

Are organic cows less stressed?

K Lawrence¹ A.Thatcher¹ K Govindaraju³ and B Dobson-Hill²

¹*Institute of Veterinary Animal and Biomedical Sciences, Massey University, New Zealand*

²*DairyNZ, South Taranaki, New Zealand*

³*Institute of Fundamental Sciences, Massey University, New Zealand*

Background

In 2001, Massey University set up the Dairy Cattle Research Unit (DCRU) as a system comparison between organic and conventional farming. Each farmlet is managed individually according to “best practice” for its particular type of management system (Kelly *et al.* 2006). The organic unit carries typically 46 cows (2.27cows/Ha) and the conventional unit 51 (2.39cows/Ha).

Introduction

Cortisol, often referred to as the “stress hormone”, is a glucocorticoid secreted by the hypothalamic-pituitary-adrenal (HPA) axis. Levels of cortisol are known to increase in response to physical or psychological stress. Cortisol plays an important role in the body and primarily affects metabolic and immune function. Improved animal welfare is considered one of the key benefits of converting to the organic system (Rosati and Aumaitre, 2004) which logically should equate to reduced cow stress. The aim of this analysis was to test the null hypothesis that there is no difference in the cortisol levels between organic and conventional cows.

Materials and methods

The plasma cortisol levels were measured at 7, 10 and 28 days post calving as part of a prospective cohort study to compare lactational and reproductive parameters within the Massey organic and conventional herds. A total of 37 cows managed in the organic farming system (‘Organic cows’) and 38 conventionally-managed cows (‘Conventional cows’) were enrolled for this study. These groups contained all of the cows that calved before 15th September 2006. As part of the original study the following data were also collected; body condition score at days 7 and 28 post calving, aerobic and anaerobic bacterial counts of uterine fluid sampled at days 7, 10 and 28, the diameter of the cows’ cervix (measured trans-rectally) on days 7, 10 and 28 and production data and somatic cell counts recorded at six herd tests. The age structure of the two herds is shown in Figure 1.

Statistical methods

Exploratory data analysis was used to compare the variability of the cortisol measurements for the two herds. Both a multivariate ANOVA (MANOVA) and a mixed linear model (PROC MIXED, SAS) were used to model the cortisol response measured on days 7, 10 and 28. Unlike a mixed linear model, Manova cannot handle missing values, this left a reduced data set of only 24/38 organic cows and 22/39 conventional cows. Age of cow was categorised and tested as a covariate in each of the models. Chernoff faces were constructed to give a visual comparison of the cortisol levels of cows

in the two herds. Chernoff faces represent multivariate data by using it to draw human faces whose features vary depending on the data. It is easy for humans to ascertain features in the faces and to notice differences between different faces and between faces from different datasets (Martinez-Pastor et al, 2008). Different data dimensions are mapped to different facial features, for example the face width, the level of the ears, the radius of the ears, the length or curvature of the mouth, the length of the nose, etc. All analyses were undertaken using either SAS v9.1 (SAS Institute Inc, Cary, USA) or R v2.10.1 (R Development Core Team, 2004; R Foundation for Statistical Computing, Vienna, Austria).

