one very important step in working and responsible for analysis performance of geostatistics.

Finally, the data processing was performed using Kriging method that estimates an unknown value of the random variable and then makes a sampling of areas that have not submitted data collection, that are, the areas where there was decibelimeters in acquisition of data. The efficiency of this sampling is a consequence from the model selected in the previous step. Thus, it is possible to know the variance of predicted points and, through command *image*, build a map with colors gradient that correspond to the noise predictions generated by the chosen model which provides the spatial variation of analysis points.

Results and Discussion

The aim of this study was to compare two methods for noise levels collection of pigs confined in a nursery. Thus, the noise levels were collected and stored by decibelimeters during 10 days, for each configuration, and the data acquired every minute according to the maximum interval between each acquisition. After unloading the data were made daily noise averages obtained by each decibelimeters in each point of the two configurations.

The descriptive analysis generated graphics relating to trends presented in the two orientations, the points distribution in the installation and histogram for each of the configurations to mean noise of 10 consecutive days. Then, the graphs of points distribution were shown and also the histogram to verify the normality and skewness of the data. In the last graph, it was informed that there was no need for data standardization due to the value around 1 of sigma parameter. The graphs related to the noise data and coordinates room inform its trend in relation to the guidelines east-west and north-south, if they are necessary for adoption in the models presented below. The analysis of trend is not always conclusive, therefore should not be taken as the only trick for guidelines review. Curves of trend in the graphs were added to the data analysis during one day for each configuration in Figures 2 and 4, to facilitate the data viewing.

The histograms showed an initial trend for differences due of different pressures noise produced during the days, as local noise and sounds emitted by animals. The graphs present a pronounced skewness. However, the normality in all cases was not possible because the parameter (λ) lambda to be close to unity, so, the Box-Cox transformed was not applied.

The command *trend* was used for the models development and their co-variables. The models used for selection, for a prediction of the subsequent noise data in the nursery room were:

- Linear Model
- Model linear first-order, without effect of the east-west (trend = ~ coords [, 1])
- Model linear second order, without effect of north-south direction (trend = ~ coords [, 2])

The days showed the same pattern due to the same management in the farm throughout the days. The Figure 3 shows the histograms of 3 of 10 days on the configuration 1, showing in the X axis the noises levels end the Y showed the occurrence frequency.

The semivariogram referring to the last model, it presented greater stability of downward curve in order for all the days analyzed. This model may be a good choice to show spatial dependence. According Diggles & Ribeiro (2006), it is necessary use the log likelihood method to model adoption. The logL value for each model was calculated. The results for the Model 1, 2 and 3, to day 1, are respectively:

