A COMPUTER SIMULATION ON NEWCASTLE DISEASE SPREAD IN CHICKENS

Corresponding Author: Douglas M. Doloriel[1]
Surigao del Sur State University
Tagbina, Surigao del Sur, Philippines
douglas_doloriel@yahoo.com
+639213033518

Ariston O. Ronquillo
Surigao del Sur State University
Tagbina, Surigao del Sur, Philippines
r_ariston@yahoo.com
+639399263797

Nancy S. Doloriel
Surigao del Sur State University
Tagbina, Surigao del Sur, Philippines
ndoloriel2009@gmail.com
+639462276293

Abstract

Newcastle Disease (NCD) is one of the viral diseases that occasionally infect chickens. Spread of NCD is through exposure with contaminated exhaled air, feces and respiratory discharges from infected birds. This paper examined the factors that determined the rate of NCD spread. Results indicate that high contact of flock with contaminated exhaled air, feces and respiratory discharges coupled with short time chickens spent with flock yielded highest NCD infection rates in chickens.

Keywords: chickens,Newcastle Disease (NCD), Newcastle Disease Virus (NDV), velogenic, mesogenic, ventogenic, morbidity, mortality rate

1.0 Introduction

Chickens (*Gallus gallusdomesticus*) are gregarious birds and live together in flocks. Currently, there are approximately 180 million chickens in our country

(www.countrystat.psa.gov.ph) wherein 45% of these are native and kabir chickens while 37% and 18% are broilers and layers, respectively. Chickens are raised mainly for their meat and eggs. Chickens are also valued for pest control and for manure fertilizer. Conversely, there are factors that bound growth of flock such as poultry diseases and feed resources.

Chickens are susceptible to many infectious diseases. One of the most important of these is the viral disease known as Newcastle Disease (NCD), which causes devastating losses in both commercial and village chickens (Grimes, 2002).NCD is caused by a gram-negative, single-stranded RNAparamixovirus. NCD spread is through exposure with contaminated exhaled air, feces and respiratory discharges from infected birds. NCD outbreak results in up to 100% mortality (Saidu and Abdu, 2008; Alders and Spradbrow, 2001).

There are three (3) strains of virulent Newcastle Disease Virus (NDV). *Velogenic* strains are highly virulent, spreads rapidly and cause up to 100% mortality. *Mesogenic* strains have intermediate virulence, cause coughing, affect egg quality and production and could cause up to 10% mortality.*Ventogenic* strains produce mild signs with negligible mortality. Chansiriponchaiand Sasipreeyajan (2006), mentioned that incubation period of NCD is usually 5-6 and up to 15 days. NCD affects respiratory, gastro-intestinal and nervous systems of infected birds. Common symptoms include listlessness, increased respiratory rate, yellowish to greenish diarrhea and weakness followed by prostration and death (Okwor and Eze, 2010).

Some factors influence the range and severity of the clinical signs of NCD as perceived from aforementioned studies. These factors include virulence of the strain, climatic factors, systems of production, management factors and flock density.

The model of the study will be generated from the software called NetLogo (version 5.2.1), an agent-based programming language and integrated modelling environment (Kornhauser et al.,

2007). The study aims to determine the Newcastle Disease (velogenic strain - highly virulent) spread on chickens.

2.0 Model Definition

The Newcastle Disease model relies on the comprehensible behavior of chickens in a rural scenario. It recognizes the potent infecting nature of the NCD, specifically the highly virulent strain (velogenic) wherein it can infect 100% of the flock and cause up to 90% mortality.

The model relies on the following basic assumptions that:

- chickens are social birds and live together in flocks
- native chickens are free ranged, spent time mostly foraging for food, high contact with birds, wild fowls and other poultry
- native chickens' diet are insects, earthworms, plant parts and left-overs of humans, pets and other chicken breeds
- native chickens spend less time with the flock and marketed at 5 to 6 months of age weighing a kilogram
- kabir chickens are semi-confined (controlled feeding (commercial ration) and ranging)
- kabir chickens covered short distances (area) due to big-bodied breed
- chicks undergo artificial incubation, low incidence of inbreeding and most of the time is spent with flock
- broilers (chickens farmed for meat) are confined in pens and fed *ad libitum*
- broiler chicks undergo artificial incubation
- broiler chickens spend all the time with the flock and have less contact with birds and other poultry species
- layer chickens are confined in pens or cages and are controlled-fed

- That the viral strain of Newcastle Disease Virus is of the velogenic type (highly virulent)
- That the velogenic type has 100% morbidity and 90% mortality rate in chickens

The model mimics the scenario initially with the NCD virus coming in contact with a healthy chicken and infecting that chicken. The sick chicken then spread the disease through exhaled air, fecal matter and respiratory secretions to the flock.