Results

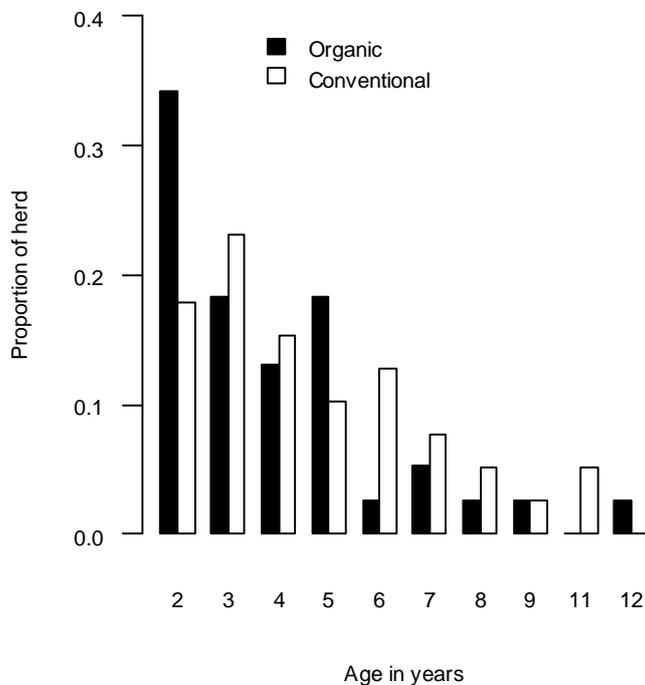


Figure 1 Age structure of organic ■ and conventional □ herds

The age structure of the two herds, Figure 1, shows that there is a tendency for the organic herd to have younger cows than the conventional herd (34% versus 19% 2 year olds) and for the conventional herd to have a higher proportion of middle aged cows (6, 7 and 8 year olds). The condition scores at day 7 or at day 28 post calving were not significantly different between the two herds.

The boxplots, Figure 2 show that the cortisol measurements are more variable and the median measurement at each measurement day is higher for conventional cows than organic. The organic data contains two extreme outliers one on day 7 and one on day 10, these measurements are from two separate cows.

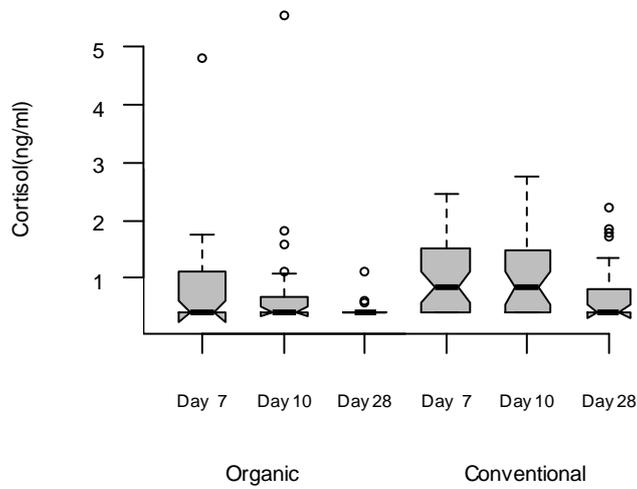


Figure 2 Boxplots showing variability of cortisol measurements for organic and conventional cows at days 7, 10 and 28.

The results for the MANOVA showed that the Wilk's Lambda statistic was moderately significant, $p=0.029$ indicating a difference between the mean cortisol response for organic compared to conventional cows. For the repeated measures model an unstructured covariance structure was found to give the lowest AIC and log likelihood. The results showed that the mean cortisol level was 0.27 ng/ml higher in conventional cows than organic cows (0.94 versus 0.67 ng/ml, $p=0.006$) and that the mean cortisol levels on days 7 (0.92 ng/ml) and 10 (0.90 ng/ml) were significantly different to day 28 (0.60 ng/ml) ($p<0.02$) but not from each other ($p=0.97$). There was no significant interaction between herd system and day of sampling in the final model and age was not found significant when tested in either model, see Figure 3.

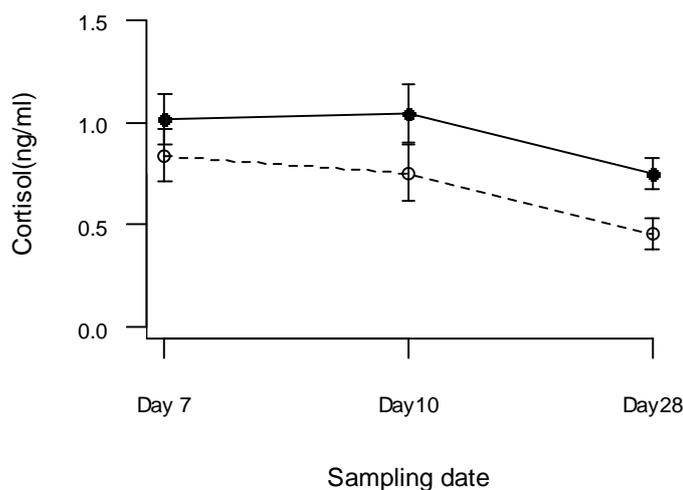


Figure 3 Sampling date least square means (\pm SEM) of plasma cortisol concentrations in conventional cows ● and organic cows ○

Figure 3 shows the profile of LSM of plasma cortisol levels for the two herds. The profile is similar for both herds but cortisol levels for the conventional herd are always higher at each sampling date.

