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Exploring the role of small-scale livestock keepers for national biosecurity – The pig case

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Abstract

Small-scale keepers are less likely to engage with production organisations and may therefore be less aware of legislation, rules and biosecurity practices which are implemented in the livestock sector. Their role in the transmission of endemic and exotic diseases is not well studied, but is believed to be important. The authors use small-scale pig keepers in Scotland as an example of how important small-scale livestock keepers might be for national biosecurity. In Scotland more than two thirds of pig producers report that they keep less than 10 pigs, meaning that biosecurity practices and pig health status on a substantial number of holdings are largely unknown; it is considered important to fill this knowledge gap. A questionnaire was designed and implemented in order to gather some of this information. The questionnaire comprised a total of 37 questions divided into seven sections (location of the enterprise, interest in pigs, details about the pig enterprise, marketing of pigs, transport of pigs, pig husbandry, and pig health/biosecurity). Over 610 questionnaires were sent through the post and the questionnaire was also available online. The questionnaire was implemented from June to October 2013 and 135 questionnaires were returned by target respondents. The responses for each question are discussed in detail in this paper. Overall, our results suggest that the level of disease identified by small-scale pig keepers is low but the majority of the small-scale pig keepers are mixed farms, with associated increased risk for disease transmission between species. Almost all respondents implemented at least one biosecurity measure, although the measures taken were not comprehensive in the majority of cases. Overall as interaction between small-scale keepers and commercial producers exists in Scotland the former can pose a risk for commercial production. This investigation fills gaps in knowledge which will allow industry stakeholders and policy makers to adapt their current disease programmes and contingency plans to the reality of small-scale pig-keeping enterprises' health and biosecurity status. We predict that some conclusions from this work will be relevant to countries with similar pig production systems and importantly some of these findings will relate to small-scale producers in other livestock sectors.

Keywords: Small-scale keepers, Biosecurity, Health, Backyard pigs

Introduction

Although the livestock industry and its officials do not always recognise the important role of small-scale producers, it is acknowledged that such producers should be considered part of the livestock industry as a whole. There is potential for health and disease management practices adopted by small-scale producers to pose a threat to the livestock industry; in an extreme situation – e.g. outbreak of exotic disease – the sustainability of the industry could be at risk. The importance of small-scale producers will vary in terms of productivity and scale between countries (i.e. for some countries they will be the majority of the producers while for others their contribution to overall production is marginal). However, with regard to the introduction and spread of an exotic or endemic animal disease, small-scale producers are considered by livestock officials and regulators to be a high-risk sector (Limon et al, 2014; Schembri et al, 2015; Tornimbene et al, 2014). Further information on the characteristics of this type of production and the biosecurity protocols adopted is therefore of value to several sectors: for regulators to adapt their contingency plans in case of exotic diseases, for livestock officials to adapt their control programmes for endemic diseases and for academics to include this information into models and their research activities. Due to the integrated nature of pig production we have focused on small-scale pig production in Scotland as an example of how important small-scale keepers can be.

Backyard pigs have been identified as playing a role in the epidemiology of African swine fever (ASF) in the Russian Federation (FAO, 2013) and classical swine fever (CSF) in Bulgaria (Alexandrov et al, 2011); it would be prudent to assume that similar management systems would have similar levels of importance in terms of sustaining or spreading some endemic or exotic diseases. Backyard and small-scale pig producers are often considered to

pose a threat to the commercial pig sector. There are a number of potential reasons why this may be the case. Firstly, in contrast with the commercial sector where many producers belong to assurance schemes, small scale producers are generally not engaged with production organisations and are unlikely to be professional producers. This may have implications in terms of levels of knowledge and awareness of legislation and statutory requirements. In the absence of quality assurance criteria, small-scale producers may also have less impetus to implement good biosecurity and management practices (Laanen et al, 2013; Ribbens et al. 2008). Biosecurity is defined as "the implementation of measures that reduce the risk of the introduction and spread of disease agents; it requires the adoption of a set of attitudes and behaviours by people to reduce the risk in all activities involving domestic, captive/exotic and wild animals and their products" (FAO, 2010). Small scale producers are likely to differ from commercial producers in implementation of both external biosecurity (the prevention of pathogens entering a herd) and internal biosecurity (reducing the spread of pathogens within a herd (Laanen et al., 2013; Lambert et al., 2012, Gunn et al., 2008)). Secondly, whilst low biosecurity may result from lack of awareness or knowledge, it is also influenced by production type; in outdoor systems, for example, the potential for wildlife contact is one factor contributing to lower biosecurity (Bailey et al. 2013; Ribbens el al. 2008). Thirdly, small-scale pig producers frequently keep other livestock species as well as pigs, with up to 80% of pig herds having cattle or sheep also present on the same property (Porphyre et al, 2014). Mixed farms have more animal contacts than single species farms and therefore pose an increased risk for disease transmission (Nigsh et al, 2013).

