A Spatiotemporal Dynamic Model of Trade Patterns of Backyard Chickens in Thailand – Implication on disease spread

A Wiratsudakul[1,2*], M Paul[3,4], T Tiensin[5], W Triampo[6], K Chalvet-Monfray[1]

[1] INRA, UR346 d'Epidémiologie Animale/Université de Lyon VetAgro Sup Campus Vétérinaire de Lyon, FRANCE
[2] The Monitoring and Surveillance Center for Zoonotic Diseases in Wildlife and Exotic Animals, Faculty of Veterinary Science, Mahidol University, THAILAND
[3]INRA, UMR 1225 IHAP/Ecole Nationale Vétérinaire de Toulouse, FRANCE
[4] Université de Toulouse, INP, Ecole Nationale Vétérinaire de Toulouse,FRANCE
[5]Division of Livestock Foreign Affairs, Department of Livestock Development, THAILAND
[6]Department of Physics, Faculty of Science, Mahidol University, THAILAND
*Corresponding author E-mail : anuwat.wiratsudakul@vetagro-sup.fr

Background

Outbreaks caused by the Highly Pathogenic Avian influenza H5N1 (HPAI H5N1) virus, in Thailand, were mainly reported in the backyard chicken sector. In traditional trade networks, backyard chickens reared in rural areas are aggregated by collectors to supply urban markets. Movements of live chickens through these traditional networks can be a potential risk for spreading the virus along the trade chain. Moreover, the temporal pattern (including variations related to Chinese New Year festival) of trade networks is believed to play a role for HPAI spread, but has been poorly known so far. **Main objective**: This work aimed to model the movements of backyard chickens along the trading networks in space and time.

Materials and Methods

Phitsanulok, the province with the highest number of confirmed HPAI H5N1 outbreaks in chickens in Thailand, was chosen for this study. A total of 52,180 chicken flocks located in 1,045 villages was derived from 'x-ray' census carried out in March 2012 and was used in the model. Also, from June to August 2012, twenty collectors in Phitsanulok province were visited and interviewed. These field data were used to quantify exchanges of chickens between the different actors, set the initial conditions and simulate a likely network.

A compartmentalized stochastic dynamic model was developed to represent the dynamic flows of backyard chickens from villages to different types of collectors, and then to slaughterhouses. Live poultry movements in time and space varied according to the market demand, which was mainly determined by the main festivals present in Thailand. The model also accounted for the age structure of chicken populations (adult chickens, age > 5 months, were moved from the compartment of young chickens).

Statistical Program R version 2.14.1 was used for data analysis and model construction.

- Package 'fitdistrplus' was used in fitting the distribution.
- Package 'igraph' was used in illustrating the sociogram.
- Package 'sp' was used in creating spatial coordinates.
- Package 'spdep' was used in locating the villages within the defined range.

