RATE OF NEWCASTLE DISEASE SPREAD AMONG CHICKENS: COMPARATIVE SIMULATION EXPERIMENT

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Abstract

Newcastle Disease (NCD) is one of the deadly diseases that occasionally infect chickens. Transmission occurs by exposure to contaminated exhaled air, feces, and respiratory discharges. This paper determined the rate of NCD spread among chickens. Six (6) comparisons were made from the combination of four (4) breeds of chickens in this comparative simulation expirement. Results indicate that significant differences in NCD infection rates can be observed between each of the four (4) breeds of chicken. Layer chickens have significantly fastest NCD infection rate among the chicken breeds.

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

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1.0 Introduction

The chicken (*Gallus gallusdomesticus*) is a domesticated fowl. It is a subspecies of the red jungle fowl. At 19 billion in 2011, there are more chickens in the world than any species of bird or domestic animal (FAO, 2011). Humans raise chickens for meat, eggs, special festivities and traditional ceremonies (Alders and Spradbrow, 2000). Chickens are also active in pest control and provide manure fertilizer. However, several factors limit flock expansion of chickens such as feed resources and poultry diseases.

One of the deadly diseases that occasionally infect chickens is the Newcastle Disease (NCD) wherein its outbreak could result in a mortality up to 100% (Alders and Spradbrow, 2001; Saidu and Abdu, 2008). The Newcastle Disease Virus (NDV) is the causative agent of NCD. NDV is a single-stranded, gram-negative RNA virus. NCD spread is through contact with manure and other secretions from infected/diseased birds, contaminated food, water, equipment, and clothing.

There are three (3) categories of NDV strains. Velogenic strains are highly virulent, spreads rapidly, produce severe nervous and respiratory signs, and cause up to 90% mortality. Mesogenic strains have intermediate virulence and cause coughing, affect egg quality and production and result in up to 10% mortality. Ventogenic strains are non-virulent and produce mild signs with negligible mortality. The incubation period of NCD is usually 5-6 days but can vary from 2-15 days (Chansiripomchai and Sasipreeyajan, 2006). Okwor and Eze (2010) also reported that Newcastle Disease affects the respiratory, gastrointestinal and nervous systems of the infected birds with common signs of listlessness, increased respiratory rate, yellowish to greenish diarrhea and weakness followed by prostration/incapacitation and death.

It can be perceived from aforementioned studies that the range and severity of the clinical signs of Newcastle Disease can be influenced by some factors. These factors include virulence of the viral strain, age and condition of the birds, climatic conditions and density of the flock.

The model of the study was 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 rate of Newcastle Disease (velogenic strain - highly virulent) spread on chickens.

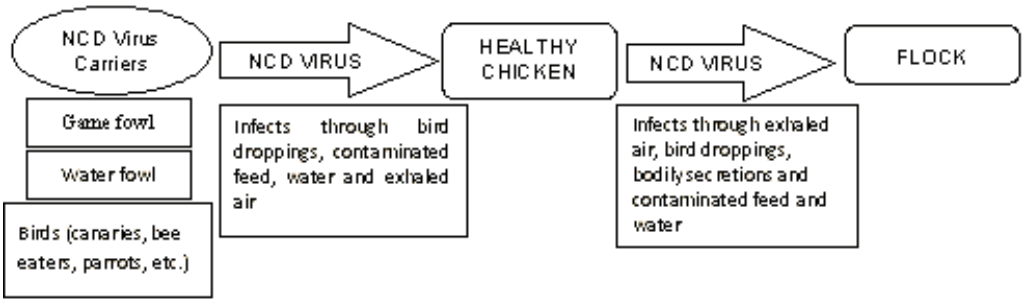

Figure 1. Schematic Diagram of the Scenario

2.0 Model Definition

The Newcastle Disease model relies on the comprehensible behavior of chickens in an actual 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 gregarious birds and live together in flocks
>That native chickens are free-ranged in a rural scenario
>That layers (chickens farmed for eggs) are confined in cages or pens
>That broilers (chickens farmed for meat) are confined in pens
>That Kabir chickens (chickens farmed for meat) are semi-confined
>That the native chickens are always in contact with water fowls, game fowls, and aerial birds
>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 simulates the scenario starting 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. This scenario is shown in first page.