Despite these potential risks, knowledge of the management practices and production systems associated with these producers is not well studied and backyard and small-scale pig producers represent an important knowledge gap in management of the pig sector. Only through attempts to improve our knowledge of the approach to biosecurity taken by all pig-keepers in this sector can estimates of any potential risk they may or may not pose be refined. There have been a number of studies on small scale pig production outside Europe,

for example in Madagascar, Vietnam, Philippines and Cambodia (Alawneh et al, 2014; Costard et al, 2009; Roessler et al, 2009; Tornimbene et al, 2014). Such studies are not directly comparable to the UK situation however, as small-scale pig producers are responsible for 70%-80% of total pig production in those countries (Alawneh et al, 2014; Roessler et al, 2009). Although small-scale pig production in Scotland and Europe has not been well characterised, it is likely to differ significantly from this scenario. Due to lack of information, small-scale production systems are often left out of disease models. This could be a significant omission, making it difficult to assess the importance of these systems with regard to disease transmission and control; it must, therefore, be a focus for future work. A recent study tried to assess this gap in knowledge for England (Gillespie et al, 2015).

Further information on small-scale producers may help to target knowledge transfer and management practices appropriately to reduce the risk that these producers could pose to animal health at a national level and to increase the likelihood of compliance with disease control or surveillance activities. Knowledge of potentially vulnerable areas in this production system and the identification and characterisation of different profiles of management and biosecurity practices will assist the development of tailored recommendations for pig producers and will also allow a better focus for disease control and surveillance activities (Alawneh et al., 2014; Costard et al., 2009).

The Scottish swine sector comprises over 318,000 pigs in total of which almost 31 thousand are breeding females (Defra, 2016; RESAS, 2016) but accounts for 6.7% of the UK pig herd (Defra, 2016). The industry contributes about 3% of the Scottish Agricultural Output (approximately £85 million) (RESAS, 2016). In addition to commercial producers, Scotland has a number of small-scale pig producers. This sector of the industry represents a small proportion of the swine industry in terms of the numbers of animals reared (Porphyre et al, 2014), but a substantial proportion in terms of the numbers of producers involved: around 72% of the producers with fattening pigs in Scotland report that they keep less than 10 pigs (RESAS, 2016).

The objective of this study was to explore the role of small-scale livestock keepers for national biosecurity using small-scale pig keepers as an example. For this the small-scale pig production in Scotland was characterised according to motivation, management and also biosecurity, with a focus on the potential risk the latter could pose to the pig industry on a larger scale.

Material and methods

Target population

The target population for this cross-sectional survey was small-scale pig keepers in Scotland, i.e. those involved in pig-keeping without a major commercial component. The chosen definition of small-scale pig keepers was those producers owning less than 50 finishing pigs (pigs over 12 weeks old kept for meat production) or less than 15 adult pigs (over one year old) or having finished less than 100 pigs during 2012. According to UK law, pig keepers are required to register the location at which pigs are kept with the local Rural Payments and Inspections Directorate Office. The sampling frame for the survey was a list of registered pig keepers in Scotland in 2011, obtained from Animal and Plant Health Agency, APHA (formerly Animal Health Veterinary Laboratories Agency). This list was cross-checked with a list of quality assured pig keepers obtained from Quality Meat Scotland (QMS). Any producers that appeared on both lists were removed from the sampling frame, on the assumption that quality assured producers registered with QMS were more likely to be involved in pig production at a commercial level. Name, address and county/parish/holding (CPH) number were available for all producers. Holdings which were not located in Scotland were also removed from the list. In total around 5% of holdings were removed from the original list.

Sample size calculation

155 The survey was conducted via a postal questionnaire that was also made available online.
156 Calculation of the required sample size dictated the number of postal questionnaires sent,
157 while the online survey was considered an additional tool to help maximise response rate.
158 Assuming, given the lack of knowledge of the sample population, that 50% of respondents
159 answer as yes or no in the case of yes/no questions, and with a desired confidence level of
160 95% and an error of ± 6.0%, the sample size was calculated to be 244 when adjusted for the
161 total population size of 2799 small-scale pig keepers registered with APHA in Scotland (this
162 figure does not contain the quality assured producers). The response rate for mailed
163 questionnaires tends to be low (around 50%) but highly variable (from as low as 10% to as
164 high as 70%) (Thrusfield, 2005). In this study we assumed a 40% response rate which gave
165 a final sample size of 610. The final sample was chosen via random number selection in R
166 (version 3.0.1, available from www.r-project.org).

