

Estimation of Body Condition Score in Dairy Cattle Using Digital Images

Session 21: Abstract 0827

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Introduction

- Body condition scoring (BCS) is a valuable research and herd management tool.
- Time constraints and subjectivity have limited adoption.
- Automated BCS could:
 - Require less time
 - Be more objective
 - Be less stressful on the animal
 - Be more cost-effective



Introduction

- Digital imaging has been utilized in the swine industry to describe body traits.
- Previous researchers have explored digital imaging for BCS of dairy cows (Coffey et al., 2003, Leroy et al., 2005, Pompe et al., 2005).



Materials and Methods

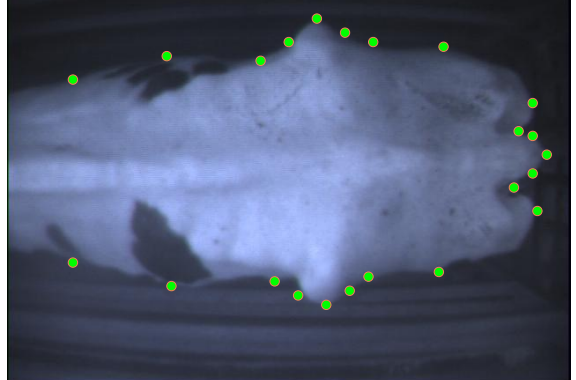
- Data were collected at the Scottish Agricultural College Crichton Royal Farm in Dumfries, Scotland, UK from September to November 2006
- Cows were scored weekly using the Mulvany et al. (UKBCS) and Ferguson et al. (USBCS) BCS systems.
- When a given BCS differed from preceding and subsequent scores by more than ± 0.25 , the score was removed from the data set (N=129 and N=59 for UKBCS and USBCS, respectively).
- Means were 2.12 (± 0.35) and 2.89 (± 0.40) for the UKBCS (N=2346) and USBCS (N=2571), respectively.

Image Collection

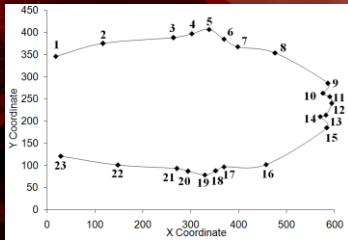
- Images collected with a digital camera
- Camera triggered to capture image when gates closed
- Image timestamps matched with weigh station timestamps to ID cows
- Images only available during afternoon milking because of lighting



Anatomical Points Identified

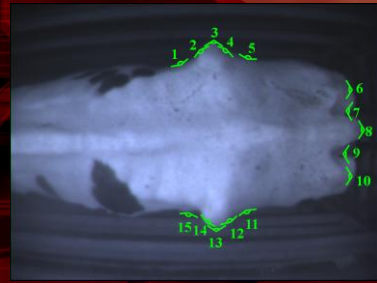


Anatomical Point Coordinates



1 & 23	Foreribs	7 & 17	Hook Ends
2 & 22	Short Rib Starts	8 & 16	Thurls
3 & 21	Hook Starts	9 & 15	Pins
4 & 20	Hook Anterior Midpoints	10 & 14	Tailhead Nadirs
5 & 19	Hooks	11 & 13	Tailhead Junctions
6 & 18	Hook Posterior Midpoints	12	Tail

Calculated Angles



1 & 15	Hook Anterior Angles	5 & 11	Hook Posterior Angles
2 & 14	Hook Anterior Curvatures	6 & 10	Thurl to Pin Angles
3 & 13	Hook Angles	7 & 9	Tailhead Depressions
4 & 12	Hook Posterior Curvatures	8	Tailhead Angle

Data Editing



- For each image, 7 composite anatomical angles were calculated using the mean of opposing angles from the cow's left and right sides.
- A within image coefficient of variation (CV) was calculated for each pair of angles.
- When the CV corresponding to an individual image composite angle was more than 3 standard deviations from the population mean CV for that angle, the respective angle was discarded.

Data Editing



- A weekly average of each composite angle, along with tailhead angle, was calculated for each cow/week combination.
- Weeks were defined relative to the date of scoring for the respective BCS systems with the date of scoring in the middle of the week.
- Weekly averages with less than two composite hook angles were discarded from the data set prior to model creation.

Images

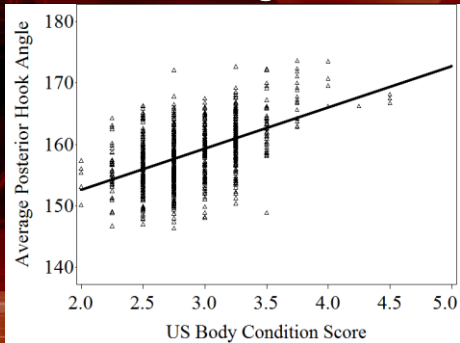
- If both hooks were not clearly visible, the image was considered to be of insufficient quality and no points were recorded.
- 3332 usable images remained in dataset.
- Usable images were available for 46 of 61 days.
- There were 72.44 ± 42.91 usable images per day and 13.77 ± 8.59 usable images per cow.
- Lighting (not enough contrast between cow and background) was biggest problem
- Cow position, tail, and dirt also presented difficulties.

