Wilhelm Pflanz, Jürgen Beck and Thomas Jungbluth, Hohenheim, Josef Troxler, Wien, and Hansjörg Schrade, Stuttgart

Assessment of Innovative Pig Fattening Methods in a Field Study

Statistical Analysis of Behaviour Observations and Integument Ratings

In a field study on four innovative pig fattening systems, each was tested on ethological and process-engineering aspects in five stables per system. In this paper, the statistical test planning for behaviour observation, realisation and analysis, using a mixed effects model, will be presented. The effect of the husbandry system was significant for nearly all of the observed parameters.

Dipl.-Ing. sc. agr. Wilhelm Pflanz was a scientific co-worker, Dr. Jürgen Beck is a Senior Academic Councilor in the department of Livestock Systems Engineering, whose director is Prof. Dr. Thomas Jungbluth at the Institute of Agricultural Engineering, University of Hohenheim, Garbenstraße 9, D-70599 Stuttgart; e-mail: *pflanzwi@uni-hohenheim.de*
Prof. Dr. Josef Troxler is director of the Institute of Animal Husbandry and Animal Welfare at the Veterinary University, A-1210 Vienna, Austria
MR Hansjörg Schrade is head of the unit Animal Breeding, Animal Husbandry, Fishery and Immission Control in the Ministry of Nutrition and Rural Areas Baden-Württemberg, D-70029 Stuttgart.
The investigations had been funded by the Ministry of Nutrition and Rural Areas Baden-Württemberg.

Keywords

Pig-fattening, ethological assessment, integument scoring, mixed effects model

Literature

Literature references can be called up under LT 06218 via internet http://www.landwirtschaftsverlag.com/landtech/local/literatur.htm.

The aims and the composition of the research project for the integrated assessment of four innovative pig fattening systems have already been presented in detail in several publications [1, 2, 3]. On the basis of a broad field study containing 20 practical pig fattening farms reliable knowledge should be gained about animal welfare as well as about the economic ranking of the single systems.

On principle the results of field studies have to be regarded in contrast to laboratory investigations before the background of a multiplicity of not directly controllable influences. Nevertheless under the prerequisite of a good experimental planning and setup, it is possible to take disturbances (i.e. influences that cannot be standardized) as a covariable in a multifunctional analysis of variance into consideration [4]. For the statistical analysis of complex problem formulations in applied ethology especially Mixed-Effects-Models are well suited, as they represent hierarchical nested designs in a simple way and are able to consider repeated measurements [5].

Animals, Material and Methods

The experimental setup of the entire study, especially the ethological investigations, has been described in detail in Landtechnik [1, 3] and in the Agrartechnische Forschung [2]. The investigation included conventional fattening houses with slot-reduced lying areas, sloped floor fattening houses with minimum straw litter, open front stables with sleeping boxes, and stables with exercise yards and straw litter. While selecting the five single practical stables per system there has been great importance to the best possible standardization of housing criteria, within and between the systems. Every farm of the 20 has been investigated every quarter of a year; during the single seasons the systems as well as their stables had been observed one after the other in a randomised sequence following the distribution matrix of 4 • 5. The observations respectively the assessments always took place during two consecutive days to compensate the daily effects. On every farm visit four pens had been drawn randomly for observation (two per live mass range). Two pens were observed together during the morning and during the afternoon with a daily shift. For the integument score, 20% of the animals of four other pens (at least five pigs) got scored, they were selected randomly, too. Due to the fact that scoring was done in two weight ranges, it was a principle to never take animals twice for the investigation (independent replicates [6]). The investigation was done by five persons, who got allocated also by chance to single farm visits. To standardize the persons among them, several comparative tests were carried out in the years 2003/2004. The obtained mean correlation coefficients in the single behavioural observations were r = 0.89 and are comparable to values from literature in an elevated level [8]; the correlation coefficients of the integument scoring were in average r = 0.65.

Data Processing and statistical Data Evaluation

After in total 80 farm visits (each for two days), with 20 from each season, at the end of the investigation, after data reassessment resp. processing finally 9495 data sets of behavioural observations were available for evaluation. They got aggregated to in total 320 pen data sets. The observation method „Scan-sampling“, which has been used was based on the registration of a six minutes scan interval regarding a well defined ethogramme including all the animals of a pen. This means that always the number of animals was counted and registered, which showed the single behavioural patterns. This value was related to the total number of ani-

mals (percentage of shown behaviour). For the evaluation this meant that therefore always the pen was the statistical reference parameter (smallest investigation unit [4]). For the evaluation of the integument scores also data sets from 320 pens were available (in total 1820 sets of data); but here the single individuals of a pen had been scored. Therefore all the time the single individuals had been used as statistical reference parameter.

$$Y_{ijklmnop} = \mu + ZVi + BNUM_j + BB_K + BP_l + GB_m + (BNUM*BB)_{jk} + b(TZ_{ijklmn} - TZ) + b(Nfla_{ijklmno} - Nfla) + b(LB_{ijklmnop} - LB) + e_{ijklmnop}$$

with the following meaning:

