Screening for ‘Frog Pond Effects’ in Hierarchically Structured Data

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Abstract

The socalled ‘frog pond effect’ is a term derived from the phenomenon observed when a frog living in a pond with small relatives is perceived as being larger than (the same) frog living in a pond with large relatives. That is, the size of the frog will appear to be dependent on the frog’s social context. The potential importance of the ‘frog pond effect’ is widely recognized in the social sciences. In the dairy industry there is an increasing use of Body Condition Scores (BCS) obtained by classifiers by means of visual or physical inspection of individual cattle. Such scoring may be prone to a frog pond effect bias. The objective of this study was to demonstrate an approach to assess whether a BCS in one herd is comparable to the same BCS in another herd. We did a study aiming at predicting the heart girth of heifers from BCS, hip height and hip width that were recorded by 8 local veterinarians in 18 herds on 604 heifers. The data were modelled by means of hierarchical mixed models (structure: veterinarian (classifier), herd and heifer). Inclusion of the within herd mean of the predictive variables into a model, thereby making these new variables herd level predictors, can indicate the existence of a frog pond effect. The herd mean of the BCS was highly significant statistically in contrast to the other better standardized measurements. Consequently, we conclude that some degree of relative judgement of the BCS occurred between herds within veterinarian.

Introduction

Body Condition Score (BCS) is found to be a valuable tool in monitoring herd conditions, e.g. feeding, growth and production. The BCS is recorded by physical and visual inspection of the individual and then scored on an ordinal scale in a range from 0 to 5 with increments of 0.25. BCS is in most analyses applied as a continuous variable. Both validity and precision of BCS can be highly variable. However, a recent study shows that classifiers, which have trained their skills in BCS and adjusted their results with other experienced classifiers, can achieve very good measurements of agreement (Kristensen et al, in press). Never the less, it is always important to address questions about bias. In this paper we will address a kind of bias known as the ‘frog pond effect’. The frog pond effect is a term derived from the phenomenon observed when a frog living in a pond with small relatives is perceived as being larger than (the same) frog living in a pond with large relatives. The frog pond effect is widely known in social sciences, where it e.g. describes the situation where a student in one class will get a higher grade because the student is relative better than the classmates. If this effect exists then the grades will not be comparable from class to class. Another way to state the frog pond effect is that the individual scores depend on the context that the individual is in. These models are also known as contextual models. The use of contextual models is controversial and people with interest in this field should look into the discussion in Kreft et al (1995). The opponents against this approach focus on that introducing the contextual variable in the models give information that is available in the original dataset. Hox (2002) argue that the use of contextual models may only be valid when then primary goal is to test the hypothesis of a ‘frog pond’ effect.

We have attempted to identify if a frog pond effect existed in a study to access the relations between BCS, hip width, hip height and heart girth measurements in dairy replacement heifers.

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Materials and Methods

The dataset for analysis consisted of recording of heart girth, hip height, hip width and BCS on 604 Danish Holstein heifers in 18 herds. Data were recorded by 8 local veterinarians and the data structure was strictly hierarchical.

Hierarchical mixed models all with heart girth as the outcome and hip height, hip width and BCS in separate analyses with herd and veterinarian as random effects were analysed. These models are now referred to the hip width model, the hip height model and the BCS model, respectively. The quantitative predictor variables of the models were grand mean centered. Initially, base line models with polynomials of the predictor variables were created.

Contextual Models

A new variable that should be able to explain the context of the other variables was created by taking the average of the predictor variables within each herd. This new variable is now a herd level predictor variable and included into the models as a continuous variable after grand mean centering.

Results

The contextual variable could be removed form the models of hip height ($p=0.53$) and hip width ($p=0.19$) whereas the contextual variable in the BCS model was highly significant ($p<0.0001$). The variance component from the hip width and hip height model were then identical to the corresponding baseline model. In the BCS model the variance components related to veterinarian was reduced with 32 percent and the variance component related to the herd was reduced with 62 percent compared with the baseline model. Because the residual variance in the baseline model is large, the reduction in variance related to the veterinarian and herd level of the model only contributed to a 13 percent reduction of total variation in the data. The final equation for estimation of the heart girth from BCS is given in the formula below.

$$\text{Heart Girth} = 164.5 + 49.1(BCS-3.25) - 20.6(BCS-3.25)^2 - 36.2(BCS_{herd}-3.25)$$

Discussion

The interesting part of the equation is that it indicates that a heifer living in a herd with a BCS average above the grand mean BCS will have a smaller heart girth than a heifer with the same BCS living in another herd. This situation is what previously has been stated to be a ‘frog pond’ effect. This can be due to some degree of relative scoring by the classifiers. That the contextual variables could be removed form the hip width and hip height models supports this conclusion, because theses measurements can be considered to be conducted similarly in different herds and veterinary practices. Other possible explanations could be that truly herd specific conditions occurred. For example that herd specific feeding caused some specific growth patterns within the breed of Danish Holstein heifers.

References

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