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Modeling a stochastic avian influenza model under regime switching and with human-to-human transmission. (English) Zbl 07336049

By constructing suitable Lyapunov functions and a bounded domain, this paper establishes the existence of stationary distribution of an avian influenza model under regime switching, giving sufficient conditions for the extinction of the disease. A synopsis of the paper, consisting of four sections, goes as follows. §2 presents a stochastic avian influenza model under regime switching and with human-to-human transmission, proving the positivity of the model solution. §3 shows that there is an ergodic stationary distribution of the stochastic system. §4 presents sufficient conditions for extinction of stochastic bird and human systems. Some numerical simulations are given to assure the theoretical results.

Reviewer: Hirokazu Nishimura (Tsukuba)

MSC:

37N25	Dynamical systems in biology
60H10	Stochastic ordinary differential equations (aspects of stochastic analysis)
60J28	Applications of continuous-time Markov processes on discrete state spaces
60J65	Brownian motion
92D30	Epidemiology

Keywords:

stochastic avian influenza model; white noise; Markovian switching; stationary distribution; extinction

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References:

[1] World Organisation for Animal Health, Avian Influenza Portal, http://www.oie.int/en/animal-health-in-the-world/web-portal-on-avian-influenza.

[2] Gumel, A. B., Global dynamics of a two-strain avian influenza model, Int. J. Comput. Math.86 (2009) 85-108. · Zbl 1154.92032

[3] Liu, Z. and Fang, C., A modeling study of human infections with avian influenza A H7N9 virus in mainland China, Int. J. Infect. Dis.41 (2015) 73-78.

[4] Nickbakhsh, S.et al., Modelling the impact of co-circulating low pathogenic avian influenza viruses on epidemics of highly pathogenic avian influenza in poultry, Epidemics17 (2016) 27-34.

[5] Gonzales, J. L.et al., Risk based surveillance for early detection of low pathogenic avian influenza outbreaks in layer chickens, Prev. Vet. Med.117 (2014) 251-259.

[6] Xiao, Y., Sun, X., Tang, S. and Wu, J., Transmission potential of the novel avian influenza A(H7N9) infection in mainland China, J. Theor. Biol.352 (2014) 1-5. · Zbl 1412.92303

[7] Saucedo, O. and Martcheva, M., Competition between low and high pathogenicity avian influenza in a two-patch system, Math. Biosci.288 (2017) 52-70. · Zbl 1377.92100

[8] Chong, N. S., Tchuenche, J. M. and Smith, R. J., A mathematical model of avian influenza with half-saturated incidence, Theory Biosci.133 (2014) 23-38.

[9] Yin, Q., Feng, G. and Zhang, X., Dynamics of two avian influenza models, Math. Appl.28(3) (2015) 481-489(in Chinese).

[10] Iwami, S., Takeuchi, Y. and Liu, X., Avian-human influenza epidemic model, Math. Biosci.207 (2007) 1-25. · Zbl 1114.92058

[11] Chong, N. S. and Smith, R. J., Modeling avian influenza using Filippov systems to determine culling of infected birds and quarantine, Nonlinear Anal. RWA24 (2015) 196-218. · Zbl 1330.34075

[12] Nisbet, R. M. and Gurney, W., Modelling Fluctuating Populations (Wiley, Hoboken, 1982). · Zbl 0593.92013

[13] Wang, R. H.et al., A simple stochastic model with environmental transmission explains multi-year periodicity in outbreaks of avian flu, PLoS One7(2) (2012) e28873.

[14] Mao, X., Marion, G. and Renshaw, E., Environmental Brownian noise suppresses explosions in population dynamics, Stoch. Process. Appl.97 (2004) 95-110. · Zbl 1058.60046

[15] Greenhalgh, D., Liang, Y. and Mao, X., SDE SIR model with demographic stochasticity and varying population size, Appl.