The model's scenario is revealed below:

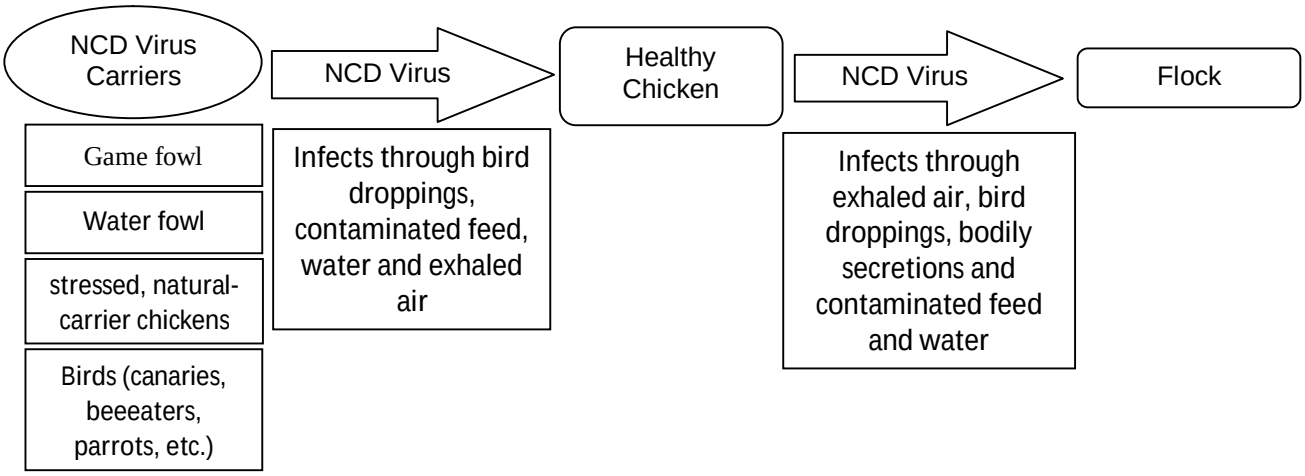

Figure 1.Schematic Diagram of the Model's Scenario

Parameters

The present scenario of Newcastle Disease infecting chickens is the subject of the algorithm which will be coded based on the following model parameters:

1. Initial Number of Chickens
2. Average Contact of Chickens with Exhaled Air, Feces/Droppings and Respiratory Discharges
3. Average Time Chicken Spent with the Flock
4. Average NCD Vaccinations in a Year
5. Average Blood/Sera Testing

This study will make use of the existing AIDS model of Uri Wilensky (2007), found in the net logo models library with the following changes in the parameter definition, which is shown in Table 1.

Table 1. Analysis on the Parallelism of Parameters Used in Different Model

Parameters in AIDS Model	**Parameters in Newcastle Disease Model**
Initial-People	Initial Number of Chickens
Average Coupling Tendency	Average Contact of Chicken with Exhaled Air, Feces and Respiratory Discharges in a Flock (A)
Average Commitment (weeks)	Average Time Chicken Spent With the Flock (weeks) (B)
Average Condom Use	Average Vaccinations in a Year
Average Test Frequency (0.00 times/year)	Average Blood/Sera Testing (0.00 times/year)

The rate of Newcastle Disease (NCD) spread can be patterned with the AIDS virus model. The spread of AIDS virus originate from attached individuals (couple) finding work in far-flung places away from the family. Infidel individuals then get in contact with other individuals and in the process acquired the virus. The spread of the virus starts when that individual goes back to its family and spread first the virus to the spouse. The infidel spouse then has sexual encounters with other partners and so with the spread of the disease.

Same pattern could be said with NCD virus. NCD virus originate from chickens going long distances searching for food or a mate and in the process gets in contact with wild fowls, birds and other poultry species such as ducks, etc. that are natural carriers of NCD virus. The wandering chicken then acquired the virus and spread it when it gets back to the flock. This chicken carrying the virus will also infect other chickens the next time it gets in contact with other chickens it will meet in the way when foraging for food or seeking a mate and so the spread of the disease.