167 **Postal questionnaire and online survey**

168 The questionnaire was piloted on 17 pig-keepers selected from the total survey sampling
169 frame and from colleagues keeping pigs. All pilot questionnaires were sent by post and
170 included a covering letter to explain the purpose of the survey, which also detailed the online
171 location of the survey, if that response method was preferred. Those pig-keepers involved in
172 the pilot were removed from the sampling frame for the survey proper. There were three
173 respondents to the pilot survey, a fourth person made contact to explain that they no longer
174 kept pigs and two further questionnaires were returned in the post as the addressee was no
175 longer at that address. Following the pilot, the questionnaire was adapted to improve clarity.
176 The final questionnaire comprised a total of 37 questions divided into seven sections
177 (location of the enterprise, interest in pigs, details about the pig enterprise, marketing of pigs,
178 transport of pigs, pig husbandry, and pig health/biosecurity); the questions were aggregated
179 in these sections to provide answers related to exotic disease contingency planning (e.g.
180 Where are the producers? What is their biosecurity level?), and for endemic disease
181 programmes (e.g. Which are the important pig health issues for these producers? From

whom and to whom do they buy and sell their pigs? What approach to biosecurity do they take?). A combination of open and closed questions was used. For some questions, respondents were asked to choose only the most applicable answer, while for others they could select all options that applied to them (see Table 1 for the list of questions and options available). All questions incorporating "other" as a potential response offered the opportunity for the respondent to elaborate. For the sections dealing with sale and transport of pigs, the initial question established whether or not the section was relevant to the respondent and the remainder of the section could be ignored as appropriate. Questionnaires were posted with a covering letter and return envelope enclosed. The letter explained the purpose of the survey and included both a uniform resource locator (URL) and a printed quick response (QR) code, leading to the online version of the survey. This was designed to offer an alternative mean of response to those who received the postal version, in order to maximise response rate. The online survey was opened concurrently with posting of the paper questionnaires – at the end of June, 2013. Reminder letters were sent two months after the initial questionnaire. The end date for the postal responses was the end of September, 2013, and the online survey was closed on October 18th. Copies of the final questionnaire and cover letter are available upon request to the corresponding author.

Additional efforts were made to maximise response rate. Contact was made with several websites relating to smallholdings and small-scale pig-keeping. Two of these – www.accidentalsmallholder.net and www.fifesmallholder.co.uk – agreed to place a link to the online survey on their website, together with a brief description of the study. A similar paragraph detailing the study aims and the survey link was included in the SAC Consulting Farm Business News issue for June 2013 and the same paragraph, together with the survey link and QR code, was printed on leaflets and taken to the Royal Highland Show at the end of June 2013 and to the Dumfries Agricultural show in early August 2013. Contact was also made with the Scottish representative of the British Pig Association (BPA), who forwarded the survey link to pig-keepers for whom the BPA had access to an email address.

Statistical analysis

Descriptive statistics were generated for all the variables in the dataset. The results were summarised by question using counts and percentages for categorical variables and a summary of descriptive measures (e.g. mean, median) for quantitative variables. The denominator for the descriptive statistics presented below varied according to the numbers of respondents to each question. The denominator for questions concerning sale and transport of pigs was the number of respondents who had initially indicated that they did sell or transport pigs. For the questions which the respondents could choose more than one answer the denominator was kept as the number of respondents to the question, therefore, the percentages do not sum to 100%. Chi-squared test or Fisher test (when the assumptions for chi-squared test were not fulfilled) was used to test if there was any statistically significant difference between variables (such as for the proportion of questionnaires received from the different Scottish postcode areas in relation to what was sent, and the knowledge of biosecurity versus the implementation of biosecurity practices).

Results

Survey response

A total of 145 pig owners responded to the questionnaire (24 online and 121 by post). Ten of these (6.7%) were excluded from the study as they did not meet the criteria for a small-scale producer, leaving 135 respondents to be included in further analyses.

Analysis of non-respondents

Around 4% of the questionnaires sent were returned either because the address was incorrect or because the person in question no longer lived there. Others (5.4%) contacted the research team (telephone contacts were given in the covering letter) to advise that they

no longer keep pigs. If these cases were excluded the questionnaire response rate was 25.2%.

Out of the completed questionnaires, the overall non-response rate per question ranged from 0.0-12.6% for the majority of the questions (summarised in Table 1). Only two questions had a higher non-response rate: the county-parish-holding (CPH) code (47%) and the reasons as to why the respondent did or didn't feel part of the British pig industry (48%).

Representativeness

The respondents represented all 16 different Scottish postcode areas. No statistically significant difference was observed between the proportion of questionnaires received from the different Scottish postcode areas in relation to what was sent ($p=0.165$).

