

Role of haulage companies in the connectivity of pig farms in Great Britain — A network analysis



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Introduction

- Understanding the complexity of the live pig trade network is critical to predict the spread and control of infectious diseases in swine industries. However, attention has mainly focused only on the direct movements of live animals.
- Little is known about the impact of using private haulage companies (PHC) to transport pigs to slaughter or to other premises on the structure of the pig contact network and the potential spread of infectious diseases in the British swine industry.
- Objective:** To explore the structural changes of the topology of the live pig trade network in Great Britain (GB) when connection through PHC is accounted for.

Method

- All movements reported between April, 1st 2012 to March, 30th 2014 were extracted from the Scottish livestock electronic identification and traceability database (ScotEID) and the electronic movement licensing database (eAML2).
- Nodes: All premises, except slaughterhouses, actively involved in moving pigs in GB.
- Edges: Details on individual vehicles used for transporting pigs were not sufficiently recorded. Therefore, nodes are connected through either the direct movement of pigs or the use of same PHC when moving pigs (Fig. 1).
- Slaughterhouses are not nodes but were involved in defining edges between nodes (Fig. 1).

Figure 1. Building the network through PHC contacts.
Schematic showing how edges between pig premises (i.e. nodes) has been defined when the role of private haulage companies (PHC) is accounted for and complement contacts through the movement of pigs.

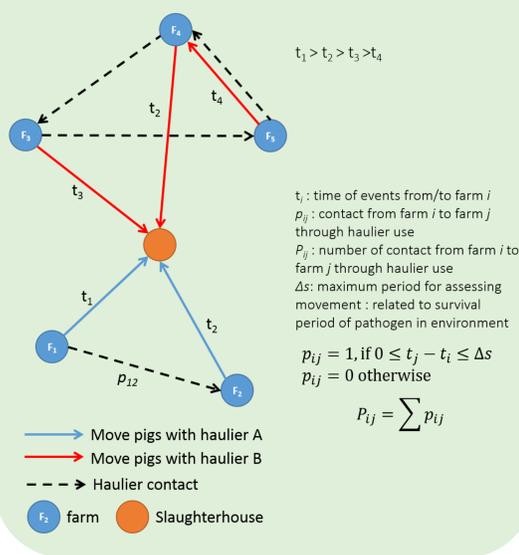
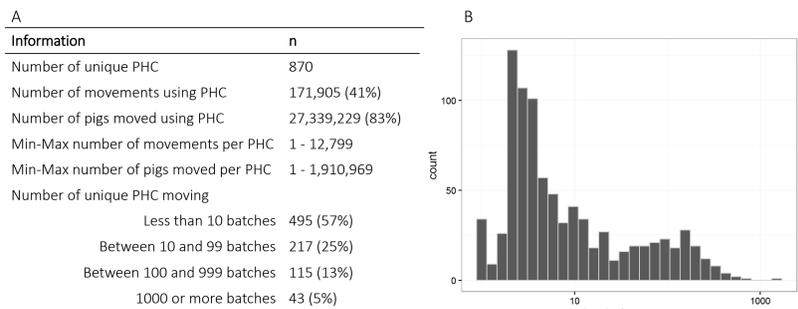


Figure 2. Importance of PHC in the movements of pigs in Great Britain.