3.0 Research Design and Methods

In this study, the variable of interest is the percentage of chickens infected with NCD virus at any given time. This shows the virulence of NCD and its infection rate to the flock.

Since the study suggests that the rate of NCD spread is influenced by contact of chickens with contaminated air, feces/droppings and respiratory discharges in a flock, we set up a computer simulation experiment. In this simulation, we controlled the indicators of the flock's movement such as: (A) average contact of flock with exhaled air, feces and respiratory discharges and (B) average time chicken spent with the flock and then observed the percentage of NCD infection rate under each combination of indicators. Each indicator is set at three (3) levels: low (0), average (2.5) and high (5) in (A) and short (0), average (25) and long (50) in (B). Initial number of chickens for all chicken breeds was fixed at 500 heads.

The experimental design is a 3X3 Two Factorial Experimental Design. This factorial experimental design yields nine (9) possible treatment combinations. Twenty (20) observations were generated to allow approximation of interaction effects of various levels of indicators. This brings the total sample size to 180 random observations.

For each combination of the two factors, the simulation generates an initialnumber of infected chickens. This random number is obtained from a uniform probability distribution on the interval [0, 2.5 and 5 for (A) and 0, 25 and 50 for (B)]. Random observations from this distribution will have a mean of 0.84, 2/09 and 3.8 for (A) and 8.33, 20.84 and 37.5 for (B) and standard deviation of $\sqrt{\frac{1}{12}}$.

The data obtained were subjected to a two-way analysis of variance (ANOVA) with interaction effects. Two (2) main effects were measured: A, and B interactions effects were

observed which wasA x B. Each of these effects specified the combinations of indicators that led to faster NCD infection rates.

4.0 Results and Discussion

Table 2 shows the data collected from the simulation of NCD infection rate in chickens using the two indicators with three levels.

Table 2.Data Collected from the Simulation of Agent-based Model onNewcastle Diseaseof Chickens (%)

		Average Contact of Chicken with Exhaled Air, Feces and Respiratory Discharges in a Flock		
		Low (1.67 and below)	Average (1.68-2.5)	High (2.6 and above)
Average Time Chicken Spent With the Flock (weeks)	Short (16.67 and below)	2.78 3.33 2.78 2.78 2.78 2.78 2.78 2.78 3.33 2.78 2.78 2.78 2.78 2.78 3.33 3.33 3.33 3.33 2.78 3.89 2.78 2.78 2.78 2.78 3.33 2.78 2.78 2.78 3.33 2.78	11.67 13.33 7.22 15.00 5.56 12.22 4.44 5.00 7.78 4.44 4.44 3.33 6.11 8.89 7.78 10.00 4.44 13.33 17.78 3.89 6.11 6.67 13.33 14.44 12.78 10.00 6.67 8.33 10.00 10.00	68.89 73.89 79.44 55.56 70.00 63.89 36.67 64.44 64.44 68.89 72.22 45.00 61.67 59.44 56.67 49.44 39.44 60.56 76.11 49.44 46.11 62.22 21.11 57.22 81.11 68.89 77.22 51.11 43.89 57.22
	Average (16.68-25)	3.89 2.78 2.78 2.78 3.89 3.33 3.33 2.78 2.78 3.89 3.33 2.78 3.33 3.33 3.89 3.33 2.78 2.782.78 2.78 2.78 3.332.78 4.44 2.78 3.332.78 2.78 2.78 2.78	7.227.22 15.56 6.112.78 6.115.56 4.44 3.89 2.78 5.566.67 6.11 6.11 10.56 5.56 6.67 5.00 6.67 7.78 11.67 13.89 6.67 3.33 9.44 6.67 5.56 7.78 7.78 10.00	38.3332.2231.67 35.5635.00 16.6726.11 18.8928.33 36.11 10.0038.8935.5627.2238.89 42.7831.67 17.22 40.0020.00 18.89 24.44 34.4422.22 36.67 37.7839.4425.0021.6726.11
	Long (25 and above)	2.78 2.78 2.78 2.78 2.78 2.78 2.78 2.78 2.78 2.78 3.332.78 2.78 3.893.33 3.893.33 2.78 2.78 3.333.892.783.332.782.78 2.782.78 3.89 4.44 2.78	5.008.336.113.337.78 5.003.894.444.44 4.44 4.447.228.33 4.448.89 8.33 3.89 5.569.44 3.89 4.446.675.56 5.56 5.00 7.78 6.11 4.44 11.11 4.44	17.22 8.33 10.56 8.89 22.78 22.78 11.11 2.78 11.11 15.00 18.89 20.56 10.56 12.7823.33 21.11 27.22 17.22 11.67 13.33 12.78 3.33 15.56 28.89 6.11 18.33 13.89 19.44 20.5610.56

