Adjusting for Seasonal Effects in an Animal Model using Fuzzy Classification

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Abstract

A problem with the traditional classification of cows into (herd-year-) season classes is that cows calving in opposite ends of the class (e.g. one or more months apart) are considered to be contemporaries whereas cows calving a day apart but on each side of a class border are not. To amend this a fuzzy classification was used where a cow was classified with a proportion *x* (>0.5) in the class she calved and with a proportion (1-*x*) in the closest adjoining class. The effect of classifying a cow calving on the border between classes as having calved in the former or the following class was studied for both the traditional and the fuzzy classification method using simulation. For the traditional method the correlation between the estimated breeding values before and after moving a cow over a class (month) border was 0.93, whereas it was at least 0.9997 for the fuzzy method, indicating that the fuzzy classification improves on the adjustment for season effects, especially for cows calving close to a season class border.

Introduction

When estimating breeding values for cows using an animal model, all cows calving in a specific herd-year-season class are adjusted as if they had calved in the middle of this class. Cows that calve in the beginning and the end of a class are considered to be contemporaries even if their calvings are months apart. On the other hand, even when only hours separate two calvings the cows are still corrected differently if they happen to be on different sides of a border between classes, and the adjustment is the same as if the calvings had occurred weeks or months apart (Simianer, 1994). For cows calving near the border between classes this could be expected to lead to imprecise estimates of their breeding values and even re-ranking.

The aim of this paper was to study a new method to improve the adjustment for season effects, especially for cows calving close to a season class border. The method used is to classify a cow partially in the class in which she is calving and partially in the closest adjoining class; a so-called fuzzy classification. The term @fuzzy@ comes from fuzzy logics, a methodology used in expert systems to handle inexact reasoning (Lacroix and Wade, 1994).

Material and methods

Breeding values for milk yield were simulated for 10 sires and 120 dams, comprising the base population. The sires were randomly mated to dams to give rise to 120 daughters with milk yield records. These daughters calved on one of the days: 1, 2, 6, 11, 15, 16, 20, 25, 29, or 30 in each month (all months having 30 days). The phenotypic values were simulated as:

$$P = \mu + s + A + E$$

where μ is the mean (7000 kg), the season effect $s = a \sin(d\text{-}180)$; where a is the amplitude (250 kg), d is the day of the year, and sin() is the sine function; A is the breeding value (~N(0; 147,000)), and E is the environmental deviation (~N(0; 343,000)). This resulted in a heritability of 0.3. Cows that calved on day 30 in one month and on day 1 in the next month were given the same season effect *s* (corresponding to calving on day 30.5).

For the traditional classification method a cow was classified in the month she calved. For the fuzzy classification method the cow was classified with a proportion (>0.5) in the month she calved and with the remaining proportion in the closest adjoining month class. The proportion used was a linear function of the distance in days from the middle of the month (Figure 1). A cow calving on the first of February would be classified with 0.517 in February and 0.483 in January, whereas a cow calving on the 15th of February would have proportions 0.983 and 0.017, respectively. However, cows calving in the first half of January and in the second half of December were fully classified in their calving month also in the fuzzy method.

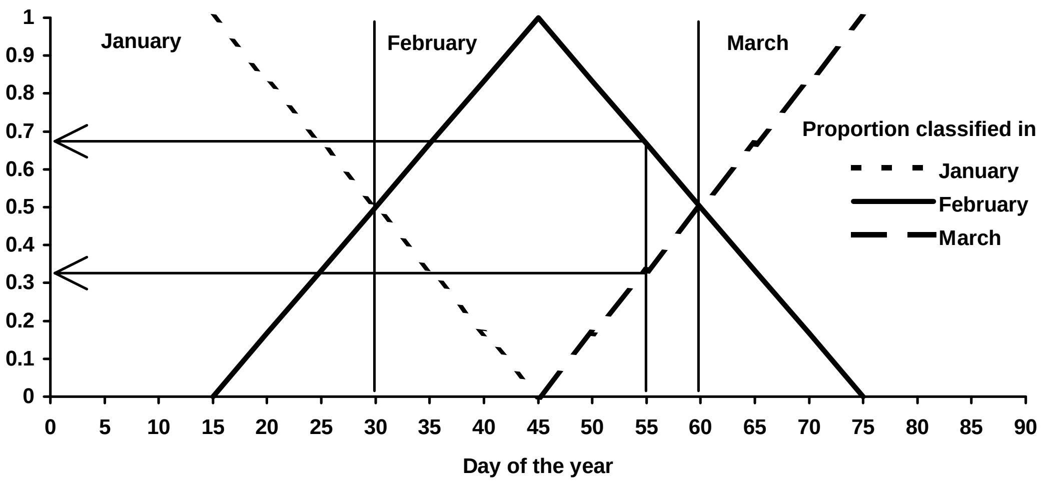

Figure 1. Illustration of the fuzzy classification method. An observation 25 days into February is classified as 0.6833 in that month and 0.3167 in March.