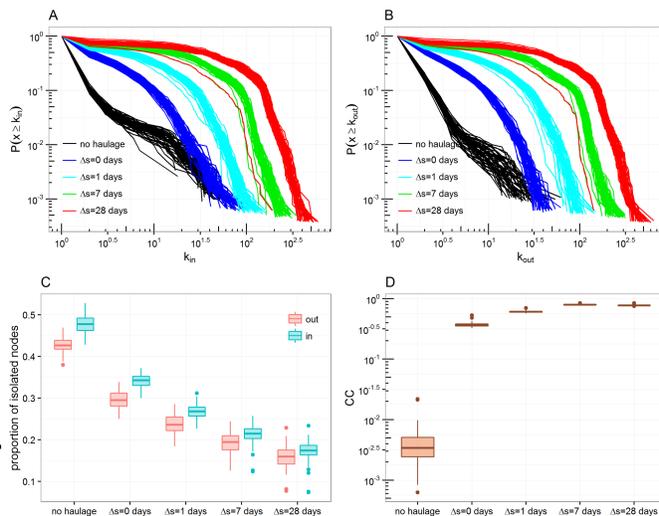
(A) Table highlighting key statistics regarding the importance of private haulage companies (PHC) in the British swine industry. (B) Histogram showing the distribution of the average batch size moved per PHC.



- In GB, nearly half of the 415,448 batches were moved by a PHC, accounting for >80% of the moving pigs (Fig. 2A).
- Most (57%) PHC carried out less than 10 batches (Fig. 2A).
- On average, PHC transported a median of 4.5 pigs (95% range 1 – 249) but showed a trimodal distribution (Fig. 2B).

Figure 3. Structural changes of the network topology when connection through PHC is and is not accounted for.

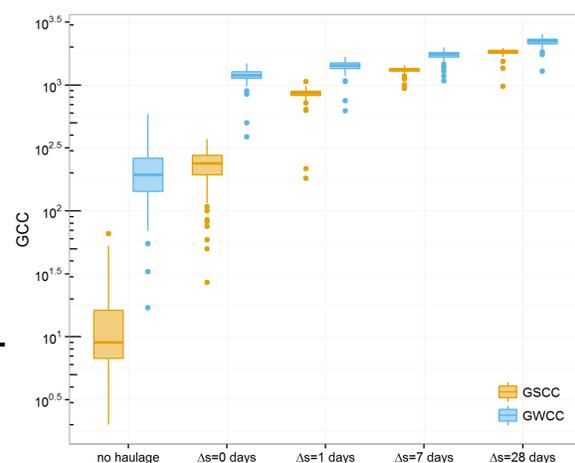
Comparison in the distributions of nodes (A) in-degree, k_{in} , and (B) out-degree, k_{out} , for each premises (nodes) involved in moving pigs in each full week of the study period and for increasing values of contamination period, Δs . (C) Proportion of isolated premises and (D) global clustering coefficient (CC) of the weekly pig trade networks for increasing value of Δs when defining PHC contacts.



- Using PHC increases the number of potential connections between pig premises, even with minimum period of contamination (i.e. $\Delta s=0$, Figs. 3A-B).
- It is easier to reach isolated premises through animal movement when accounting for PHC contacts (Fig. 3C).
- The density of the pig trade network is significantly more dense when accounting for PHC contacts than through animal movement alone, progressively increasing the overall level of clustering in the network (Fig. 3D).

Figure 4. Changes in the size of the weekly giant components when connection through PHC is and is not accounted for.

