Ovine progressive pneumonia virus infection rate and incidence of genetic susceptibility diplotype in North Dakota sheep flocks[1]

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The objectives for the project were to determine the incidence of sheep serologically positive for ovine progressive pneumonia virus (OPPV) and frequency of diplotypes known to affect OPPV susceptibility in sheep. Of the 12 flocks tested, 1/3 had a high incidence of OPPV positive sheep and 2/3 had a low incidence or no sheep test positive for OPPV. Sheep with both copies of the more favorable diplotype "1" had a lower incidence of OPPV positive sheep than sheep with at least one unfavorable haplotype "2 or 3". Younger ewes had a lower OPPV infection rate.

INTRODUCTION

Ovine progressive pneumonia (OPP) is a slowly progressive viral disease of adult sheep. Often, the first sign noticed is a general loss of body condition referred to as "thin ewe syndrome." Another common sign of OPP is an increased breathing effort at rest. Infected ewes can develop "hard bag," an enlarged, firm udder with reduced or no milk flow.

Once infected, animals remain infected for life, although many never show clinical signs of the disease. Flocks infected with OPPV can have lowered production efficiency because higher adult death loss, early culling, decreased milk production and lower weaning weights. Recent research at the U.S. Meat Animal Research Center (US-MARC) in Clay Center, Neb., has discovered a genetic marker that can identify animals that are less susceptible to OPPV infection. This new genetic test, TMEM 154, determines the risk level for infection with OPPV. There are three haplotypes that are most common and they are depicted as 1, 2, and 3. Every animal has two copies of a haplotype, which is referred to as a diplotype.

This disease is transmitted from ewe to lamb at an early age (vertical transmission) or transmitted from sheep to sheep as adults (horizontal transmission) throughout their lifetime. Although, some literature indicates that most transmission is from ewe to lamb, research at US-MARC has shown that horizontal transmission is quite common and typically occurs during the lambing season and/or when sheep are housed in close quarters.

PROCEDURES

We identified 12 different sheep flocks in North Dakota who volunteered to be a part of the project. Each flock was able to test up to 50 adult animals per breed. In total, we sampled 735 adult sheep. Sheep breed and age data were recorded on each animal. Blood samples were taken

via jugular venipuncture. Samples were sent to a centralized laboratory (GeneSeek, Lincoln NE) where they were analyzed for OPPV serum antibody and tested with the OPPV genetic susceptibility test (TMEM 154). Serological samples were classified into positive, negative, and questionable categories based on the assay guidelines. Questionable samples were rerun and all sheep were placed into positive or negative categories based on the second assay. If any flock had at least one positive animal they were categorized as an infected flock. Breed, age and diplotype were used as class variables. Animal infection status was analyzed using the GLIMMIX procedures of SAS for all sheep and sheep from only infected flocks. Means were considered different at $P \leq 0.10$.

RESULTS AND DISCUSSION

Figure 1 categorizes each flock by the percent flock OPPV infection rate. Eight of the 12 flocks (66 %) had at least one sheep test positive for OPPV, which is considerably higher than what the Animal and Plant Health Inspection Service (APHIS) estimates the US sheep industry's prevalence rate of OPP (36%). This could be due to our relatively small sample size or the difference in flock management in North Dakota compared to the rest of the nation. Within infected flocks, 2 to 76 % of the sheep within each flock tested positive for OPPV. There were only 2 flocks that had a greater than 25% infection rate. The majority of flocks did not have any sheep test positive or had a low OPPV prevalence rate (≤ 25%). The overall OPPV prevalence rate of all sheep tested was 28 %, which is similar to the 24% prevalence rate estimated for the U.S. sheep industry by APHIS.

Diplotype status had an effect ($P < 0.01$) on OPPV infection rate of sheep in all flocks and within infected flocks (Table 1). Across all flocks, sheep with diplotype "1 1" had a lower ($P < 0.10$) infection rate than sheep with less favorable diplotypes ("1 2" "1 3" "1 4" "2 2" and "2 4"). Within infected flock, sheep with the diplotypes "1 1" "1 4" and "4 4" had a lower ($P < 0.10$) OPPV infection rate than sheep with the diplotypes "1 2" or "1 3". Sheep with diplotypes "2 2" "2 3" and "2 4" were not detected to be different ($P > 0.10$) from all there diplotypes, which is likely due to a low number of these diplotypes in the population. This data are consistent with findings from US-MARC that indicate an increase in risk of infection for sheep with at least one of the more undesirable haplotypes (2 or 3). Less is known about haplotype 4 and ongoing investigation of this haplotype is currently being done in collaboration with our lab and US-MARC. This data indicates that haplotype 4 provides some protection from infection; whereas, research from US-MARC indicated that the diplotype "4 4" was fully resistant to OPPV.