Respondents

Most of the respondents (75.6%) described their location as isolated rural areas or rural villages (20.7%) and kept their pigs at home (91.9%). Only 4.7% of respondents were relatively new to pig-keeping, having kept pigs for less than two years; the median length of time for keeping pigs was 5 years. Figure 1 shows the respondents' motivation for keeping pigs. The main reason was to obtain quality pork from a known source. The majority consider that they have a medium level of knowledge about biosecurity (53.3%), legislation (58.5%), pig health (69.6%) and pig nutrition (69.6%), while 30.4%, 26.6%, 20.7% and 22.2% consider their knowledge in these areas to be high, respectively.

Figure 1: Respondents' motivation for keeping pigs (percentage of responses per reason).

Pig enterprise

256 The predominant breeds were Gloucester Old Spot (32.6%), Tamworth (31.9%) and
257 Saddleback (29.6%). Respondents were asked to indicate how they would classify their
258 enterprise, through selecting one or more of ten options. Of these options, the keeping of
259 backyard pigs for home consumption was most popular, being chosen by around 57% of
260 respondents. Pets, finishers from 10-12 weeks and breeder-finisher were the next most
261 common, at 23%, 22% and 20.7%, respectively. By comparison, gilts units (2.2%) and
262 nursery units (1.5%) were least commonly selected. Over 52% of the respondents had at
263 least one adult pig (more than one year old) reported on the 1st of June 2013, with a median
264 of two adult pigs per farm; 17.4% of the respondents had young pigs (from four to 12 weeks
265 old) with a median of seven young pigs per farm; over 39% of the respondents had finishing
266 pigs (aged over 12 weeks and for finishing) with a median of 4.5 finishing pigs per farm on
267 June 1st 2013. The median number of finished pigs in 2012 was four. Table 2 describes in
268 detail the size of the pig enterprises. More than half of the respondents (56.1%) only kept
269 pigs for part of the year. The respondents who kept pigs all year round were more likely to
270 keep adult pigs ($p<0.001$) than the ones who kept pigs for part of the year and were more
271 likely to classify their enterprise as pets or breeder-finisher ($p=0.012$ and $p<0.001$
272 respectively).

273 Respondents source their young pigs and gilts or sows mainly from commercial breeders or
274 producers. For those who identified themselves as backyard producers it was more common
275 to borrow a boar for breeding, while for those who identified themselves as having a
276 commercial aim it was more common to source boars from breeders or producers, use
277 artificial insemination or rear their own boar. Around 6% of the respondents reported using
278 artificial insemination while almost 15% reported borrowing a boar for breeding.

279 On average the respondents (the owners of the farm) spent 8.6h per week on pig-keeping
280 activities; just under a third of respondents (32.6%) have a second person working in the
281 enterprise apart from themselves.

Around 91% of respondents kept at least one other species; 22.2% kept two additional species and 21.5% kept three species other than pigs. Table 3 shows the percentage of respondents with other livestock animals and the numbers of animals kept. The information provided in this section demonstrates the tendency for mixed enterprise among small-scale livestock keepers.

The majority of respondents (88.5%) felt that they were not part of the British pig industry; their reasons were due to their enterprises being small in size and focused on production for home consumption.

Selling and transporting of pigs

Over half of respondents sold their pigs (around 53%), the majority by word of mouth (78.3%). Local markets and butchers were also a common way for marketing pigs (16.7% each) and internet advertising was used by 11.7% of respondents. More than one third of respondents experienced problems when selling their pigs; the most common of these were difficulty finding buyers, the poor price of pork, the extensive legislation to fulfil and the distance to an abattoir.

Most respondents (83.2%) transported their pigs at least once, mainly to the abattoir (52.3%), to the abattoir and to purchase pigs (22.9%), and to the abattoir and for sale (5.5%). Only 2.9% of the respondents said that they had transported their pigs to shows and markets. The median distance pigs were transported was 34.1 miles and the furthest distance travelled was 300 miles. The respondents' own vehicle was the most common means of transport (82.6%), while 11.9% said that they have used haulier companies for transporting their pigs. Ear tags were the most common means of identification of pigs for transport (51.4%), followed by slap mark (11%). Around 41% of the respondents said that identification of pigs was not necessary for the category of pig they transported (in the UK it is not compulsory to identify pigs younger than one year old). Only 2.8% reported that they did not identify their pigs for transport.

Pig husbandry

The majority of the pigs, regardless of age, were kept outdoors (e.g. 86.6% of finishing pigs, 91.7% of adult breeding pigs) and straw was the preferred bedding material used. The majority of respondents fed pigs on pellets (75.9%), but other feed types also included garden scraps and dry meal. The feed was mainly sourced from specialised shops or suppliers (91.5%); feed from the respondents' own land and garden was sometimes supplied to pigs, though none of the respondents reported that they fed pigs on kitchen scraps. The drinking water came from mains (58.5%) followed by well (18.5%) and other natural sources (15.4%). Pig waste was composted (20.7%) or composted for being put on fields (37.2%) and 28.1% of respondents said that the waste was left on fields and they would rotate the pasture as a management procedure.