Results



- Hooks were easiest to identify.
- Tailhead and pins were more difficult.
- Hook posterior angle ($r=0.5239$), hook angle ($r=0.4834$), and tailhead depression ($r=0.3104$) had strongest correlations with USBCS.
- The hook posterior angle ($r=0.4601$), hook angle ($r=0.3301$), hook anterior curvature ($r=0.1984$), and tailhead depression ($r=0.1856$) had strongest correlations with UKBCS.

Example: Posterior Hook Angle vs. USBCS



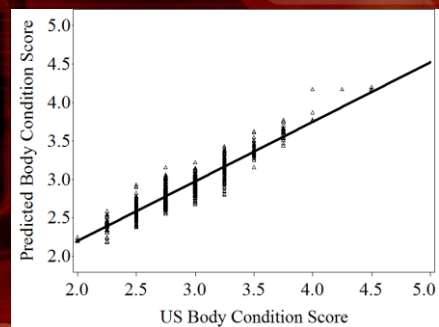
Model Development

- MIXED procedure of SAS® for prediction of BCS using the angles obtained from the images
- Repeated measures analysis with variables repeated by week with cow as the random subject
- AR(1)-autoregressive covariance structure
- Variables selected if significant at $p < 0.05$
- Six models developed (only most descriptive models presented here)

Model parameters and p-values for fixed effects

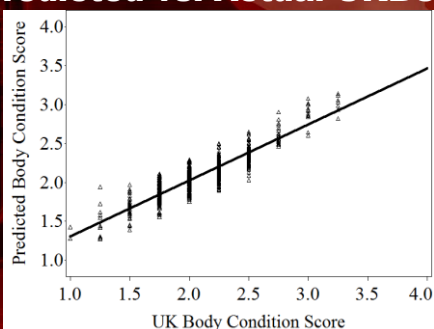
	USBCS	UKBCS
No. observations	834	767
AIC	-230.8	-96.7
BIC	-220.7	-87.1
Fixed effects:		
Intercept	0.0109	0.0039
Avg. Hook Angle	0.0427	0.0053
Avg. Posterior Hook Angle	0.0545	0.0141
Avg. Hook Angle * Avg. Posterior Hook Angle	0.0254	0.0048

Predicted vs Actual USBCS



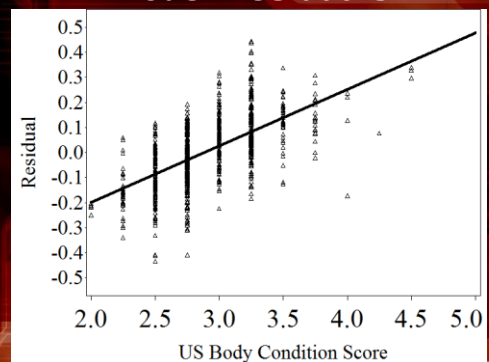
- 100% of predicted BCS were within 0.50 points of actual BCS.
- 93% were within 0.25 points of actual BCS.

Predicted vs. Actual UKBCS

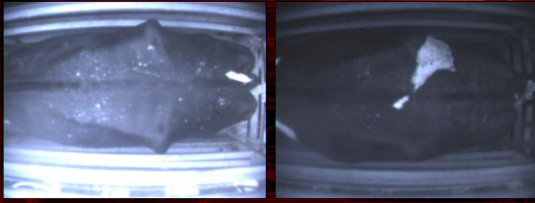


- 99.9% of predicted BCS were within 0.50 points of actual BCS.
- 90% were within 0.25 points of actual BCS.

Model Residuals



Example



USBCS	2.50	USBCS	3.50
Predicted BCS	2.63	Predicted BCS	3.32
Posterior Hook Angle	150.0°	Posterior Hook Angle	172.1°
Hook Angle	116.6°	Hook Angle	153.5°

Model Limitations



- Small number of images-minimal outlier removal
- Few cows of extreme BCS
- Short duration-unable to detect changes in BCS
- Human error in point identification
- Limited number of BCS evaluators
- BCS is not a perfect indicator of body fat

Conclusions



- Strong relationship between the angles measured in this work with BCS as determined by trained evaluators.
- Angles around the hooks and tailhead have the highest correlations with BCS.
- Potential exists for assessment of BCS using digital imaging.

Moving Forward



- Other technologies, such as thermal imaging, should be explored to facilitate extraction of information from images automatically.
- Many research opportunities remain.
- As these imaging technologies are applied to other industries, costs of these technologies will continue to decrease.
- Automated body condition scoring may become an integral part of decision making on modern dairy farms.

Acknowledgements



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Questions?

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