Table 3 shows the two-way table for the effects of Factor A (average contact of flock with exhaled air, feces and respiratory discharges) and Factor B (average time chicken spent with the flock (weeks):

Table 3.Effect of Contact of Chicken with Exhaled Air, Feces and Respiratory Discharges in a Flock and Time Chicken Spent With the Flock on Newcastle Diseaseof Chickens(%)

		Average Contact of Chicken with Exhaled Air, Feces and Respiratory Discharges in a Flock		
		Low (1.67 and below)	Average (1.68-2.5)	High (2.6 and above)
Average Time Chicken Spent With the Flock (weeks)	Short (16.67 and below)	2.96	8.83	59.41
	Average (16.68-25)	3.13	7.04	29.59
	Long (25 and above)	3.08	5.94	15.22

High contact of flock with exhaled air, feces and respiratory discharges yielded high newcastle disease at short time the chicken spent with flock.

Table 4.Two-way ANOVA for New Castle Disease of Native Chickens

Sources	*d*f	SS	MS	*F*	*p* –value
Main Effects					
Average Contact of Flock with Exhaled Air, Feces and Respiratory Discharges (A)	2	11449.7	5724.8	151.95	**0.000**
Average Time Chicken Spent with the Flock (weeks) (B)	2	53286.9	26643.5	707.19	**0.000**
Interaction Effects					
Treatment A x B	4	19154.4	4788.6	127.10	**0.000**
Error	261	9833.2	37.7		
Total	269	93724.2			

Analysis of variance (ANOVA) for NCD of chickens is presented in Table 4. The table shows that *p*-value of main effects, i.e. average contact of flock with exhaled air, feces and respiratory discharges (A) and average time chicken spent with the flock (B) and its interaction (A X B) have significant effect on the rate of infection of NCD on native chickens. As the level of average contact of flock increases and average time chicken spent with flock decreases, the rate of NCD infection increases.

Discussion and Interpretation

Although proper management practices such as culling, sanitation on poultry house and proper feeding/supplementation on chickens act as restriction, however, cannot overcome the spread of this highly infectious disease.

5.0 Conclusion and Policy Recommendation

Fastest rate of NCD spread on chickens is achieved if there is high contact of flock with exhaled air, feces and respiratory discharges of infected birds and short time chickens spent with the flock.

Rate of NCD infection on chickens in can be averted if the system of production will be altered to minimize disease spread. Combination of free range during season of least disease spread and restriction during outbreak season will lessen/minimize NCD spread. Also, limiting/culling of chickens over two (2) years of age will eliminate natural reservoirs of NCD virus in a flock. Lastly, proper management practices such as sanitation on housing and proper feeding and timely culling should be observed to minimize/eliminate NCD disease spread.

6.0 Literature Cited

Alders, R. and Spradbrow, P.B. 2001. Controlling Newcastle Disease in Village Chickens: A Field Manual. Australian Center for International Agriculture Research (ACIAR). Canberra, Australia. p. 112.

Chansiripomchai, N. and Sasipreeyajan, J. 2006. Efficacy of live B1 or ulster 2C Newcastle Disease vaccines simultaneously vaccinated with inactivated oil adjuvant vaccine for protection of Newcastle Disease virus in broiler chickens. Acta Vet. Scand., 48:1-4.

Grimes, S.E. 2002. A basic laboratory manual for the small-scale production and testing of

I-2 Newcastle disease vaccine. RAP PUBLICATION 2002/22. http://www.fao.org/DOCREP/005/AC802E/AC802E00.HTM

Okwor, E.C. and Eze, D.C. 2010. The Annual Prevalence of Newcastle Disease in Commercial Chickens Reared in South Eastern Savannah Zone of Nigeria. Journal of Poultry Science 3: (2) 23-26.

Saidu, L. and Abdu, P.A. 2008. Outbreak of viscerotrophicvelogenic form of Newcastle Disease in vaccinated six week old pullets. Sokoto J. Vet. Sci., 7: 37-40.