Health and biosecurity

Almost half of respondents (49.2%) considered their veterinarian as their first port of call for pig health advice; the internet was the second most popular source of information (23.1%). Most of the respondents had never seen the following health problems in their pigs: respiratory (80.9%), digestive (80.9%) or reproductive (82.5%) issues. Locomotor complaints were the most reported health problems (36.6%). A large majority (87%) of respondents reported that a veterinarian visited their pigs less than once a year or never. With regard to pig health management, over half of respondents (54.2%) reported routinely administering anthelmintics, with a much smaller proportion reporting giving routine mange treatment (20%) or vaccination (7%). The vaccines used were for porcine respiratory and reproductive syndrome, parvovirus, erysipelas and circovirus (porcine circovirus 2). Around 55% of the respondents said that they never had any dead pigs on farm, while 33.8% of the total respondents reported that they would use the fallen stock collector if they needed to dispose of a dead pig. Four percent of all respondents said that they would bury dead pigs.

The respondents were asked to indicate which biosecurity measures they adopted out of a total of 15 options. Table 4 lists these measures and their uptake; the median number adopted was seven; but only 4.4% implemented all the practices included in the questionnaire and around 8% of the farms reported not implementing any of the biosecurity practices included in the questionnaire. Those respondents who isolate new stock (38% of the respondents) do so for a median of four weeks and around 42% of those have adult animals.

A significant statistical association was found for three particular biosecurity practices in relation to the respondent's reported knowledge of biosecurity:

i. cleaning and disinfection of vehicles before entry to the premises ($p=0.03$)
ii. disinfection of clothes and footwear after visiting other farms/areas with animal ($p=0.04$)
iii. use of boot dips/baths at entry to animal areas ($p<0.001$).

Reassuringly, the group reporting a high knowledge level of biosecurity reported a higher implementation of these biosecurity practices.

Respondents were asked about sightings of other domestic and wild animals in or near their pigs' environment to assess the potential for animal contacts. The majority of respondents (Figure 2) had never seen neighbours' pigs, neighbours' livestock, foxes, deer, badgers or wild boar in the area where they keep their pigs; birds, cats and dogs were most commonly seen. Birds (83.8%), deer (16.9%), foxes (15.6%) and badgers (7.7%) were seen by the respondents near pigs every day, week or month.

Figure 2: Frequency of sightings by respondents of other domestic and wild animals in or near their pigs' environment.

Around 1% of the respondents reported having seen wild boar or feral pigs near their farm and 6.2% were aware of these animals in their area.

Discussion

The objective of this paper was to explore the role of small-scale livestock keepers for national biosecurity using small-scale pig keepers as an example. The motivation, management and also biosecurity of small-scale pig keepers were characterised, with a focus on the potential risk the latter could pose to the pig industry on a larger scale.

The list of pig keepers used for the sampling frame was reasonably accurate and proved to be useful, although the details of around 10% of people contacted for the survey were incorrect (wrong address or no longer kept pigs). A more regular update of this list would be useful for future epidemiological studies and in case of implementation of contingency plans for exotic diseases. Pig keepers are required to inform the relevant authority when they cease pig-keeping activities, it would be beneficial to encourage this practice.

The response rate to this questionnaire was 25.2%, which was lower than the estimated response rate used for the sample size (40%). This could influence the results derived by the questionnaire, as the high percentage of non-response could be a source of selection bias. No statistically significant difference was observed in the proportion of completed questionnaires received from the different Scottish postcode areas in relation to what was originally sent, which should reduce the risk of bias in terms of respondent location. This gave the authors some confidence to assume that these results can be extrapolated to Scotland as a whole. This was a self-administered questionnaire, which can decrease the response rate when the questionnaire subject is not interesting enough to the respondents; however, the overall non-response rate per question was low.

