A Computational Model for Orf Disease in Native/Upgrade Goats

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Abstract

Orf/soremouth/contagious ecthyma is a contagious disease that infects free range or teetered native/upgrade goats in the Philippines. It is caused by a parapoxovirus. Blister-like lesions typically develop around the body and secondary bacterial infections set in leading them to death. The paper observed the factors that determined the spread of orf disease on native/upgrade goats using the agent-based model. Nine (9) treatment combinations were made from this 3X3 two factorial simulation experiment. The findings of this study establish that infectiousness and chance-recover is statistically significant at 0.05 significance level. Selection of goat breeds highly tolerant to orf disease and observing proper herd health such as proper nutrition and eliminating stress to the herd would counteract the effect of orf disease spread.

Keywords: goats, orf/soremouth/contagious ecthyma, infectiousness, morbidity, mortality

1. Introduction

Goats are very popular among Filipinos because they require low initial capital investment, fit the smallhold farm conditions and multiply fast. Culturally, goats are integral to every special occasion such as birthdays, baptisms, weddings and fiestas. Hence, they command a higher price compared with other meats in the market (PCARRD, 2010). Goat production in the Philippines has two types: commercial and backyard. Backyard goat production involves the raising of native or upgrade breeds. They are usually free range or teetered. Nevertheless, several factors limit herd expansion of native/upgrade goats such as feed resources, system of production and diseases.

One of the contagious diseases that occasionally infect free range or teetered native/upgradegoats is the orf/soremouth/contagious ecthyma. It is caused by a parapoxovirus. Blister-like lesions typically develop on the mouth and muzzle approximately 4-8 days after the animal is exposed to the virus. These blisters become crusty scabs. Lesions can also be seen on other parts of the body including the face, teats, feet, vulva and scrotum. Severe painful lesions in and around the mouth of kids prevent them from nursing or eating. Does with lesions on their teats refuse to nurse their kids leading to starvation and death. Most adult goats with lesions will continue to eat and milk well. Animals with weakened immune system will show severe signs of the disease and secondary bacterial infections set in leading them to death (Motes and Motes, 2016).

The disease is spread via direct contact with an infected animal or indirectly from a contaminated environment (equipment, feed troughs, bedding). The virus enters the body through broken or damaged skin (e.g. coarse feeds that cause abrasions to the inside of the mouth). Nursing kids may spread the infection to the udders of susceptible does. The virus remains viable on the skin for approximately one month after the lesions have healed. Not only are scabs that fall to the ground a source of infection, but carrier animals, those that appear healthy but shed the virus, can also spread the disease (particularly during times of stress). The virus is very hardy, which makes it difficult to control. It can survive for months to years in cool, dry environments; but is destroyed by high and very low temperatures. Once infected, immunity to the disease is not life-long. Immunity is reported to last approximately 2-3 years. Reinfection after this time is possible, although the disease is less severe. Treatment of individually infected animals is not necessary unless lesions are severe. Severely affected kids will require good nursing care to ensure that they are eating and drinking. Does and ewes may require antibiotic treatment if they develop mastitis. Udder salves may be used to soften scabs on teats (Ontario Ministry of Agriculture, Food and Rural Affairs, 2016). Orf's morbidity is 100% and mortality rate is 25% (Molina, et al, 1982).

It can be perceived from aforementioned studies that disease spread of orf can be influenced by several factors. These factors include health and density of the goat herd, climatic conditions, management and system of production.

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., 2009). This studyaims to define the orf/soremouth/contagious ecthyma disease spread on native/upgrade goats in a village scenario.

2. Model Definition

The Orf Disease model relies on the coherentbehavior of native/upgrade goats in a rural scenario. It identifies the potent infecting nature of the Orf, where its morbidity is 100% and could cause 25% mortality in the herd.

