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

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INTRODUCTION

About Bumblefoot
- Highest score footpad dermatitis.
- Bacterial infection- *Staphylococcus aureus.*
- Swelling, abrasion, hyperkeratosis, and ulceration of pad.
- $460 million revenue.
- > 40% bumblefoot.

How Bumblefoot occurs?
- Litter type & quality.
- Litter moisture content.
- High stocking density.
- Manure deposition.
- Inadequate or unsanitary perches.
- Drinker design and maintenance.
- Nutritional factors.

Related research
- Visual observation.
- Invasive and holding hen.
- Infrared thermal imaging technology.

Why Bumblefoot detection(BFD) required?
- Non-invasive.
- Real-time monitoring.
- Alert the producer.

Figure 1: Bumblefoot a) side view and b) top view.

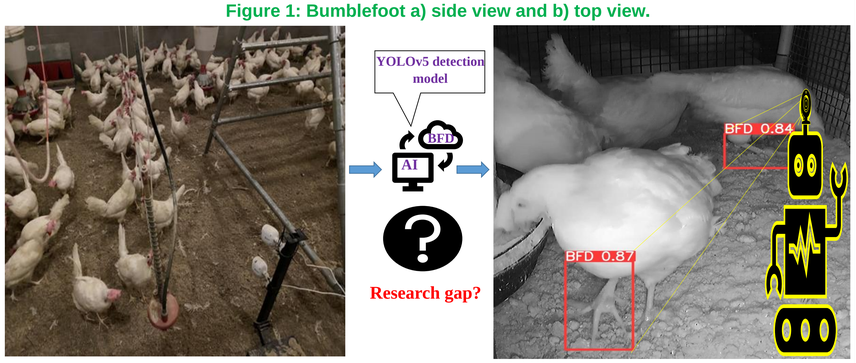

Figure 2: New deep learning-based technology required for BFD.

OBJECTIVES

(1) Develop and test a YOLOv5 model as a diagnostic tool for detecting clinical bumblefoot in CF layers.
(2) Compare the performance of YOLOv5s, YOLOv5m, and YOLOv5x-BFD model.
(3) Evaluate the performance of optimal YOLOv5 model under different settings.

MATERIALS AND METHODS

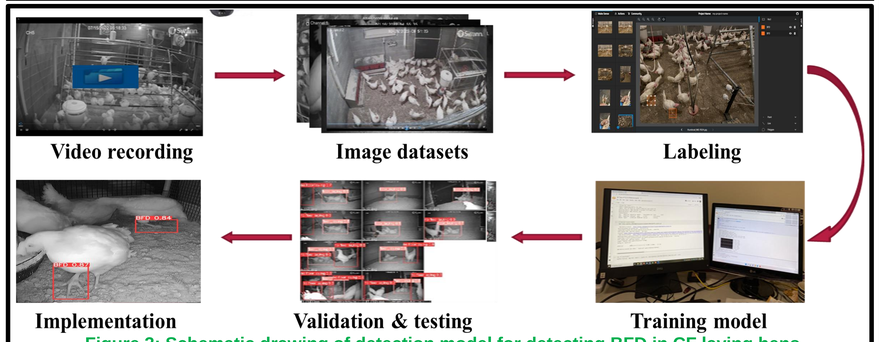

Figure 3: Schematic drawing of detection model for detecting BFD in CF laying hens.

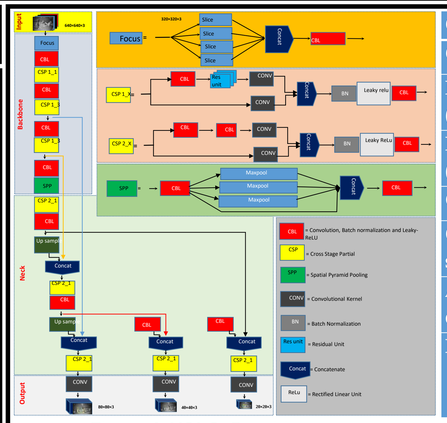

Figure 4: YOLOv5 architecture.

Configuration	Parameters
CPU	64 core OCPU
Memory (RAM)	1024GB
Drive (2 counts)	7.68 TB NVMe SSD
GPU (4 counts)	4×NVIDIA® A10 (24GB)
Operating system	Ubuntu 22.10 (Kinetic Kudu)
Accelerated environment	NVIDIA CUDA
Libraries	OpenCV-python 4.1.1, Torch 1.7.0, NumPy 1.18.5, Torch-vision 0.8.1

Table 1: Experimental configuration.

Model evaluation metrics:

$$Precision = \frac{TP}{TP+FP} \times 100\% \quad (1)$$

$$Recall = \frac{TP}{TP+FN} \times 100\% \quad (2)$$

$$mAP = \frac{\sum_{i=1}^{C} APi}{C} \quad (3)$$

$$F1\ Score = \frac{2 \times Recall \times Precision}{Recall + Precision} \quad (4)$$

where, TP, FP, and FN indicate true positive, false positive, and false negative values

Data Pre-Processing:

Class	Original dataset	Train (70 %)	Validation (20 %)	Test (10 %)
BFD_{total}	2200	1540	440	220
$BFD_{batch4\text{-}32}$*	2200	1540	440	220
$BFD_{epoch50\text{-}400}$#	2200	1540	440	220
$BFD_{height30,50cm}$	1100	770	220	110

Table 2: Data pre-processing by classes.