We were unable to detect an effect ($P = 0.15$) of age of sheep on OPPV infection rate of sheep within all flocks; however, within infected flocks age of sheep had an effect ($P = 0.02$) on OPPV infection rate (Table 1). Within infected flocks, 1 and 2 year old sheep had a lower ($P \leq 0.10$) OPPV infection rate than 3, 4, 5, 6, and 7 year old sheep. No differences ($P \geq 0.10$) were detected between sheep older than 8 years of age and sheep younger than 8 years of age, which was likely due to a low number of ewes tested beyond 7 year of age. Similarly, research at US-MARC indicates that the sheep with an undesirable diplotype are 3.5 and 7 times more likely to test positive for OPPV at 1 and 2 years of age, respectively. We likely reported a lower level of infection rate per year because many of the flocks had a low level of OPPV infection. Similarly, the disease is also known to increase ewe culling rate, which could skew the data because

infected animals that show symptoms would likely have been removed from the flock. However, it does appear that our data is somewhat consistent with US-MARC and adult animals within an infected flock become OPPV positive over many years. Management decisions that reduce the contact between uninfected or younger ewes from contracting the disease from older or infected ewes warrants further investigation.

Breed of sheep had an effect ($P < 0.01$) on OPPV infection rate across all sheep and within infected flocks (Table 1). Within infected flocks, Rambouillet and Montadale sheep had lower OPPV infection rates than all of breeds. Similarly, Polypay and Suffolk sheep had lower ($P < 0.06$) OPPV infection rates than Columbia, Dorset, Hampshire, and Katahdin sheep. Katahdin sheep from infected flocks had the highest ($P < 0.01$) infection rate of all breeds. Frequency of haplotypes varied among breeds (Table 2). Within infected flocks, breeds that had a 90% or higher frequency of the more favorable haplotype "1" were less likely to be infected with OPPV, except for the Columbia breed. Similarly, the breeds that had 60% or lower frequency of the more favorable haplotype "1" were more likely to be infected with OPPV.

IMPLICATIONS

Ovine progressive pneumonia is prevalent in the North Dakota sheep industry. One third of the flocks tested had a high incidence of OPPV positive sheep. The prevalence and impact of the disease in these flocks is likely due to a combination of genetic susceptibility, presence of the virus, and management system. The OPPV genetic susceptibility test (TMEM 154) does not guarantee that sheep will be resistant to OPPV but those that had more unfavorable at least one of the unfavorable haplotypes were more likely to test serologically positive. Breed of sheep has an impact on OPPV infection rate; however, this is likely a result of frequency of diplotype within breed. Additionally, younger ewes were less likely to be infected with the virus, which indicates that management decisions to isolate young uninfected ewes from older infected ewes could help reduce the impact of this disease on sheep flocks.

LITERATURE CITED

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Table 1. Number and percent of OPPV infected[1] sheep by diplotype, age, and breed