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

Parameters in Virus Model	Parameters in Newcastle Disease Model
Number People **A**	Initial Number of Chickens **A**
	Average Contact of Chickens with Exhaled Air, Feces and Respiratory Discharges **B**
	Average Time Chicken Spent With the Flock **C**
Infectiousness (%) **B**	Infectiousness (%) **D**
Chance-Recover (%) **C**	Chance-Recover (%) **E**
Duration (weeks) **D**	Duration (days) **F**

PARAMETERS

This study used of the existing Virus 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.

Four (4) parameters are included in the Virus Model. These parameters are: Number People (A), Infectiousness (B), Chance-Recover (C) and Duration (D).

Two (2) parameters were added in Newcastle Disease Model. The parametrs in the Newcastle Disease Model are: Initial Number of Chickens (A), Average Contact of Chickens with Exhaled Air, Feces and Respiratory Discharges (B), Average Time Chicken Spent with Flock (C), Infectiousness (D), Chance-Recover (E) and Duration (F).

Average contact of chickens with exhaled air, feces and respiratory discharges and average time chicken spent with flock were included because they are the means wherein NCD infection could be disseminated in a flock. The unit for Duration (F) parameter was changed to days instead of weeks in the Virus Model because NCD causes infection in days and infects an entire flock in an average of 30 days.

In an actual scenario, usually the first to be contracted with NCD are the native chickens, due to their system of production. Native chickens are free-ranged. They roam around the village searching for food. They are the first to get in contact with game fowls, waterfowls and birds. Usually, these fowls and birds are natural carriers of the virus they acquired from other species of fowls and birds such as the exotic birds and chickens they have socialized with. Natural carriers are individuals who have the virus but do not show symptoms of the disease.

Infected native chickens then spread the virus when they roam around searching for food and come across chicken farms. These native chickens then eat the left-overs or rations and socialize or get in contact with other breeds or farm chickens such as the layers, broilers, and kabirs. The spread of disease is then rapid due to the system of production of these chicken breeds.

The following are the typical characteristics of aforementioned breeds of chickens: 1) native – chickens raised for meat and eggs. They are free-ranged and have an average lifespan or reach market weight in five (5) to six (6) months, 2) layers – are chickens farmed for their eggs. They are usually kept in cages or pens by hundreds or thousands. Layers reach one and a half (1.5) years before culled. They are vaccinated against NCD but of the ventogenic strain (non-virulent), 3) broilers – chickens farmed for meat only. Nowadays, broilers reach market weight in less than a month. Some producers vaccinate broilers with the ventogenic strain of NCD and 4) kabirs – big, hardy chickens farmed for meat only. They reach market weight in three (3) to four (4) months.

3.0 Research Methodology

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 a couple of factors (Table 1), we set up a computer simulation experiment. In this simulation, we controlled the indicators of the chicken's movement in a flock and observed the percentage of NCD infection rate under each combination of indicators.

Table 2. Data Gathered on Actual Activity of Chicken in Their Flock

Parameters	Breed of Chicken			
	Kabir	Native	Broiler	Layer
Initial Number of Chickens (A)	75	70	100	500
Ave. Contact of Chicken with Exhaled Air, Feces and Respiratory Discharges (B)	70	40	100	100
Ave. Time Chicken Spent with Flock (C)	100	17	100	100

Parameters A (Initial Number of Chickens), B (Average Contact of Chicken with Exhaled Air, Feces and Respiratory Discharges) and C (Average Time Chicken Spent with Flock) are set based on the data/value gathered by the researchers observed on the actual activity of the chicken in their flock (Table 2).

Parameters D, E, and F were held constants in this simulation. Infectiousness (D) was placed at 100%, Chance-Recover (E) was set at 10% (from 90% mortality rate of velogenic strain) and Duration (F) was placed at the maximum of 30 days.

Six (6) comparisons were made from the combination of four (4) breeds of chickens in this comparative simulation experiment. Ten (10) observations were generated for each breed of chicken run with the given set of indicators. A 2 sample T-Test was used to test differences of data on NCD infection rates between breeds of chickens.

4.0 Results and Discussion

Table 3 shows the data collected from the simulation of NCD in chickens. In this study, the highest average infection rate was observed in layers having 99.7%, followed by broiler chickens with 42.9%, native chickens with 36.1% and Kabir chickens had the least with 35.1%.

Statistical analysis using the 2 Sample T-Test showed that the p-value in Tables 4 to 9 for the six (6) comparisons of the four (4) chicken breeds are higher than their T-value. This indicates significant differences on NCD infection rates between each chicken breed.