The full study found no significant differences in reproductive parameters measured between the two herds. However there was a slight, non-significant, tendency for organic cows to conceive earlier and for the conventional cows to have greater aerobic and anaerobic bacterial counts at each uterine sampling. As expected the conventional cows produced significantly more volume and milk solids which was probably attributable to differences in pasture production between the two farmlets. There was no significant difference in SCC between the two herds.

There were 24 Organic cows and 22 Conventional cows with complete data sets and these were used to construct the Chernoff faces, Figures 4 and 5. Cow number 5 from the organic herd had a very high cortisol measurement on day 10 and could be considered almost an outlier. Other than cow 5 the faces of the organic cows are all reasonably similar and appear relatively unstressed, by comparison the faces of the conventional cows are much more variable and some appear to be markedly stressed!

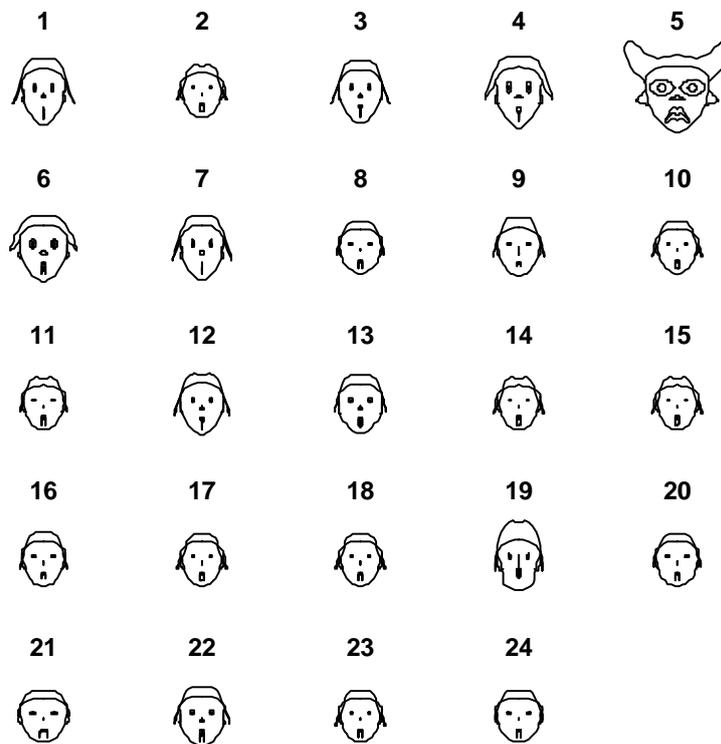


Figure 4 Chernoff faces representing the cortisol data for the organic cows

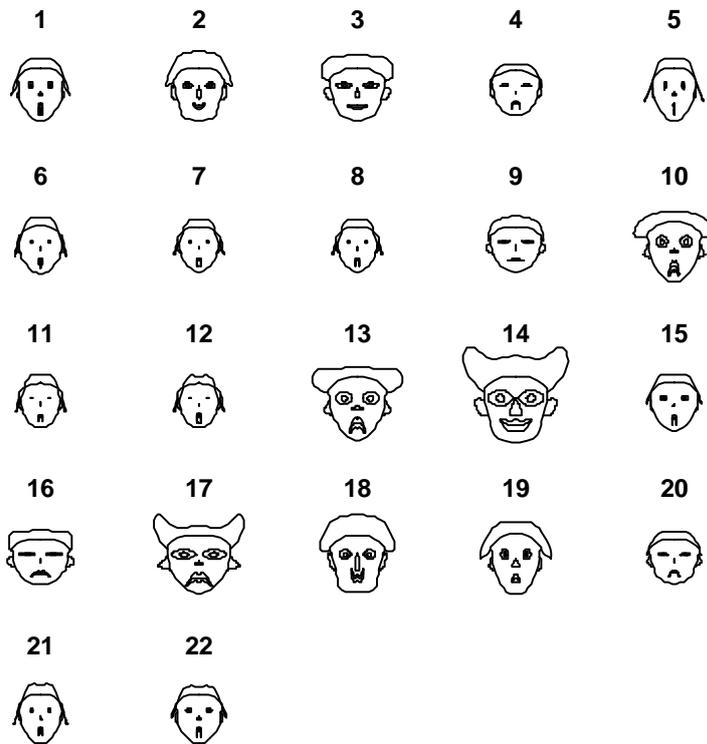


Figure 5 Chernoff faces representing the cortisol data for the conventional cows

Discussion

These results show that the conventional cows had significantly higher cortisol measurements than the organic cows. The lack of a significant interaction between herd and day of sampling indicates that the profile of cortisol measurements over the three sampling dates is similar for the two groups of cows, see Figure 3. Furthermore the lack of significance of age in either model indicates that the difference in cortisol measurements is not confounded by the different age structure between the two herds, Figure 1. The cortisol levels reported in this study are similar to levels presented by Presler et al 1999 but far lower than those recorded by Smith et al 1973 and Torres et al (1997) who found that the basal cortisol levels in normal cows were 5.1 ± 0.8 and 3.1 ± 0.9 ng/ml respectively in the first week postpartum. These differences in basal cortisol measurements probably reflect different methods of cortisol measurement. Cortisol levels normally peak around calving before returning to pre-partum levels about 1 to 9 days later (Smith et al 1973, Presler 2000). In this study without prepartum samples it is difficult to ascertain at what time the cortisol levels in this study returned to normal; however levels at day 10 were still significantly higher than day 28.