1.-8.48
2.-8.47
3.-6.20

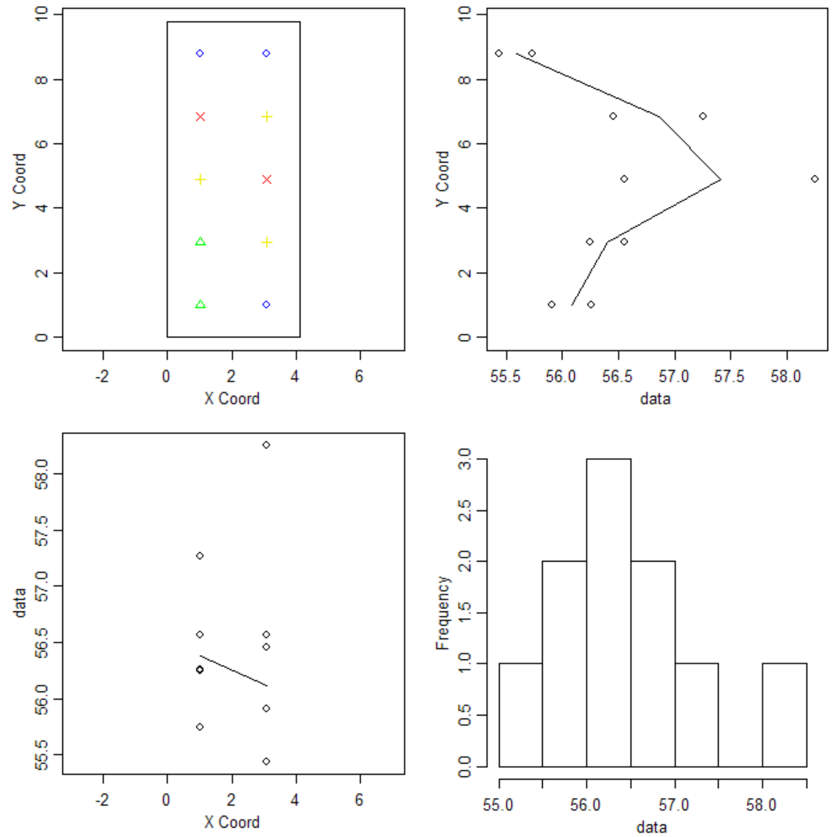

Figure 2. Graphic representation of one day: descriptive analysis of noise levels (data) inside the nursery room using the design 1.

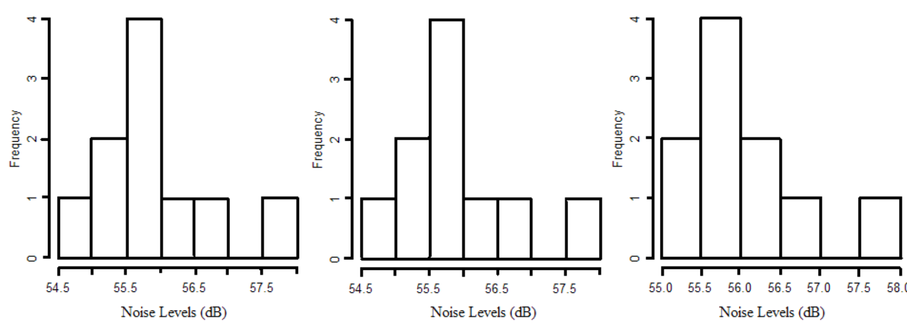

Figure 3. Histogram of 3 days of collection of noise levels using the configuration 1.

The Model 3 was chosen due to the fact that it presented the most value from logL. This model was applied to predict the data; the parameters found by R program were adopted. A point's grid is then provided for the data. The command *expand. grid* was used to limit the points to be sampled in the region where the decibelimeters.

The models used were the same and there was adoption of new parameters. The map below showed the kriging results (Figure 4). The gray scale has been adjusted to the noise values that reflect the different situations of sound pressure throughout the room. The minimum and maximum values of sound pressure remained between 55.86 and 56.55 dB.