The model relies on the following basic assumptions:

- That the native/upgrade goats are free range or teetered in a rural setting
- That some apparently healthy goats are carriers of the disease
- That the parapoxovirus could cause 100% morbidity and 25% mortality in a goat herd
- That the lesions could appear 4-8 days after a goat is infected with the virus
- That the infection could affect the entire herd in 1 to 2 months
- That the goats' immunity after infection lasts from 1 to 2 months up to 3 years after the entire herd is infected

The model simulates the scenario starting with the Orf virus in an apparently healthy carrier goat. The virus then is transmitted to the weakened/vulnerable goat via direct contact with an infected animal or indirectly from a contaminated environment (equipment, feed and water troughs, bedding). This scenario is shown below:

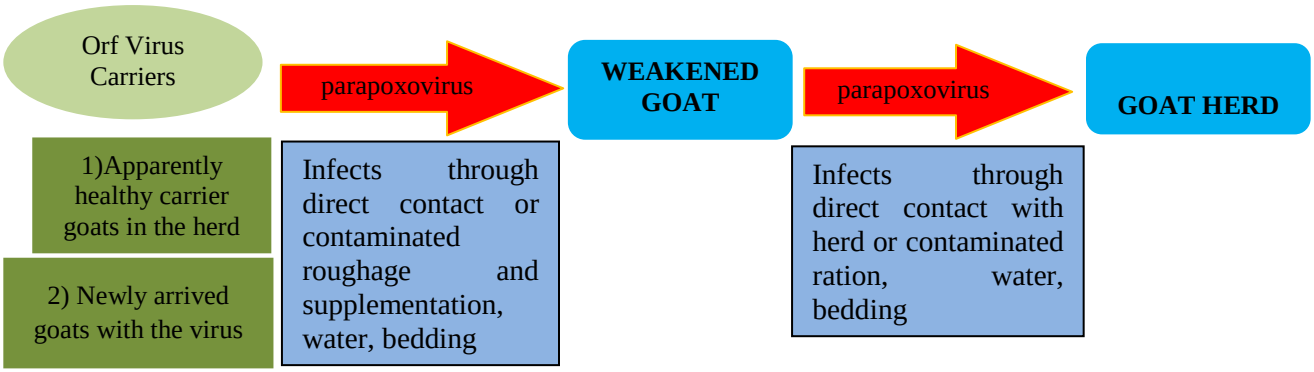

Figure 1.Schematic Diagram of the Scenario

Parameters

The present scenario of Orf Disease infecting native/upgrade goats is the subject of the algorithm which will be coded based on the following model parameters:

1. Initial Number of Goats
2.Infectiousness
3. Chance-Recover
4. Duration

This study usedthe existing Virus Model of Uri Wilensky (1998), 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 Virus Model

Parameters in Virus Model	Parameters in Orf Disease Model
Number People	Initial Number ofGoats
Infectiousness	Infectiousness
Chance-Recover	Chance-Recover
Duration	Duration

3. Research Design and Methods

The study assumed that the rate of orf disease range is influenced by native/upgrade goats' population. The researchers set up a computer simulation experiment. In this simulation, the researchers controlled key indicators such as: (A) infectiousness and (B) chance-recover and then observed the percentage of infection under each combination of indicators. Each indicator is set at three (3) levels, low (1), medium (2), and high (3). The experimental design is, therefore, a 3x3 two factorial experimental design.

The factorial experimental design yielded nine (9) possible treatment combinations. For each combination, thirty (30) observations were generated to allow the estimation of the interaction effects of the various indicators. This brings the total sample size to 270 random observations.

For each combination of the two factors, the simulation generated an initialnumber of goats. This number is obtained from a uniform probability distribution on the interval [0, 1]. Random observations from this distribution will have a mean of 0.50 and standard deviation of $\sqrt{\frac{1}{12}}$.

The data obtained were subjected to a two-way analysis of variance with interaction effects. Two (2) main effects were measured: A, and B interactions effects were observed which is A x B. Each of these effects specified the combinations of indicators that lead to faster orf disease infection rates.

Computer-simulated data on orf disease infection rate of native/upgrade goats is presented in Table 2.

Table 2.Computer-Simulated Data on Orf Disease Infection Rate in Native/Upgrade Goats (%)

