Baa-ttling Sore Mouth in Sheep with Mathematical Modeling

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Sore mouth is a ubiquitous, highly contagious, enzootic disease in ruminants that has profound economic and cultural impacts throughout the world. Although sore mouth has been observed for centuries, advancements in our ability to prevent and mitigate outbreaks have been minimal, with some outbreaks achieving morbidity rates of nearly 100% in a matter of weeks. The animal science literature has proposed a number of recommendations to prevent sore mouth outbreaks such as the isolation of infectious sheep, vaccination, and pasture management; however, several open questions remain regarding the relative importance of these approaches, their possible interactions, and their implementation. As a result, the consequences of sore mouth outbreaks continue to degrade the prosperity of animal welfare, economic output, and cultural celebrations. We developed two mathematical models of sore mouth in sheep to address these challenges, including (1) an ordinary differential equation model to simulate outbreaks in large, well-mixed flocks and (2) a cellular automata continuous time Markov chain model to simulate outbreaks in smaller flocks in spatially heterogeneous environments. We applied both models to measure the effectiveness of existing management strategies and to identify novel approaches that could either prevent or mitigate outbreaks. Our results suggest that (1) the routine surveillance of populations is essential to quickly isolate infectious sheep to prevent outbreaks, (2) shared infectious fomites can rapidly accelerate outbreaks and should be reduced or cleaned during a potential infection season, and (3) preventive vaccination with isolation can confer a degree of herd immunity that limits the impact of sore mouth outbreaks.