To study the effect of the two types of classification for seasonal effects on the estimation of breeding values for cows close to the border between classes, 11 variants of the described control data set were created. In variant 1, the cow calving on day 30 in month 1 was classified as having calved one day later and the cow calving on day 1 of month 2 was classified as having calved one day earlier. In variant 2, the cow calving on day 30 of month 2 was classified as having calved one day later, and the cow calving on day 1 of month 3 was classified as having calved one day earlier, and so on. The estimated breeding value for the misclassified cow was then compared to that from the original (control) data set and the difference and correlation between estimated breeding values were calculated. Each population was replicated 200 times.

The breeding value estimation was done for all 250 animals in each data set using an animal model with the effects of calving month (fixed), animal (random) and residual, using the relationship matrix and the simulated genetic parameters. Equations were solved using Gauss-Seidel iteration and convergence was assumed when the sum of the squared deviations of estimates from one round to the next relative to the sum of the squared estimates in a given round, was less than 10^{-4}. For the fuzzy classification method, an overall mean was also included in the model and the calving month effects were forced to sum to zero after each iteration, the remainder was moved to the estimate of the mean.

Results and discussion

The correlations and the average absolute difference between estimated breeding values in the misclassified data set (EBV*) and in the control data set (EBV_0) for cows at various month borders are shown in Table 1. Correlations were approximately 0.93 for the traditional method, whereas they were almost unity for the fuzzy method (at least 0.9997). This means that the fuzzy method is less sensitive to misclassification for animals close to the border.

Table 1. Correlations and average absolute differences between estimated breeding values from the data set where a certain cow was misclassified, either by moving it forward or backwards into the adjoining month class, and from the control data set. Estimates from traditional and fuzzy classification methods, based on 200 replicates (each value represents 400 individuals).

Month	Traditional		Fuzzy	
border	Corr.	Abs. diff.	Corr.	Abs. diff.
1-2	.9335	57.3	.9998	2.90
2-3	.9300	51.6	.9998	2.90
3-4	.9182	56.4	.9997	3.34
4-5	.9105	59.2	.9998	3.04
5-6	.9414	55.7	.9998	3.21
6-7	.9298	67.9	.9998	3.72
7-8	.9326	71.9	.9998	4.14
8-9	.9253	81.7	.9998	4.31
9-10	.9426	81.9	.9998	4.42
10-11	.9160	89.3	.9998	4.52
11-12	.9318	73.1	.9998	3.62

The difference ($EBV^* - EBV_0$) (not shown) changed sign, depending on whether a cow was moved forward or backwards. The average absolute value of this difference was much larger for the traditional classification method (67.8, SE 2.6) than for the fuzzy method (3.65, SE 0.14). All these results show that the fuzzy method is less sensitive to whether a cow is determined as having calved in one class (month) or another.

General discussion on the fuzzy classification method

For a situation with larger classes (e.g. 2 or 3-month classes), the effect of misclassification for cows calving near a class border would, especially in the traditional method, be expected to be larger than in this rather ideal situation with monthly season classes. One reason for making larger classes is that there are too few cows calving in a certain month. The fuzzy method may help in this respect because it actually uses observations within a 2-@month@ period, half of the previous class, the current class and half of the following class (Figure 1). Therefore, the probability of having season classes with no or only one observations will be lower and the connections between observations will be better.

However, this approach may also lead to some problems. In a pilot study we had a herd size of 50 cows and uneven calving distribution. In the traditional method a month with no cows calving will simply get an estimate of zero. However, in the fuzzy method a month class may get a very small contribution (e.g. 0.017) from an animal calving in an adjoining month. This contribution squared on the diagonal of X=X (e.g. 0.0003) is then used in solving for month effect and the right-hand-side value is divided by a small number. This may lead to a sensitive set of equations where the estimates may drift to unrealistic values. This problem can probably be solved by assuming season to be random instead of fixed.

There are also other procedures suggested in the literature to improve upon the adjustment for seasonal effects that need be compared with the fuzzy classification method (e.g. Chauhan and Thompson 1986; Wade and Quaas 1993; Wade *et al.* 1993).

Conclusions

The fuzzy classification method is less sensitive to whether a cow is determined as having calved in one class (month) or another. The adjustment for seasonal effects becomes more continuous and the estimation of breeding values should be improved, especially when comparing cows calving on opposite sides of a class border. The method can also have advantages in connecting observations in a better way but there may be problems with instability of solutions when having small proportions in any one class. This problem should be studied further before applying it to a real situation.

References

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