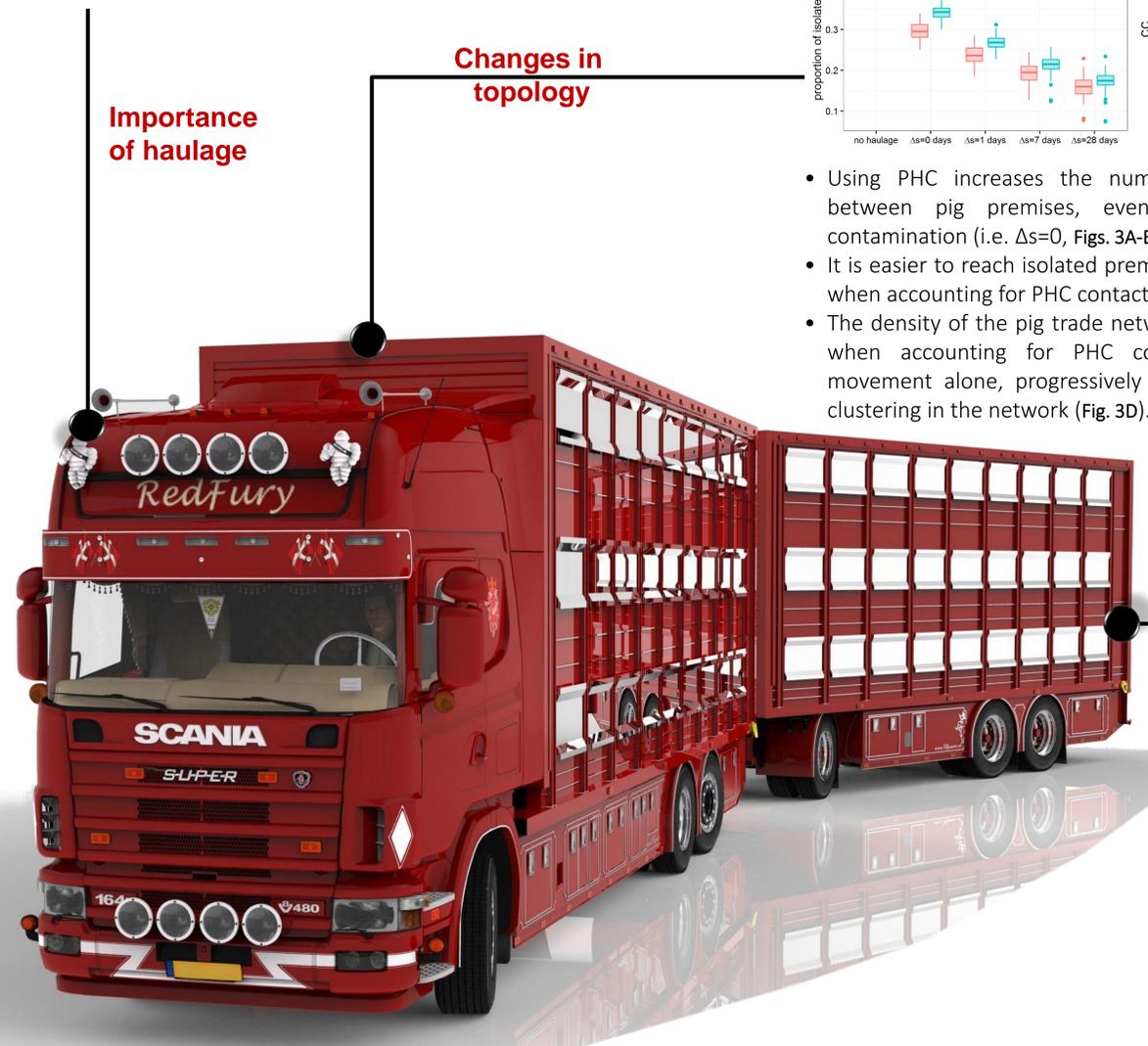
Comparison in the distributions of the size of the giant strong (GSCC) and weak (GWCC) component of the weekly pig trade networks for increasing value of Δs when defining PHC contacts. GSCC and GWCC are considered as proxy measures for lower and upper bounds of maximal epidemic size, respectively, for epidemics spreading in the considered network



- The lower bound of the largest disease outbreak in the British swine industry increases from a median of 9 nodes (95% range 3 – 46) when PHC contacts are not considered to 239 nodes (95% range 55 – 352) when minimum period of contamination (i.e. $\Delta s=0$) is used to define PHC contacts (Fig 4).

Conclusion

- Our findings highlight the role of PHC in the live pig trade network in GB, increasing the level of connectivity between pig premises.
- Quality and frequency of cleaning procedures of haulage vehicles after animal movements have been shown suboptimal in GB. As such, PHC have the potential to drastically amplify the spread of pig pathogens in GB.



Changes in topology

Importance of haulage

Changes in component size