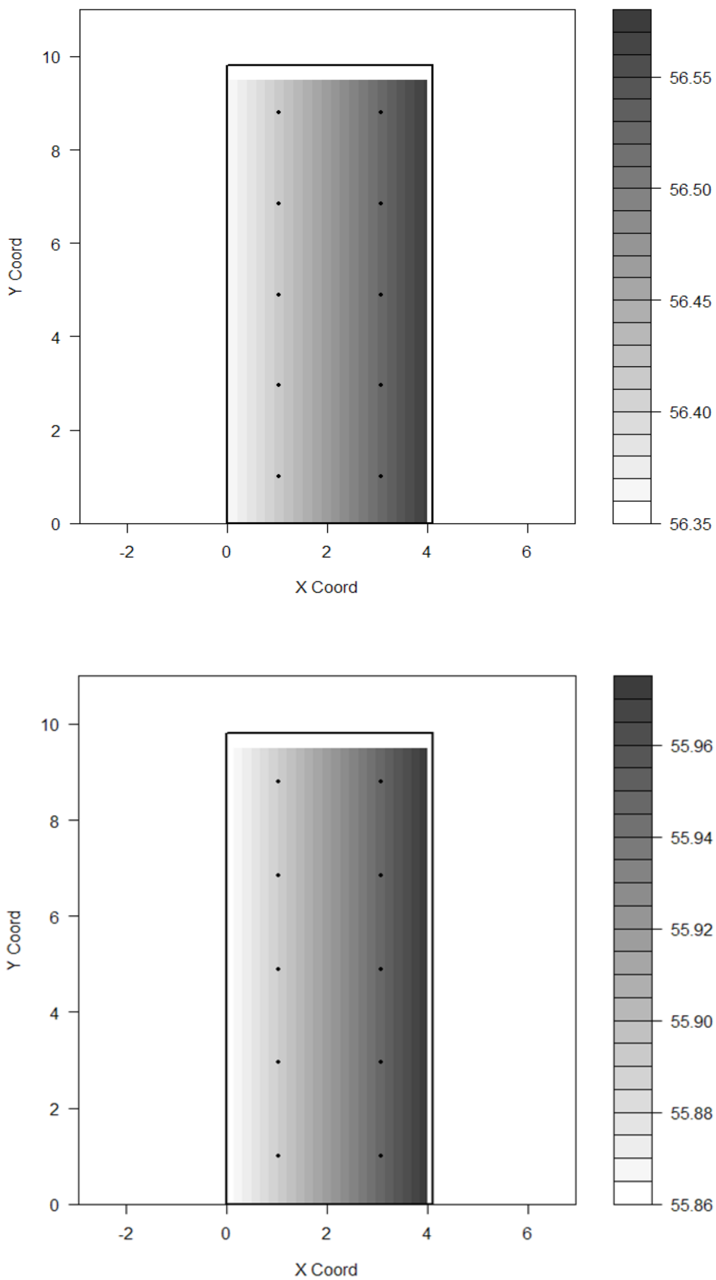

Figure 4. Kriging map generated from noise levels collected by decibelimeters in configuration 1.

During ten days it was observed a similar standards in the curve in X and Y axes, as shown in Figure 5, which represents one day of collecting data. This behavior was repeated throughout the 10 days of collection.

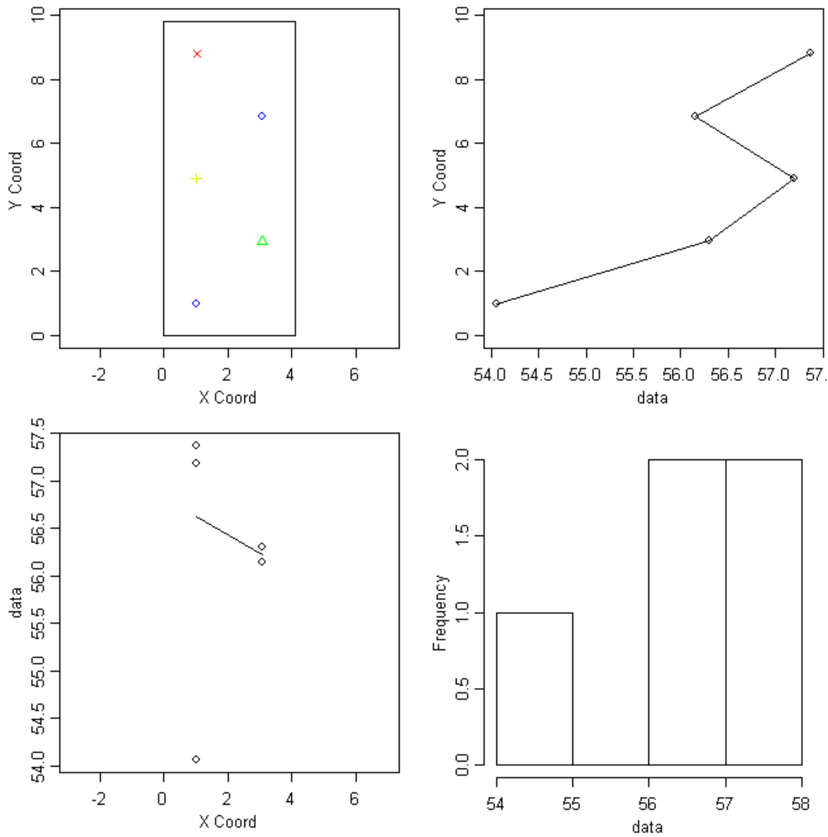

Figure 5. Graphic representation of one day: descriptive analysis of noise levels (data) inside the nursery room using the design 2.

It was presented the histograms of the nine consecutive days of collecting data for the configuration 2, as it was done for the analysis of the configuration of 10 decibelimeters. The histograms showed skewness for the configuration two, which was also explained by the different noises measured during the period, due random variables of interest for the study in question (Figure 5).

The data collected did not present normal distribution, thus the normalization was not possible as explained previously. The models used were the same and there was adoption of new parameters. Kriging maps are illustrated below, based on data predicted by the model adopted for 2 days of collection as shown in Figure 6. The minimum and maximum values of sound pressure remained between 54.20 and 56.15 dB.

The purpose of this study was to compare the kriging maps of two configurations and verify whether the predicted values for each ones were consistent. This hypothesis was confirmed and the patterns between the two equipment configurations in the rooms could admit the first one, in which only five decibelimeters was used. It will be important to reduce the number of equipments without harming the quality of the information. There are not significant differences in mean values of noise when there is a removal of these decibelimeters, due the same pattern of first configuration prediction.