Math. Comput.276 (2016) 218-238. · Zbl 1410.92120

[16] Gray, A.et al., A stochastic differential equation SIS epidemic, SIAM J. Appl. Math.71 (2011) 876-902. · Zbl 1263.34068

[17] Chang, Z., Meng, X. and Zhang, T., A new way of investigating the asymptotic behaviour of a stochastic SIS system with multiplicative noise, Appl. Math. Lett.87 (2019) 80-86. · Zbl 1426.60069

[18] Tuckwell, H. C. and Williams, R. J., Some properties of a simple stochastic epidemic model of SIR type, Math. Biosci.208 (2007) 76-97. · Zbl 1116.92061

[19] Schurz, H. and Tosun, K., Stochastic asymptotic stability of SIR model with variable diffusion rates, J. Dyn. Differ. Equ.27 (2015) 69-82. · Zbl 1312.60077

[20] Liu, Q. and Jiang, D., The threshold of a stochastic delayed SIR epidemic model with vaccination, Phys. A461 (2016) 140-147. · Zbl 1400.92517

[21] Xu, Y., Allen, L. J. S. and Perelson, A. S., Stochastic model of an influenza epidemic with drug resistance, J. Theor. Biol.248(1) (2007) 179-193. · Zbl 1451.92318

[22] Yuan, Y. and Allen, L. J. S., Stochastic models for virus and immune system dynamics, Math. Biosci.234(2) (2011) 84-94. · Zbl 1244.92043

[23] Zhang, X., Jiang, D., Alsaedi, A. and Hayat, T., Stationary distribution of stochastic SIS epidemic model with vaccination under regime switching, Appl. Math. Lett.59 (2016) 87-93. · Zbl 1343.60095

[24] Takeuchi, Y., Du, N., Hieu, N. and Sato, K., Evolution of predator-prey systems described by a Lotka-Volterra equation under random environment, J. Math. Anal. Appl.323 (2006) 938-957. · Zbl 1113.34042

[25] Wei, Q., Xiong, Z. and Wang, F., Dynamic of a stochastic SIR model under regime switching, J. Inf. Comput. Sci.10(9) (2013) 2727-2734.

[26] Qi, K. and Jiang, D., Threshold behavior in a stochastic HTLV-I infection model with CTL immune response and regime switching, Math. Methods Appl. Sci.41 (2018) 6866-6882. · Zbl 1405.35229

[27] Li, X., Gray, A., Jiang, D. and Mao, X., Sufficient and necessary conditions of stochastic permanence and extinction for stochastic logistic populations under regime switching, J. Math. Anal. Appl.232 (2009) 427-448. · Zbl 1205.92058

[28] Guo, X. and Luo, J., Stationary distribution and extinction of SIR model with nonlinear incident rate under Markovian switching, Phys. A505 (2018) 471-481.

[29] Zhang, X., Global dynamics of a stochastic avian-Chuman influenza epidemic model with logistic growth for avian population, Nonlinear Dyn.90(4) (2017) 2331-2343. · Zbl 1393.37097

[30] Chen, C. Y., Ward, J. P. and Xie, W. B., Modelling the outbreak of infectious disease following mutation from a non-transmissible strain, Theor. Popul. Biol.126 (2019) 1-18. · Zbl 1412.92274

[31] Shi, Z., Zhang, X. and Jiang, D., Dynamics of an avian influenza model with half-saturated incidence, Appl. Math. Comput.355 (2019) 399-416. · Zbl 1428.92117

[32] Centers for disease control and prevention (CDC), Bird flu in people, https://www.cdc.gov/flu/avianflu/avian-in-humans.htm.

[33] Brown, J. D.et al., Avian influenza virus in water: Infectivity is dependent on pH, salinity and temperature, Vet. Microbiol.136 (2009) 20-26.

[34] Wang, L. and Jiang, D., Ergodic property of the chemostat: A stochastic model under regime switching and with general response function, Nonlinear Anal. Hybrid Syst.27 (2018) 341-352. · Zbl 1379.92032

[35] Liu, Q., The threshold of a stochastic susceptible-infective epidemic model under regime switching, Nonlinear Anal. Hybrid Syst.21 (2016) 49-58. · Zbl 1358.92092

[36] Zhu, C. and Yin, G., On hybrid competitive Lotka-Volterra ecosystems, Nonlinear Anal.71 (2009) 1370-1379. · Zbl 1238.34059

[37] Mao, X., Marion, G. and Renshaw, E., Environmental noise suppresses explosion in population dynamics, Stoch. Process. Appl.97 (2002) 95-110. · Zbl 1058.60046

[38] Lipster, R., A strong law of large numbers for local martingales, Stochastics3 (1980) 217-228.

[39] Higham, D. J., An algorithmic introduction to numerical simulation of stochastic differential equations, SIAM Rev.43 (2001) 525-546. · Zbl 0979.65007

[40] Mao, X. and Yuan, C., Stochastic Differential Equations with Markovian Switching (Imperial College Press, 2006). · Zbl 1126.60002