It is most unlikely that the relatively low levels of cortisol observed in this study would have had a measurable biological effect. In the study by Torres et al (1997) cows with a puerperal problem had a basal cortisol level double that of the normal cows, 6.5 versus 3.1ng/ml, in the first week postpartum.

Horst and Jorgensen, 1982 found a negative correlation between calcium and cortisol levels so the possibility that the conventional herd had a degree of subclinical

hypocalcaemia cannot be discounted, however the lack of significance of age in both models tested would tend to refute this. The higher uterine bacterial contamination of the conventional herd lends some support to the finding that increased cortisol levels are associated with cases of metritis post-calving (Torres et al 1997).

Conclusion

Within the limits of this study the organic cows were shown to have lower plasma cortisol levels which could be indicative of reduced stress.

References

- Kelly, T Butcher, N Harrington, K Holmes, C Horne, D Kemp, P Palmer, A Quinn, A Shadbolt, N Thatcher A.** Organic-Conventional dairy systems trial in New Zealand: four years results. ISOFAR. <http://orgprints.org/4392/> (accessed 12 -11-2009), 2006
- Horst RL, Jorgensen NA.** Elevated Plasma-Cortisol During Induced and Spontaneous Hypocalcemia in Ruminants. *Journal of Dairy Science* 65, 2332-7, 1982
- Martinez-Pastor F, Cabrita E, Soares F, Anel L, Dinis MT.** Multivariate cluster analysis to study motility activation of *Solea senegalensis* spermatozoa: a model for marine teleosts. In. Pp 449-59. 2008
- Preisler MT, Weber PSD, Tempelman RJ, Erskine RJ, Hunt H, Burton JL.** Glucocorticoid receptor expression profiles in mononuclear leukocytes of periparturient Holstein cows. *Journal of Dairy Science* 83, 38-47, 2000
- Rosati A, Aumaitre A.** Organic dairy farming in Europe. *Livestock Production Science* 90, 41-51, 2004
- E.B. Torres, T. Nakao, T. Hiramune, M. Moriyoshi, K. Kawata, Nakada K.** Stress and Uterine Bacterial Flora in Dairy Cows Following Clinically Normal and Abnormal Puerperium. *Journal of Reproduction and Development* 43, 157-63, 1997
- Smith VG, Edgerton LA, Hafs HD, Convey EM.** Bovine Serum Estrogens, Progestins and Glucocorticoids During Late Pregnancy Parturition and Early Lactation. *Journal of Animal Science* 36, 391-6, 1973