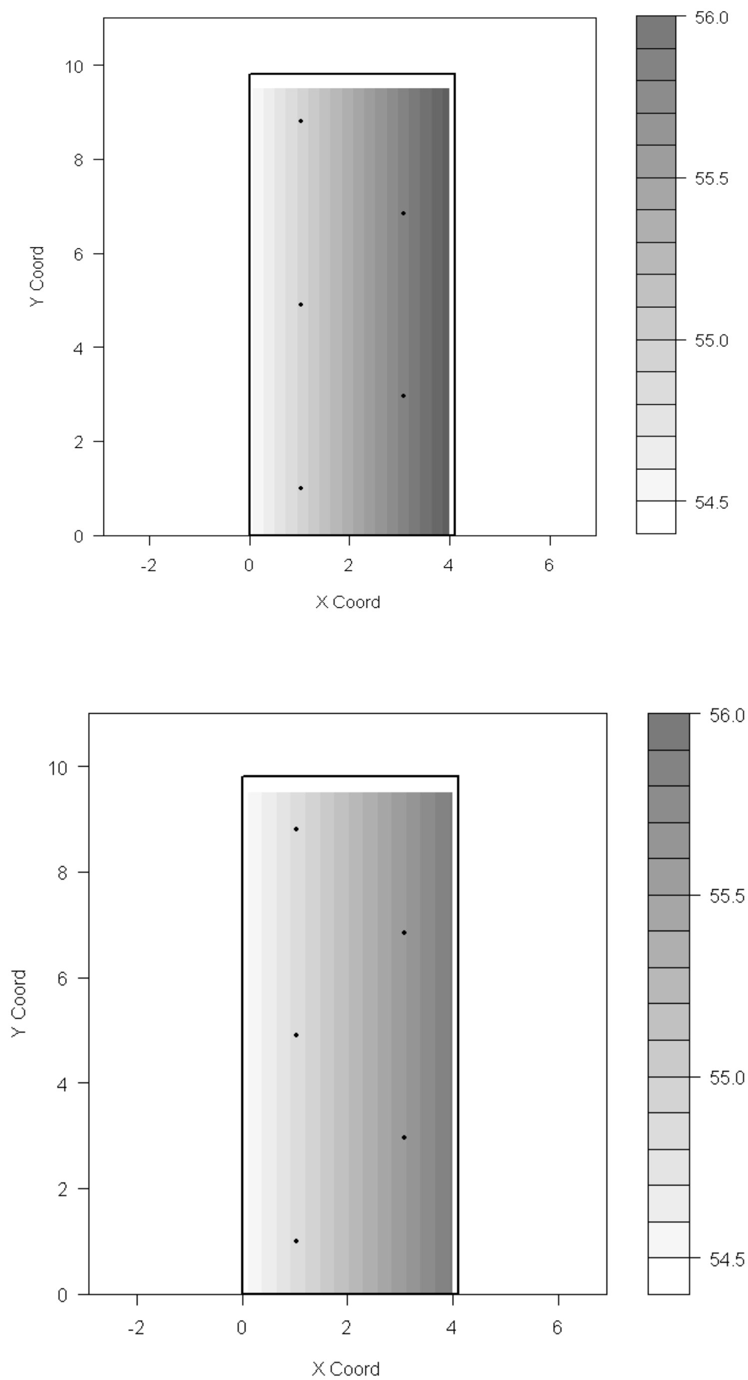

Figure 6. Kriging map generated from noise levels collected by decibelimeters in configuration 2.

Conclusions

The geostatistical technique is a method of spatial dependence analysis that shows to be informative. This experimental phase, better called pre-test, showed few data collection, however, which could work decisively to the conclusion mentioned above, was the number of repetition of this data over 10 days of analysis. The Kriging is an important way to illustrate the distribution patterns of the noise, but due to the experimental errors, this technique was not sufficient to complete the analysis, but a way to verify visually which equipments could have measurement problems. Once done, it was possible to analyze all equipment and check out the standards measurements. Although the experimental error overshadows the clarity of the analysis, it could be for the joint analysis of Kriging and descriptive analysis of the data, that the configuration 1, with 5 decibelimeters in zigzag, is sufficient to feed the model for prediction of data for the entire room where animals are confined.

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