Results

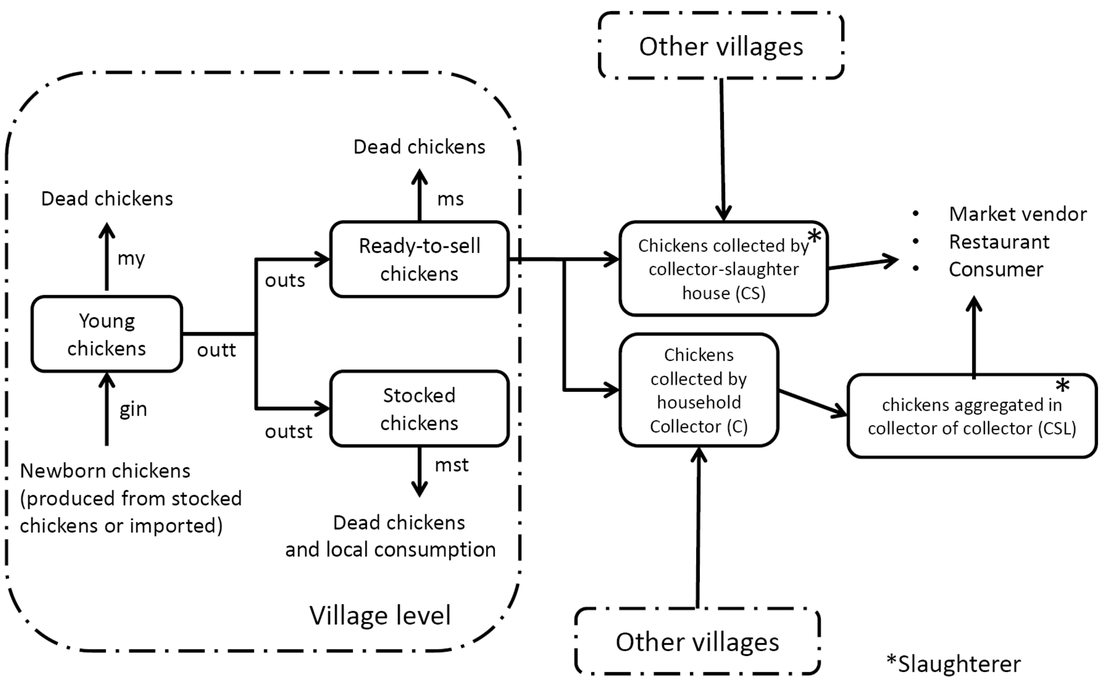

Fig. 1. Conceptual model of the trade patterns of backyard chickens in Thailand

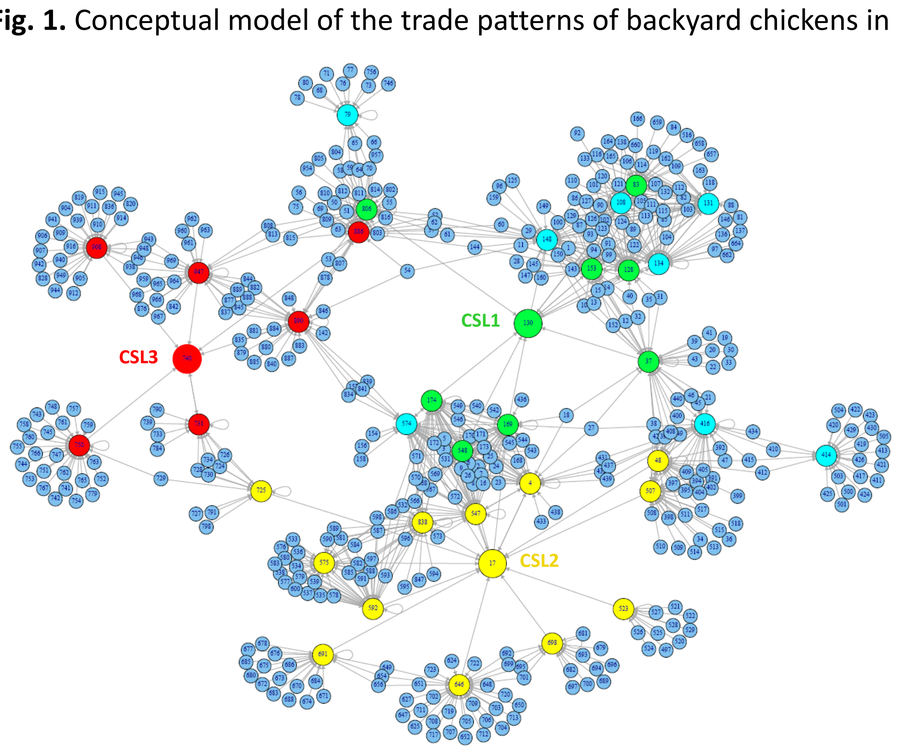

Fig. 3. Sociogram of the simulated network (469 vertices, 961 edges). Each vertex represents a village. Light blue vertices indicate the villages with collector-slaughterhouse (CS). Green, yellow and red vertices show the villages with collectors(C) belonging to the sub-networks of CSL1, CSL2 and CSL3 respectively.