$Y_{ijklmno}$	= observed value	(n = 1,...,10)
μ	= mean of all observations	
ZV_i	= fixed effect of the housing system i	(i = 1,...,4)
$BNUM_j$	= accidental effect of farm j	(j = 1,...,20)
BB_k	= fixed effect of season k	(k = 1,...,4)
BP_l	= accidental effect of observer l	(l = 1,...,5)
GB_m	= fixed effect of body mass range m	(m = 1,2)
$(BNUM•BB)_{jk}$	= accidental interaction farm • season	
$b(TZ_{ijklmn} - TZ)$	= Regression on an average number of animals per pen	
$b(Nflai_{jklmno} - Nfla)$	= Regression on an average net pen area per animal	
$b(LB_{ijklmnop} - LB)$	= Regression on an average lying area per animal	
$e_{ijklmnop}$	= residual error	

Fig.1: Mixed effects model with classification of effects

Results

After several steps to adapt the model, finally the following Mixed – Effects- Model (*Fig. 1*) was used with the „mixed models"-procedure of the SAS programme package [8] to evaluate the behavioural observations. With the help of this hierarchical multifactorial analysis of variance it was possible to consider the fixed effects (housing system, season, weight range) and the accidental effects (farm, investigator, interaction between farm • season) as well as the co-variables (number of animals per pen, net pen area per animal, size of lying area per animal. The residual error always includes the statistical reference parameter, which means in the adapted model for the behavioural data that this is the effect of the pen. The same model was used for the evaluation of the integument scores, it got only enlarged by the accidental effect of the pen, because there is integrated the effect of the single animal. The standardized residues of the analysis of variance got checked for Gaussian distribution. Parameters, whose residuals were not normally distributed, got transformed. The results of the single systems were presented with Least-Squares (LS-) means.

For all of the behavioural parameters and their results for the single systems presented hereafter, the effect „housing system„ had significant influence with the exception of the parameter „total lying". The season had a significant influence on all of the parameters of pen structuring and shown body position. The body mass range had a significant effect on the occupational behaviour. The net pen area per animal and the size of the lying area per animal had also significant influence on the parameter "lying aside in lying area". *Table 1* presents the Least-Squares (LS-) means of the occurrence of behavioural parameters in percent of the a.m. (9 to 11 o'clock) and p.m. (15 to 17 o'clock) observation period. Different letters show significant differences between the systems.

The results being published in a descriptive way in Landtechnik [3] are confirmed by the actual reassessed evaluation. Significant differences concerning the acceptance of the lying area have been testified between all systems. This area was with 82.07 % the most frequently used in the open front stable. On the other hand the dunging area was used for lying especially in the conventional stable (19.97 %) and in the sloped floor stable (18.54 % during the summer months). The parameter "Total Rooting" was observed particularly in systems with straw littering. In contrast the parameter „Occupation with Pen Elements and Toys" as well as the „negative" indicator "Occupation with Pen Mates" could be mainly observed in the housing systems without litter. The ethopathic parameters (tail and ear chewing, vacuous chewing, rail biting) were registered as declining from system one to four; in general the level was low.

Concerning the data of the integument score, the housing system in the entire model had a significant influence on the parameter "Body scratches". Here significant differences appeared between the conventional system and the three other systems; but again on a generally low level. Alterations of the tail had been significantly influenced by the net pen area per animal and by the dimension of the lying area per animal. The aggrandisements of circumference of the hind limbs appeared significantly more frequent with litterless systems compared to exercise stables with straw.

It has to be finally stated, that statistical significance is not always equivalent to ethological relevance [6]. Although differences could be testified between the systems, they varied apart from some few exceptions in a tolerable range. This results from the fact that in the study only systems got included, which had already been ethologically graded up and therefore a real comparative variant was missing.

Table 1: Occurrence of the behavioural criteria in % of the observing period

	Conventional Stables	Sloped Floor Stables	Open Front Stables	Exercise Stables	Significance in entire Model
Total Lying	75.43	78.64	74.79	73.23	n.s.
Lying in LB from total Lying	31.40[a]	43.94[a]	82.07[b]	62.64[c]	***
Lying aside from total Lying	10.94[a]	18.75[b]	14.18	16.51	*
Lying aside in LB from total Lying	2.76[a]	8.77[b]	13.57[c]	10.60[b]	**
Lying in KB from total Lying	19.97[a]	18.54[a]	4.51[b]	10.74	*
Total Rooting	7.46	9.12[a]	5.73[b]	8.34	*
Total Occupation	7.69[a]	4.57[b]	6.36[c]	3.93[b]	**
Occupation with Pen Mates	4.17[a]	2.92[b]	2.22[b]	2.29[b]	**
Occupation with Pen and Toys	3.55[a]	1.69[b]	4.20[a]	1.68[b]	**
Ethopathies	1.04[a]	0.44[b]	0.33[b]	0.17[b]	**

LB = Lying area, KB = Dunging area, ges. = total

Conclusion

The presented study shows that it was possible to obtain, after precise planning and carrying out of a field study, results that allow a critical biometric evaluation. Disturbance variables resp. varying environmental conditions got processed and were standardized to a large extent with the help of statistical methods.