25th International Congress on Modelling and Simulation, Darwin, NT, Australia, 9 to 14 July 2023
mssanz.org.au/modsim2023

Infectious disease spread in free-range egg-laying hens based on empirical mobility patterns and contact networks

Andrea Palmini [b], Andrzej Jarynowski [b], Mitchell Welch [a], Vitaly Belik [b], Terence Sibanda [c] and Isabelle Ruhnke [c]

[a] *Precision Agriculture Research Group, School of Science and Technology, Faculty of Science, Agriculture, Business and Law, University of New England, Armidale, Australia*
[b] *System Modeling Group, Institute for Veterinary Epidemiology and Biostatistics, Department of Veterinary Medicine, Freie Universität Berlin, Germany*
[c] *School of Environmental and Rural Science, Faculty of Science, Agriculture, Business and Law, University of New England, Armidale, Australia*
Email: mwelch8@une.edu.au

Abstract: Introduction and data. RFID sensors provide a promising technology for welfare and health conditions assessment in the egg production industry (Ruhnke et al., 2019). The original dataset of free-range hens movements in Australia was generated from 18 000 commercial laying hens housed in a multi-tier aviary system using an innovative custom-built RFID system. This allowed the tracking of individual hen movements on the range and in the hen house for the entire 56-week duration of the laying period. The contact dataset includes information about 2644 hens who survived whole observation and were subject to necropsy at the end of their laying period for the presence or absence of some diagnosed diseases. We investigate various definitions of spatiotemporal mobility and contacts:

- the time that individuals spent at the lower feeder area, upper feeder area, in the nest boxes, and on the range area in minutes and time stamp (Sibanda et al., 2022)
- each potential contact of every 2 individual hens (animals as nodes) which are in the range of a given antenna with duration in minutes and time stamp
- each movement of a single hen between two consecutively visited antennae being nodes with a time stamp.

Methodology. We tested the ability of mobility and contact patterns in prediction of spotty liver disease (bacterial infection), *Ascaridia galli* and cestode infection (both parasites) by using regression models. We also proposed a theoretical disease 'X' with characteristics similar to common bacterial and viral infection modelled by the SEIR approach (Vespignani, 2012). We applied social network analysis, representing the hens and antennas with nodes in the network, to understand how infectious diseases spread within the system.

Results. In a theoretical model of disease 'X' we have tested if the point of introduction of the disease (by interaction with the wildlife vs no adequate biosecurity adherence of workers) will manifest in variables measured in a free-range poultry farming context (i.e. laying productivity and hen mortality). From actual registry diseases, we have identified a possible exposure due to going outside of the shed (the birds were exposed to the environment and vectors) in parasite infections.

Conclusions. Our study demonstrates that health and performance indicators enriched with the network analysis promise to improve hen well-being as well as to allow for targeted interventions and to optimize economical efficiency of the egg production.

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Keywords: *Infectious disease modelling, social network analysis, poultry health, animal sensors*