The questionnaire aimed to target small-scale pig keepers and it was evident from the number of pigs kept by the respondents (median of two adult pigs and four finishing pigs)

384 that this was achieved. Similar numbers were reported by Gillespie et al. (2015) for England.
385 This was also reinforced by the majority of respondents indicating that quality of pork and
386 self-sufficiency were their main motivation for keeping pigs. The typical small-scale
387 production system involves outdoor backyard production, mainly of finishing pigs. Pigs are
388 kept at or near home, mainly in rural locations, generally for part of the year only and
389 producers have experience of pig-keeping over a number of years. The probability of being a
390 whole year pig keeper is associated with the type of production system (i.e. breeder-finisher,
391 pets) and age of the animals kept (adult pigs). Feed is mainly pellets from specialised shops;
392 the use of garden scraps from own land also occurs, though it is encouraging that no
393 respondents report that they feed kitchen scraps to their pigs (since this is not permitted in
394 the UK as has been associated with introduction of exotic diseases (Alexandersen et al,
395 2003; Gogin et al, 2013)). This was in contrast to an English study in which 23.9% of the
396 respondents to a questionnaire reported feeding household scraps (Gillespie et al, 2015).

397 The Scottish Agricultural Census (Scottish Agricultural June 2015 census) described the
398 small-scale pig-keeper population as consisting of mixed enterprises; this was borne out by
399 the results of this survey, with a large proportion of respondents having other livestock
400 (mainly poultry, sheep and cattle). Similar results were found for England (Gillespie et al,
401 2015). The literature suggests that mixed farms have more animal contacts than single
402 species farms and therefore pose an increased risk for disease transmission (Nigsh et al,
403 2013), which highlights the importance of external biosecurity as a risk mitigation measure
404 on such premises. In this survey there was particularly low uptake of several protective
405 strategies: for one measure this is perhaps unsurprising, as feed treatment may be expected
406 to occur more usually in the commercial setting; however, relatively straightforward
407 strategies such as boot dips, insect control and cleaning and disinfection of vehicles were
408 each adopted by less than 70% of respondents. In terms of the risk small-scale pig
409 production could pose to commercial herds and bearing in mind that over 80% of
410 respondents said that they do transport pigs, this could be important. It may be the case that

411 producers on this small scale do not always consider that they need to adopt biosecurity
412 measures; they may associate these more so with commercial industry-linked production, to
413 which, as shown in the survey, they do not feel they belong.

414 There was a tendency for those respondents who considered themselves as having a high
415 level of knowledge in the areas of interest to this survey to have a higher median number of
416 cattle and sheep, compared to respondents classifying their knowledge as low to medium.
417 It is possible that this knowledge may have been gained through the requirement to abide by
418 legislation and regulations pertaining to these other species, or simply that those keeping
419 other livestock assumed that similar practices would also apply to pigs. It might be expected
420 that self-classified “high” knowledge of biosecurity should result in greater implementation of
421 protective measures, but this was not clearly demonstrated to be the case; only three
422 specific practices – relating to cleaning, disinfection and boot dips – were significantly
423 associated with a high level of respondent knowledge. For the other biosecurity measures no
424 statistical difference was observed between the groups based on their biosecurity
425 knowledge, suggesting either an inaccurate assessment of their own knowledge (“they don’t
426 know what they don’t know”), or that some respondents choose not to implement these
427 measures, despite being aware of their value. This may again relate to a feeling of
428 disconnection from industry requirements. We must, however, acknowledge that
429 respondents may have implemented other measures not included on the list provided. This
430 sort of behaviour is likely to be the same for other smallholders.

431 The contact of domestic pigs with wild boars or feral pigs has been associated with
432 outbreaks of African swine fever in Eastern Europe (FAO, 2013). Although the wild boar
433 population is low in Scotland (Campbell and Hartley, 2010), 1% of people reported seeing
434 wild boar near their farm and 6% knew about wild boar sightings in their area. Respondents
435 did, however, report frequent contact of their pigs with birds, cats and dogs; this increases
436 the probability of transmission of diseases which are common to these species, for example
437 Salmonella and toxoplasmosis.

Correct disposal of dead stock and waste are very important management practices which can limit the spread of contaminated biological material through the environment. The majority of the respondents had never had a dead pig on farm, which is in accordance with the high proportion reporting no health problems on farm, while one third reported using dead-stock collection systems. The use of this facility was associated with having other livestock (i.e. cattle or sheep) on farm. The respondents who reported that they bury dead pigs evaluated themselves as having a medium knowledge of legislation, although this practice is considered illegal in the UK (Anonymous, 2013).

The majority of the small-scale pig keepers transport their pigs, using their own vehicles and mainly to slaughter. Considerable distances can be covered (the maximum was 300miles), but on average they transport their pigs 34.1miles. These distances can be justified by the geographical locations of the abattoirs in Scotland, which sometimes requires long distances to be travelled. Similar results were found in a study in Scotland using movement data (Porphyre et al, 2014) where the percentage of use of haulage companies by small-scale producers was low and similar distances were travelled to slaughter.