RESULTS AND DISCUSSIONS

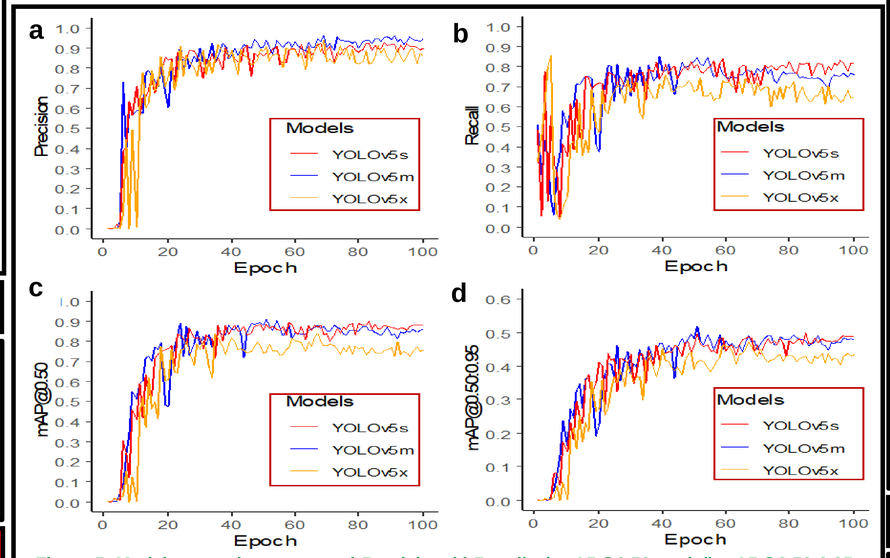

Figure 5: Model comparison curves a) Precision, b) Recall, c) mAP@0.50, and d) mAP@0.50:0.95 of different YOLOv5 models used to target BFD.

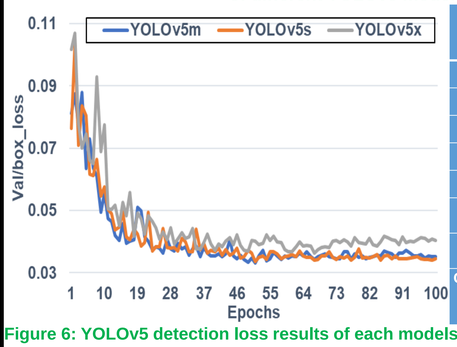

Figure 6: YOLOv5 detection loss results of each models.

Computing network	YOLOv5s	YOLOv5m	YOLOv5x
FPS	55.3	42.6	29.1
Parameters	7,012,822	20,852,934	86,173,414
Layer	157	212	322
GFLOPs	15.8	47.9	203.8
Epochs (its/s)	11.95	10.57	10.02
OSS used (MB)	14.3	42.1	173.0
Training time (h)*	0.420	0.535	1.029
GPU memory (GB)	1.04	1.83	4.95

Table 3: Comparison based on computing use.

Data summary*	Precision (%)	Recall (%)	mAP@0.50 (%)	mAP@0.50:0.95 (%)	F1-score	Training time (h)	GPU memory (GB)
BFD_{batch4}	89.2	79.8	85.5	48.9	84.0	0.932	1.27
BFD_{batch8}	89.7	86.9	90.1	52.4	88.0	0.498	1.34
$BFD_{batch16}$	93.7	84.6	90.9	51.8	89.0	0.535	1.83
$BFD_{batch32}$	94.4	75.2	85.2	48.7	84.0	0.204	3.38

Table 4: Test result of YOLOv5m model based on different batch sizes.

Data summary*	Precision (%)	Recall (%)	mAP@0.50 (%)	mAP@0.50:0.95 (%)	F1-score	Training time (h)
$BFD_{epoch50}$	88.0	76.0	82.2	46.6	82.0	0.258
$BFD_{epoch100}$	89.7	86.9	90.1	52.4	88.0	0.498
$BFD_{epoch200}$	94.9	77.2	90.6	51.7	85.0	0.919
$BFD_{epoch400}$	98.7	80.8	89.2	83.5	89.0	1.471

Table 5: Test performance of the YOLOv5m-BFD at different number of epochs.

Data summary*	Precision (%)	Recall (%)	mAP@0.50 (%)	mAP@0.50:0.95 (%)	F1-score	Training time (h)
$BFD_{height30cm}$	89.7	86.9	90.1	52.4	88.0	0.497
$BFD_{height50cm}$	77.1	64.6	70.5	39.8	71.0	0.506

Table 6: Test result of YOLOv5m BFD model based on different camera height.

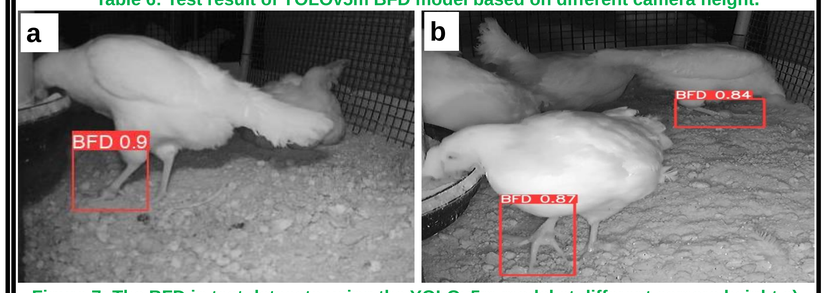

Figure 7: The BFD in test datasets using the YOLOv5m model at different camera height a) 30cm and b) 50cm.

CONCLUSIONS

a) YOLOv5m-BFD model performed best with the mAP@0.50 of 90.9% compared to YOLOv5s (88.6%) and YOLOv5x (84.0%).
b) Batch size 16.
c) Higher number of epochs.
d) Camera height of 30cm.

Future research goal:
a) Commercial CF housing
b) Detect non-invasive Footpad dermatitis detection model.

Acknowledgement