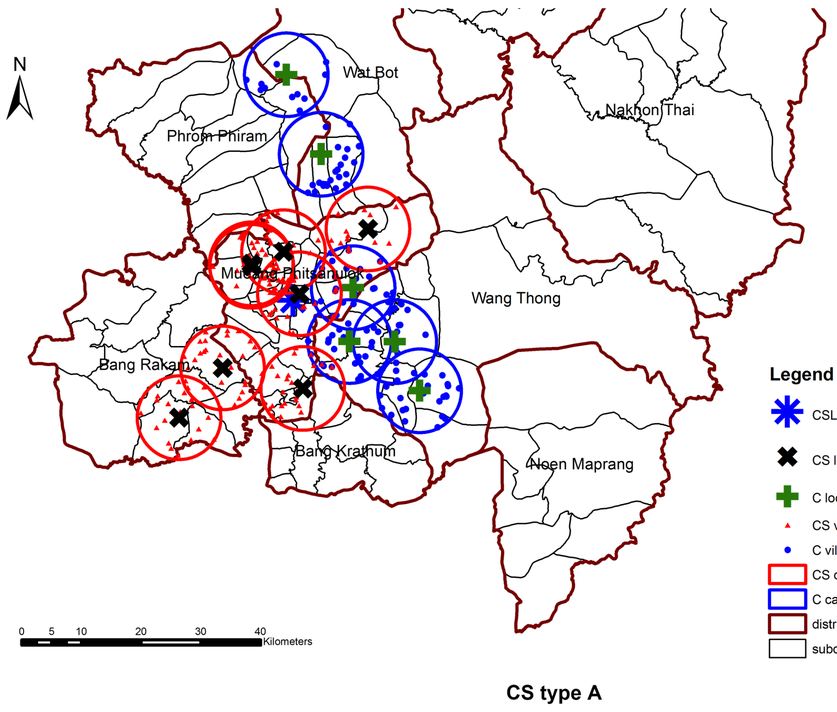

Fig. 2. Geographic locations of the simulated collectors and of the villages in their catchment area (delimited within a 7 km radius from the collector's location). Example from 1 CSL and 8 CSs.

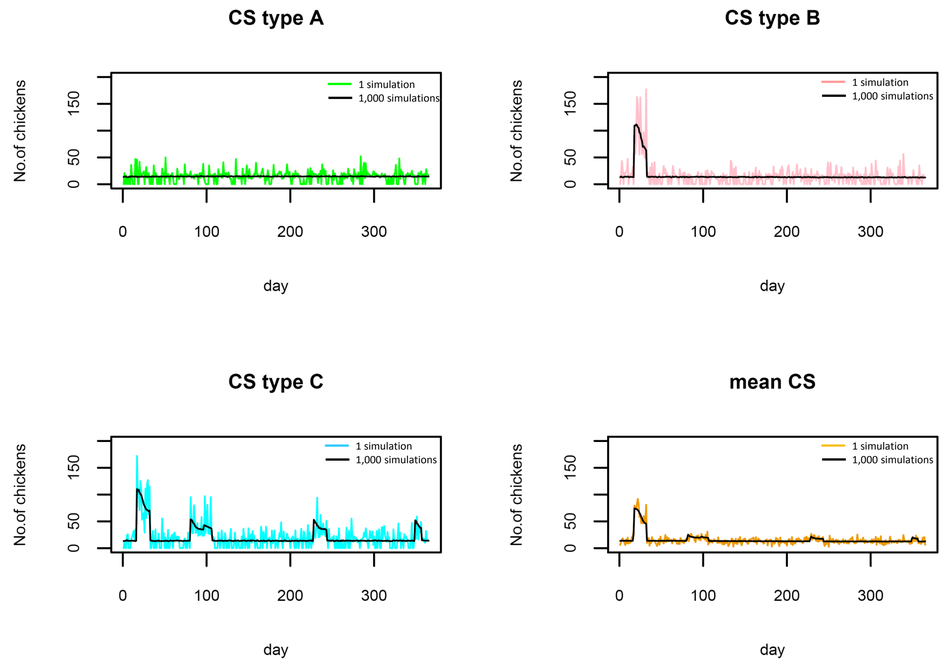

Fig. 4. Simulated temporal pattern of backyard chickens trade for each type of collector-slaughterhouse (CS) and the mean from 8 CSs in a year-round (365 days). CS type A: no change; CS type B: collect more chickens only during Chinese New Year and CS type C: collect more chickens during Chinese New Year and other major festivals.

Discussion and Conclusions

Traditional networks related to the trade of backyard chickens in Phitsanulok province (Thailand) involve many actors, including chicken collectors and villages connected to different sub-networks of collectors that can play important roles in disease spread. The spatiotemporal model we developed made it possible to quantify the catching behavior of chicken collectors according to major festivals in Thailand, and highlighted the importance of Chinese New Year. Further developments include the dynamic modeling of HPAI H5N1 spread into traditional trade networks.