The small-scale pig keepers source their pigs mainly from breeders or producers, while they mainly borrow boars for breeding. The use of markets and fairs to source their pigs is uncommon. The preference for breeders/producers over fairs could suggest that most small-scale producers have a particular type of pig in mind when they purchase, so they go to a source from which they know this type of pig will be available. However, as the majority do not clean and disinfect their vehicle before or after moving pigs, this practice could clearly pose a risk for disease transmission. This is also true for the use of borrowed breeding boars, which represent a further potential route for movement of disease between premises.

The majority of the producers, although reporting they produce for own-consumption, also report that they sell their pigs. For that they use mainly word of mouth, but local butchers and farmers markets also play a role. These marketing methods show that the pigs are being

464 sold locally, to friends and neighbours. It was interesting that 53% reported that they sell
465 their pigs, but only 25% of all respondents indicated in section 1 of the questionnaire that
466 pig-keeping activities contributes to their income in either a significant or slight way. This
467 might suggest that their level of activity in selling pigs or pig products is residual for their
468 income.

469 One aspect of commercial and certainly quality assured pig production that promotes early
470 recognition of disease issues is the requirement for attendant veterinarians to visit on a
471 reasonably regular basis. Veterinarians can have a main role in detecting disease as soon
472 as it happens in the farms and in this way mitigate disease spread. Although almost half of
473 respondents to this survey indicated that the vet would be their first port of call for advice on
474 pig health (similar to what was described for England (Gillespie et al, 2015)), over 80% of all
475 respondents also report that their pigs are seen by a vet less than once a year. This offers
476 clear opportunity for mild disease signs to go unnoticed, which could have potential
477 repercussions for disease spread, particularly if the pigs were being sold or transported
478 around that time. The answers given in this survey demonstrate that, although there is an
479 overall focus on home consumption and backyard pig-keeping, a substantial proportion of
480 small-scale producers are involved in transportation and selling activities with their pigs,
481 which is likely to increase the risk – even if only to a small degree – of pathogen
482 transmission to larger pig populations. This interaction with commercial producers was also
483 recently highlighted in a recent study in Scotland (Porphyre et al, 2014), in England (Guinat
484 et al, 2016) and in other European countries (Relun et al, 2016). Furthermore, that study
485 (Porphyre et al, 2014) highlights the risk that incursions of exotic disease in small producers
486 may remain undetected for significant periods of time due to less regular visits by
487 veterinarians and lower standards of biosecurity.

488

489 **Conclusion**

Our results suggest that the majority of small-scale pig keepers have mixed farms, the uptake of biosecurity measures was highly variable, they transport their pig within considerable distances using their own vehicles, they feel disconnected from the pig industry and rarely will a veterinarian see their pigs; all these are contributing factors for a increased risk for disease introduction and spread within this population. Furthermore because, in Scotland, interaction between small-scale pig keepers and commercial producers in terms of exchange of live pigs occurs, this type of producers might constitute a risk for the commercial sector, which can not be ignored. Likewise similar interactions happened in England and in other European countries and might occur in other livestock sectors. This investigation fills gaps in knowledge which will allow industry stakeholders and policy makers (through risk analysis/transmission models) to adapt their current disease control programmes and contingency plans to the reality of small–scale pig-keeping enterprises' health and biosecurity status. Similar studies should be considered to assess the role of small-scale keepers in other livestock sectors, such as cattle, sheep and poultry.

Awareness of the concept and importance of biosecurity in animal health management is typically associated with forward-thinking producers, for whom protection of the health status of their herd/flock is high on their list of priorities. In the commercial sector this is often driven by financial and/or regulatory considerations, as much as any desire to preserve animal health. The respondents to this survey have shown substantial variation in their approach to biosecurity: some appear to be quite proactive, others to be reasonably unconcerned. Given the absence of those drivers that carry such weight in commercial production, it is possible that small-scale producers simply do not consider that biosecurity has much relevance to their situation. The risk to the national herd/flock from such an attitude arises on those occasions, albeit rare, when backyard and commercial production meet. Such instances could be the vulnerable point in disease management and control on a national level. The results presented here demonstrate that there is work to be done in terms of knowledge transfer and exchange to small-scale keepers, to promote awareness of their position within

the livestock industry and its potential significance for animal health management.

Conflict of interest

The authors report no competing interest.

