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Early Detection of Bumblefoot in Poultry: A Novel Approach to Improve Welfare

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Abstract

Bumblefoot is a common bacterial infection and chronic inflammatory reaction in a bird that causes pain and stress, making it difficult for them to walk and perch, restricting their access to feeders and drinkers. The pain and stress in hens are detrimental to their welfare. However, it is technically challenging to monitor hens with bumblefoot. No automatic methods have been applied to track hens' bumblefoot, especially the early bumblefoot detection (BFD) in cage-free (CF) housing systems, which is expected to be dominant egg production system in North America and Europe Union. This study aimed to develop and test bumblefoot using deep learning and evaluate their performance in BFD under various settings (epochs, batch size, & camera height). The performance of three newly developed YOLOv5-BFD models (i.e., YOLOv5s-BFD, YOLOv5m-BFD, & YOLOv5x-BFD) was compared in detecting hens with bumblefoot. A dataset of 2200 images (1540 for training, 440 for validation, and 220 for testing) was generated from 3 weeks of recorded video to analyze the bumblefoot detection in Hyline W36 birds (48-50 weeks of age). The datasets were trained with the YOLOv5 model using the virtual clouding system provided by Oracle Cloud Infrastructure. Statistical analysis was conducted using one-way ANOVA, and means were separated using Tukey HSD methods ($P < 0.05$) to determine significant differences between predicted BFD and actual BFD under various models, batch sizes, and epochs. The result shows that the YOLOv5m-BFD model had the highest precision (93.7%), recall (84.6%), [mAP@0.50](#) (90.9%), [mAP@0.50:0.95](#) (51.8%), and F1-score (89.0%) compared with other models. Among several batch sizes used, a batch size of 16 resulted in overall higher performance based on performance metrics. In addition, the epoch of 100 had the overall best performance with higher recall (86.9%). Thus, the observed YOLOv5m-BFD model trained at 100 epochs and batch size 16 is acceptable for detecting BFD with 720 Hy-Line W-36 hens. This study is critical for developing a commercial system in cage-free houses.

Keywords: YOLOv5, machine vision, bumblefoot, animal welfare, cage-free housing.