Using deep learning to assess teat-end condition in dairy cows

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Background

“Mechanical forces during machine milking induce changes in teat tissue condition.”

(Hillerton et al., 2000, Zwertvaegher et al., 2013, Guarin and Ruegg, 2016)
Background

1. Short-term changes in teat condition
2. Medium-term changes in teat condition
3. Long-term changes in teat-end condition
Background

1. Short-term changes in teat condition
2. Medium-term changes in teat condition
3. Long-term changes in teat-end condition
Background

(Neijenhuis, 2004)
Background

“Clinical mastitis cows had more teat end callosity than their healthy herd mates.” (Neijenhuis et al., 2001)

“Dairy consultants should focus on monitoring and minimizing occurrence of severe teat-end hyperkeratosis to prevent clinical mastitis and subclinical mastitis.” (Pantoja et al., 2020)
Background

Industry goal: \( \leq 20\% \) of cows (Mein et al. 2001)

Industry recommendation: \( \geq 80 \) cows or 20\% of the herd (Reinemann et al. 2001)
Background
Objective:
• Investigate the feasibility of the use of a deep learning neural network for classification of teat-end condition in digital images

Hypothesis:
• Deep learning can be used to assess teat-end condition in dairy cows by means of digital imaging
Materials and Methods

Study sites:
• Farm A: 1,600 cows; Farm B: 4,000 cows
• Milking schedule: 3X
• Farm A: 60 stall rotary; Farm B: 100 stall rotary parlor

Study period:
• Farm A: September 2019
• Farm B: July 2020
Materials and Methods

A

B

C

D

E

n = 398
Materials and Methods
Materials and Methods

N (Score 1): 599 (39%)

S (Score 2): 654 (42%)

R (Score 3): 269 (17%)

VR (Score 4): 28 (2%)
Materials and Methods

Manually scored teat images

- N (Score 1)
- S (Score 2)
- R (Score 3)
- VR (Score 4)

85% of images

GoogLeNet (pre-trained convolution neural network)

Transfer Learning

Unknown Classification

Deep Learning Prediction

Re-Trained Network

15% of images
Results

Area under the curve:
• Score 1 (N): 0.78 (95% CI: 0.72-0.83)
• Score 2 (S): 0.54 (95% CI: 0.46-0.61)
• Score 3 (R): 0.86 (95% CI: 0.79-0.91)
• Score 4 (VR): 0.92 (95% CI: 0.80-0.99)

Overall accuracy:
• 47%
Discussion

Conclusion:
• Deep learning can be used to assess teat-end condition in dairy cows by means of digital imaging

Outlook:
• Improvement of deep learning network
• Automation of image acquisition
• Other teat tissue conditions
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