		Infectiousness											
		Low				Medium				High			
Chance-Recover	Low	4.4	3.8	4.4	4.8	48.2	70.9	57.1	71.5	71.5	74.6	69.0	79.9
		1.3				51.6				67.6			
		2.1	6.3	7.3	3.1	70.1	53.4	65.2	53.6	73.6	73.7	79.7	76.7
		2.8				49.8				82.0			
		2.7	5.1	2.1	2.3	52.8	60.9	48.7	60.4	74.0	85.0	63.6	80.1
		1.0				59.6				68.4			
		1.7	2.0	1.7	7.9	59.8	66.1	59.3	60.0	75.1	79.4	83.2	77.1
		5.4				58.7				79.8			
		1.1	5.0	0.0	3.8	62.1	52.0	68.0	57.1	80.3	69.5	76.5	69.9
		3.7				55.8				71.8			
		2.8	4.0	1.0	4.5	65.6	72.3	56.3	58.6	84.1	75.2	66.1	67.8
		3.5				43.3				65.4			
	Average	2.2	1.7	3.7	0.3	45.1	45.2	58.1	52.9	65.1	63.2	56.1	60.4
		4.1				49.3				51.1			
		4.7	6.6	5.0	2.1	52.5	41.3	53.0	53.1	52.3	52.1	58.6	34.8
		2.7				47.7				54.6			
		4.7	4.0	3.0	5.3	57.7	47.1	48.3	57.0	56.2	55.3	45.5	54.8
		5.9				49.3				64.3			
		4.7	3.7	2.1	3.8	45.9	49.8	48.0	43.8	51.2	59.1	51.9	69.1
		5.5				52.2				45.6			
		1.4	1.0	0.0	1.3	56.2	46.6	54.5	51.1	54.2	52.1	46.8	52.6
		3.3				50.0				57.6			
		2.9	4.0	6.0	5.3	45.9	54.9	45.5	40.9	49.3	46.3	50.3	66.2
		2.7				64.9				65.8			

	High	5.0	4.3	1.1	4.7	50.2	33.8	47.4	42.2	51.3	53.8	55.6	36.7
		2.3				48.9				35.5			
		4.4	1.3	4.0	2.7	46.6	46.6	39.5	49.0	45.5	50.4	47.3	49.3
		8.7				47.4				42.2			
		3.8	1.5	6.0	1.3	49.4	47.9	35.7	53.7	52.9	51.1	44.6	33.5
		1.7				40.2				41.0			
		2.7	2.7	6.3	4.0	41.9	44.3	61.3	62.4	46.1	40.1	51.0	30.6
		2.0				44.0				38.0			
		6.0	4.4	4.8	3.8	49.7	47.9	41.5	51.2	51.6	33.5	41.4	48.2
		9.7				45.6				49.4			
		9.4	5.5	4.3	2.0	46.6	47.1	44.6	53.3	52.1	47.3	51.9	32.4
		2.0				56.1				55.2			

4. Results and Discussion

Table 3 shows the means of data collected from the Agent-based Model on Orf disease infection rate in native/upgrade goats. High orf disease infection rates were observed when the Infectiousness Indicator (Factor A) was set at medium to high level combined with low and average Chance-Recover Indicator (Factor B). Highest infection rates were seen on high infectiousness level coupled with low level chance-recover.

Table 3.Means ofData Collected from the Agent-Based Model on Orf Disease Infection Rate in Native/Upgrade Goats (%)

		Infectiousness		
		Low	Medium	High
Chance-Recover	Low	3.39	58.96	74.69
	Average	3.46	50.26	54.75
	High	4.08	47.20	45.32

Table 4.Two-way ANOVA for the Rate of Orf Disease in Native/Upgrade Goats

Sources	*df*	SS	MS	*F*	*p* –value
Main Effects					
Infectiousness (A)	2	8641.8	4320.9	137.40	**0.000**
Chance Recover (B)	2	161145.3	80572.7	2562.18	**0.000**
Interaction Effects					
Treatment A x B	4	7091.0	1772.7	56.37	**0.000**
Error	261	8207.6	31.4		
Total	269	185085.7			

The Analysis of Variance (ANOVA) for the rate of ORF disease in native/upgrade goats is presented in Table 4. The table shows that *p*-value of infectiousness and chance recover is much less than the alpha (a) = 0.05 significance level. Thus, the infectiousness, as well as the chance recover, have significant effect on orf disease infection rates of native/upgrade goats. Among the main effects, chance-recover (Factor B) had the largest effect on the rate of orf disease infection rate in native goats followed by infectiousness (Factor A). Interaction of Factor A and Factor B, i.e. Infectiousness X Chance-Recover had the least effect on the spread of orf disease.

Observing proper management practices such as culling of sickly goats, improving feeding management and maintaining a sizeable population of the herd act as a deterrent, nevertheless, cannot overwhelm the spread of this highly contagious goat disease.

5. Conclusion

Selection of goat breeds highly tolerant to orf disease and observing proper herd health such as proper nutrition and eliminating stress to the herd would counteract the effect of orf disease spread.

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