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Quantification of different classical swine fever virus transmission routes within a single compartment

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ABSTRACT

During outbreaks of classical swine fever (CSF), CSF virus (CSFV) can be transmitted via different routes. Understanding these transmission routes is crucial in preventing the unlimited spread of the virus in a naïve population, and the subsequent eradication of the virus from that population. The objectives of the present study were to quantify virus transmission within a compartment, differentiating between transmission within a pen, transmission between pens via contact through (open) pen partitions, and transmission via the air. Furthermore, the possible contribution of each of these routes to infection of individual pigs was quantified. A CSFV outbreak was mimicked in a compartment housing 24 pigs in six different pens. Two pigs in one pen were inoculated with the moderately virulent Paderborn strain, and virus transmission to other pigs was followed in time. Virus transmission rates for transmission via the air (β of 0.33 (0.14–0.64) per day) and transmission between adjacent pens (β of 0.30 (0–0.88) per day) were comparable, but significantly lower than for virus transmission within a pen (β of 6.1 (0.86–18) per day). The route via the air created new focal points of infection, from which virus transmission continued through other routes. This shows that, at least within a compartment, transmission via the air is expected to play a relevant role in the fast spread of the virus after an initial slow start. This will have consequences for efficacy of intervention measures, including vaccination during an outbreak.

1. Introduction

Classical swine fever (CSF) is a highly contagious viral disease that affects both domestic pigs and wild boar. Many European countries eradicated CSF and implemented a non-vaccination policy. Outbreaks occur occasionally, and in areas with a high pig density this has resulted in severe economic losses due to mass destruction of pigs and export limitations (Meuwissen et al., 1999; Terpstra and De Smit, 2000).

CSF virus (CSFV) can be transmitted through direct contact, or indirectly via contaminated clothes, livestock trucks, fomites, or from a contaminated environment (Ribbens et al., 2004). Understanding these virus transmission routes, and being able to interfere, is crucial in preventing the unlimited spread of the virus in a naïve population, and the subsequent eradication of the virus from that population. CSFV can also be transmitted via the air, but this route in particular is rarely described and its relevance not yet fully understood.

During outbreaks, transmission via the air was suggested in neighbourhood infections, where farms were

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infected that were located within a 1 km radius of a previously infected farm, and where no route of infection could be identified (Terpstra, 1987; Dewulf et al., 2000; Ribbens et al., 2004). Under experimental conditions, transmission via the air was repeatedly demonstrated by connecting two isolation chambers with a pipe. In these highly artificial systems, one of the isolation chambers houses one or more infected pigs, while the other chamber houses susceptible pigs (Hughes and Gustafson, 1960; Terpstra, 1987; González et al., 2001). In a somewhat different set-up, closer to an actual field situation, virus transmission occurred when the air current was flowing from a compartment housing infected pigs to another compartment housing susceptible pigs (Laevens et al., 1999; Dewulf et al., 2000). Finally, in recent studies CSFV was detected and quantified in the air of rooms housing infected pigs (Weesendorp et al., 2008, 2009c).

All these studies provide evidence that transmission via the air is possible. However, in contrast to within- and even between-pen transmission (Laevens et al., 1998; Stegeman et al., 1999; Klinkenberg et al., 2002; Weesendorp et al., 2009a), quantitative information on the specific role airborne transmission plays is lacking. It is therefore also unclear how these different transmission routes relate to each other. This information is lacking on several levels; between farms, between compartments within a farm and within a compartment. This information is important to determine which control measures could be most effective and whether they will be sufficient in reducing the spread of CSFV during an outbreak. When transmission within a compartment can be reduced, the infectiousness of the compartment as a whole will be reduced or delayed and consequently virus transmission to other compartments and farms as well.

In the present study, the objective was to quantify virus transmission parameters within a compartment, differentiating between transmission within a pen, transmission between pens via contact through the (open) pen partitions, or transmission via the air. In a compartment housing 24 pigs in six different pens, a CSF outbreak was simulated by infecting two pigs in one pen, and virus transmission to other pigs was followed in time. It was shown that transmission via the air was significantly lower than within-pen transmission, but comparable to between-pen transmission.

2. Materials and methods

2.1. Experimental pigs and setup

Twenty-four male pigs, eight weeks of age, were obtained from a conventional, but pestivirus free pig herd in the Netherlands. Pigs were housed in six pens, with four pigs each, within one room. Pens (2 m × 2 m) were situated in two rows, pen 1–3 in row 1, pen 4–6 in row 2 (Fig. 1). Pen partitions were open, so that air could freely flow through it, and pigs in adjacent pens were able to have nose-to-nose contact with each other. The air flow in the unit was perpendicular to the rows of pens, from row 2 to 1, with an average speed of approximately 0.04 m/s. The temperature in the unit ranged from 21 to 23 °C during the whole experiment. Two pigs in pen 6 were inoculated at the start of the study, and within the 28 days the study lasted, the other 22 pigs became infected via contact within or between pens or via the air. Strict measures were taken to prevent virus transmission through other (indirect) contacts (e.g. humans, fomites, etc.). Feeding and sampling was carried out in order of least likely to most likely infected pigs, i.e. first in pen 1, followed by pens 2 and 3. Then, clothing, footwear, gloves and hairnet were changed and pigs in pen 4, followed by pens 5 and 6 were sampled. Sampling materials (sterile or newly purchased) and rectal thermometers (cleaned and disinfected) were used for individual pigs only. Every day, the manure in the pens was removed with a shovel. No water was used to clean the pens to avoid aerosols. The experiment was ended at day 28 post-inoculation (p.i.). The experiment was approved by the Ethics Committee for Animal Experiments of the Animal Sciences Group of Wageningen UR.

2.2. Viruses and inoculation of pigs

Two pigs in pen 6 were inoculated with the moderately virulent strain Paderborn (genotype 2.1). This strain was

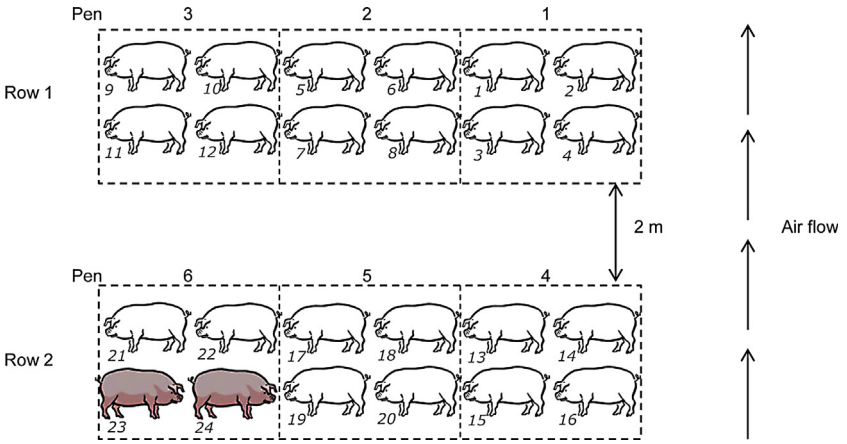

Fig. 1. Experimental setup, including the pen and pig numbers (in grey italic). Pigs 23 and 24 in pen 6 were inoculated, all other pigs served as naïve contact pigs.