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617 **Tables**

618 Table 1: List of the questions included in the questionnaire and the item non-response rate
619 per question

Question	% Non respondents (n=135 respondents)
1. Postcode and CPH (open)	3.0 (without full or partial postcode) 46.7 (without full or partial CPH)
2. Location where pigs were kept (closed)	0.0
3. If pigs were kept in the same place where people live (closed) If not how far (open)	0.0
4. How long kept pigs (open)	5.9
5. Motivation for keeping pigs (as many as apply)	0.0
6. Classification of knowledge for pig health, nutrition, legislation and biosecurity (each required an answer)	0.7
7. Breed of the pigs (as many as apply)	0.0
8. Description of the pig-keeping activities (as many as apply)	0.0
9. Number of adult pigs, young pigs and finishing pigs on June 2013 (open)	5.9 - 10.4
10. If pigs were raised all of the year or part of the year (closed)	8.9
11. Number of finished pigs in 2012 (open)	17.8
12. Source of pigs (young pigs, gilts/sows, boars, semen) (each required an answer)	0.0
13. People involved in working in the pig enterprise (time spent) (open)	0.0 8.1
14. How many livestock was keep in addition to pigs (each required an answer)	2.2 - 3.0
15. If they felt part of the British industry (close) and reasons (open)	3.0 (48.1% gave no reason)
16. If they ever sell their pigs (closed)	3.7
17. How they sell their pigs (as many as apply)	3.7
18. If they encounter problems selling their pigs (closed) if so why (open)	3.0
19. If they ever transport their pigs (closed) if yes why (open)	3.0
20. What is the furthest and common distance for the transport (open)	3.0 - 8.9
21. How the pigs were transported (as many as apply)	3.0
22. How the pigs were identified before travelling (as many as apply)	3.7
23. Pig's access to outdoor areas for each pig category (closed)	3.7 - 5.9
24. Bedding material for each pig category (closed)	3.7 - 5.9
25. Type of feed given to the pigs (each required an answer)	4.4 - 12.6
26. Feed source (each required an answer)	4.4 - 11.9
27. Source of drinking water (semi-closed)	3.7
28. How pig waste was managed (open)	8.1
29. First port of call about pig health (as many as apply)	3.7
30. Frequency of syndromic problems in pigs (each required an answer)	3.0 - 3.7
31. How often did the vet look at the pigs (closed)	3.0
32. Routine pig husbandry – vaccination, deworming, treatment for mange (each required an answer)	3.0 - 4.4
33. How dead pigs were dispose of (open)	8.1
34. Biosecurity approaches taken	3.7 - 4.4
35. If other animals were seen in the pig areas (each required an answer)	3.7 - 5.2
36. If wild boar or feral pigs were seen near the farm (closed)	3.7
37. If the producer was aware of any wild boar or feral pig populations in the area (closed)	3.7

620

621 Table 2: Percentage of respondents having different categories of pigs and the size of their

622 enterprises

Number of pigs			Number					
On June 1st 2013	Category of pigs	% having	Min	1st Q.	Med	Mean	3rd Q.	Max
	Adult	52.4	1	2	2	3.5	5	15
	Young	17.4	1	4	7	8.9	14	21
	Finishing	39.4	1	3	4.5	7	7	23
Finished pigs in 2012		77.5	1	2	4	9.7	12	80

623

624 Table 3: Percentage of respondents having other livestock and the size of their enterprises

If other livestock is also kept in addition to pigs		Number					
Livestock species	% keeping	Min	1st Q.	Med	Mean	3rdQ.	Max
Cattle	36.6	1	4	22.5	64.7	80	450
Sheep	56.1	1	15	40	172.5	107.5	3000
Goats	16.7	1	4	5.5	8.3	8	60
Poultry	73.5	1	10	20	41.1	40	500
Horses	31.8	1	2	2.5	5.7	5.7	60
Other (e.g. deer, llamas, bees)	10.6						

625

626 Table 4: Biosecurity measures taken by the respondents

Biosecurity measures	Always/Mostly (%)	Sometimes/Never (%)	No response (%)
New stock is isolated	38.0	58.9	3.1
Visitor access to pigs is restricted	38.5	61.5	0
Cleaning and disinfection of vehicles before entry to the premises	26.3	72.1	1.6
Vehicles used to transport pigs are cleaned and disinfected after movement	75.9	21.7	2.3
Clothes and footwear disinfected after visiting other farms/areas with animal	36.4	63.6	0
Boot dips/baths at entry to animal areas	13.9	84.5	1.6
Disinfect between batches of pigs using same accommodation	48.5	45.4	6.1
Treat feed before feeding to pigs	5.4	93.0	1.6
Double-fence farm boundaries	26.9	72.3	0.8
Control rodents	71.5	28.5	0
Control insects	24.6	75.4	0
Take measures to stop wildlife accessing pigs or pig pens	30.2	69.8	0
Take measures to stop wildlife accessing feed or waste areas	52.3	47.7	0

Prevent contact between pigs and other animals on the premises	52.7	47.3	0
Prevent contact between pigs and animals on other premises	57.4	41.9	0.7

627

628 **Figure captions**

629 Figure 1: Respondents' motivation for keeping pigs (percentage of responses per reason).

630 Figure 2: Frequency of sightings by respondents of other domestic and wild animals in or

631 near their pigs' environment.