In Table 4, native chickens have significantly faster NCD rate with 36.11% compared to Kabir chickens having 35.11%.

Layer chickens with 99.68% have significantly faster NCD infection rate compared to broiler chickens (42.9%) as shown in Table 5. This could be due to the higher density of layers (500 heads) compared to broilers (100

Table 4. NCD Infection Rates Between Kabir and Native Chickens

Breed of Chicken	Mean	SD	T-Value	P
Kabir	35.11	9.35	-0.24	0.811
Native	36.11	8.69		
Difference	-0.98			

Table 5. NCD Infection Rates Between Broiler and Layer Chickens

Breed of Chicken	Mean	SD	T-Value	P
Broiler	42.9	10.8	-16.18	0.000
Layer	99.68	0.235		
Difference	-56.81			

Table 6. NCD Infection Rates Between Kabir And Broiler Chickens

Breed of Chicken	Mean	SD	T-Value	P
Kabir	35.13	9.35	-1.72	0.104
Broiler	42.9	10.8		
Difference	-7.74			

Table 3. Data Collected from the Simulation of Agent-based Model on Newcastle Disease of Chickens

	% Infected of New Castle Disease of Chickens										
Breed of Chicken	1	2	3	4	5	6	7	8	9	10	Average
Kabir	25.6	28.1	28.4	32.1	31.0	50.0	42.9	46.2	24.4	42.6	35.1
Native	46.7	27.5	36.6	34.5	50.0	44.6	23.5	34.4	28.2	35.1	36.1
Broiler	33.9	30.5	42.1	43.1	56.1	31.3	44.3	63.8	36.4	47.2	42.9
Layer	99.8	99.4	99.6	99.6	100.0	99.8	99.8	99.8	99.2	99.8	99.7

Table 7. NCD Infection Rates Between Kabir and Layer Chickens

Breed of Chicken	Mean	SD	T-Value	P
Kabir	35.11	9.35	-21.83	0.000
Layer	99.68	0.235		
Difference	-64.55			

Table 8. NCD Infection Rates Between Native And Broiler Chickens

Breed of Chicken	Mean	SD	T-Value	P
Native	36.11	8.69	-1.54	0.141
Broiler	42.9	10.8		
Difference	-6.76			

Table 9. Comparative NCD infection rates between native and layer chickens

Breed of Chicken	Mean	SD	T-Value	P
Native	36.11	8.69	-23.12	0.000
Layer	99.68	0.235		
Difference	-63.57			

heads) in the actual scenario.

Table 6 shows broiler chickens (42.9%) having significantly faster NCD infection rate compared to kabir chickens (35.11%). This could be due to the higher initial number of chickens (A) and average contact of chicken with exhaled air, feces and respiratory discharges (B) of broilers than kabirs. The two breeds have a difference of 7.74% infection rate.

Table 7 shows layers (99.68%) having significantly faster NCD rates than kabirs (35.11%). This could be due to the higher initial number of chickens (A) and average contact of flock with exhaled air, feces and respiratory discharges (B) of layers compared to kabir chickens.

Broiler chickens with 42.9%, have significantly faster NCD infection rate compared to native chickens (36.11%) as shown in Table 8. Broiler chickens have higher values in parameters A, B and C compared to native chickens. The two breeds have a difference of 6.76 % in infection rates.

Layer chickens with 99.68% have significantly faster NCD infection rate compared to native chickens with 36.11% as shown in Table 9. NCD infection rates of the two breeds have a difference of 63.57%.

5.0 Conclusion

Significant differences on NCD infection rates can be observed between each of the four (4) breeds of chicken. Layer chickens have significantly fastest NCD infection rate among the chicken breeds.

References

\Alders, R. and Spradbrow, P.B. 2000. Newcastle Disease in Village Chickens: A Field Manual. Australian Center for International Agriculture Research (ACIAR). Canberra, Australia. p. 37.

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.

Food and Agriculture Organization (FAO). 2011. As reported in the Economist. Kornhauser, D., Wilensky, U., and Rand, W. 2009

Design Guidelines for Agent Based Model Visualization. Journal of Artificial Societies and Social Simulation. JASSS, 12(2),1.

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 viscerotropicvelogenicform of Newcastle Disease in vaccinated six-week old pullets. Sokoto J. Vet. Sci., 7:37-40.