	All Flocks[2]		Infected Flocks[3]	
Item	OPPV Infection Rate (%)	SE	OPPV Infection Rate (%)	SE
Diplotype[4]				
1,1	21.0[a]	5.8	41.8[a]	7.2
1,2	38.7[b]	7.0	67.3[b]	9.1
1,3	34.6[b]	7.7	74.1[b]	9.8
1,4	43.0[b]	8.2	42.1[a]	10.3
2,2	63.5[b]	24.6	59.5[ab]	31.0
2,3	21.0[ab]	21.6	34.7[ab]	30.6
2,4	52.4[b]	12.3	57.1[ab]	14.4
4,4	34.7[ab]	21.8	27.5[a]	22.7
Age, years				
1	23.0	8.6	23.2[a]	10.0
2	15.0	8.4	22.9 [a]	9.9
3	27.0	8.3	37.3 [b]	9.8
4	23.4	8.7	35.9 [b]	10.0
5	31.7	9.0	42.9 [b]	10.9
6	14.0	9.1	44.8 [b]	11.7
7	25.2	10.3	46.9 [b]	12.5
8	23.1	10.6	42.4 [ab]	13.9
9	22.6	15.3	35.7 [ab]	18.5
10	37.8	30.2	81.8 [ab]	42.8
Breed				
Columbia	54.8[c]	9.6	55.4[c]	11.3
Dorset	46.5[bc]	8.0	60.1[c]	10.0
Hampshire	46.4[bc]	9.3	70.0[cd]	11.0
Katahdin	39.6[b]	7.5	100.3[e]	10.0
Montadale	5.2[a]	13.0	8.2[a]	14.4
Polypay	42.6[bc]	8.5	40.4[b]	10.3
Rambouillet	12.2[a]	7.8	22.6[a]	10.0
Suffolk	11.0[a]	8.2	36.2 [b]	11.2

[1]Infection status was determined by serological analysis for OPPV serum antibody
[2]Sheep were tested on 12 different farms (n = 720)
[3]Sheep from farms that had at least one OPPV positive animal (n = 493)
[4]Diplotypes of sheep tested for OPPV genetic susceptibility (TMEM 154)

Table 2: Haplotype frequency for each breed of sheep

	Haplotype[1]			
Item	1	2	3	4
Breed				
Columbia	0.99			0.01
Dorset	0.88	0.10	0.02	
Hampshire	0.53	0.16		0.31
Katahdin	0.59	0.13	0.17	0.09
Montadale	0.97			0.03
Polypay	0.86	0.04	0.08	0.02
Rambouillet	0.92	0.01	0.06	0.002
Suffolk	0.76	0.16	0.01	0.08

[1]Haplotype of sheep tested for OPPV genetic susceptibility (TMEM 154)

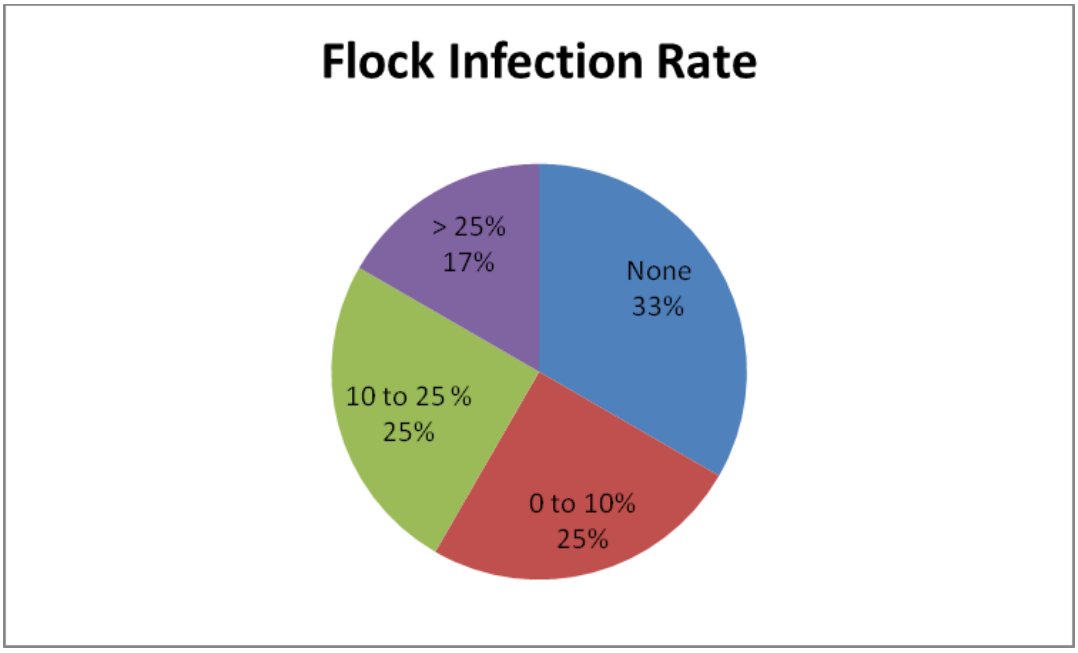

Figure 1. Flocks categorized by percent of sheep testing positive for OPPV as determined by serological testing