

Determination of swine euthanasia criteria and analysis of barriers to euthanasia in the United States using expert opinion

CR Mullins[†], MD Pairis-Garcia^{*†}, KA George[†], R Anthony[‡], AK Johnson[§], GJ Coleman[#],
J-L Rault[#] and ST Millman[†]

[†] Department of Animal Sciences, The Ohio State University, 2029 Fyffe Road, Columbus, OH 43210, USA

[‡] Department of Philosophy, University of Alaska Anchorage, 3211 Providence Drive, Anchorage, AK 99508, USA

[§] Department of Animal Science, Iowa State University, 2356F Kildee Hall, Ames, IA 50011, USA

[#] Faculty of Veterinary and Agricultural Sciences, Animal Welfare Science Centre, The University of Melbourne, Alice Hoy Building 162, Parkville, VIC 3010, Australia

[†] Veterinary Diagnostic and Production Animal Medicine, Iowa State University, 2201 Lloyd Veterinary Medical Center, Ames, IA 50011, USA

* Contact for correspondence and requests for reprints: pairis-garcia.l@osu.edu

Abstract

Timely euthanasia on swine farms can help to reduce the incidence of poor welfare outcomes for compromised pigs (*Sus scrofa*) when recovery is prolonged or impossible. Timely euthanasia relies upon caretakers' abilities to identify compromised pigs and administer euthanasia in various environments. To determine appropriate timelines and most common reasons for on-farm euthanasia, an online survey was conducted with members of the United States National Pork Board. Additionally, two focus groups were conducted to investigate barriers and possible solutions associated with timely euthanasia. Clinical signs related to poor locomotion (57.6%), prolapses (47.2%), and hernias (43.5%) were identified by the greatest percentage of respondents who believed immediate euthanasia was warranted, while a greater percentage of respondents believed euthanasia was not warranted for clinical signs related to the integumentary (90.3%), reproductive (75.8%), and respiratory (67.5%) systems. The most common reason for euthanasia was poor body condition in pre-weaned piglets and non-ambulatory or severely weak for both breeding and non-breeding pigs. In the focus groups, two themes were identified when evaluating barriers to euthanasia on-farm, and participants agreed that making timely decisions relies upon several dimensions of risk analysis. An unsupportive farm culture was identified as a critical barrier to timely euthanasia decision-making, suggesting that caretaker characteristics may play a role in the success of any timely euthanasia programme. This present study has highlighted areas for future research and demonstrated the need to extend educational efforts both to swine industry leaders and producers to improve overall animal welfare by ensuring timely euthanasia in swine.

Keywords: animal welfare, decision-making, education, euthanasia, swine, timeliness

Introduction

Performing euthanasia may be necessary on swine (*Sus scrofa*) farms for severely ill or injured pigs. Euthanasia, derived from the Greek terms 'eu' and 'thanatos,' meaning 'good' and 'death,' respectively (American Veterinary Medical Association [AVMA] 2013), is conducted to reduce the incidence of poor animal welfare outcomes when, for example, a humane death is a better alternative for a pig than a continued life of unremitting pain and suffering. As with all livestock production systems, it is inevitable that a proportion of pigs on-farm will become injured or ill to the extent that recovery is unlikely, impossible, or would require invasive and/or prolonged treatment. In these cases, timely euthanasia, considered as euthanasia performed when recovery is unlikely or when the animal has demonstrated no signs of improvement, is warranted (National Pork Board [NPB]

2008; NPB & American Association of Swine Veterinarians [AASV] 2008). Making timely euthanasia decisions is also warranted as a means to eliminate pain and suffering associated with decline in health (Fraser *et al* 2013) and physiological distress (Morton 1998).

The act of performing euthanasia is a multi-step process requiring those working with pigs to have the observational abilities to identify compromised animals and the technical skills and willingness to humanely terminate these animals. In the United States (US), swine farm caretakers are often responsible for making independent decisions regarding if and when to administer treatment, provide supportive care and, in some situations, administer euthanasia on-farm (Morrow *et al* 2006; Turner & Doonan 2010; Gemus-Benjamin *et al* 2015). These decisions are often based on the farm's established procedures and policies, which may include farm-developed standards (Morrow *et al* 2006),

auditing programme requirements, or for the US, basic euthanasia guidelines provided by industry organisations (ie, NPB & AASV 2008; AVMA 2013) and the Common Swine Industry Audit ([CSIA]; NPB 2017). Although these guidelines are available, implementing timely euthanasia may be problematic if guidelines are difficult to follow; incorrectly interpreted; or if logistical, emotional, and economic considerations associated with timely euthanasia decision-making are not addressed. Therefore, providing clear euthanasia policies that are understandable and accessible will better prepare caretakers to perform timely euthanasia.

The primary aim of this study was to evaluate how the current US industry euthanasia guidelines are understood and interpreted by industry leaders and more fully explore the challenges associated with timely euthanasia on-farm. This was accomplished with two objectives: objective one — utilise survey techniques to identify the most common reasons for on-farm euthanasia and determine appropriate time-frames to implement euthanasia; objective two — utilise focus group discussions to identify considerations associated with making euthanasia decisions and barriers to performing euthanasia. Both objectives were accomplished by drawing upon the experiences of those actively engaged in the US swine industry. This study is part of a larger project focused on developing a euthanasia-specific training programme for US veterinarians and caretakers and utilising the programme to identify caretaker characteristics which influence the decision-making process (Mullins *et al* in press).

Materials and methods

All research was reviewed and approved by The Ohio State University IRB Committee for Humans Subjects Research (Approval #2015B0467). To target a diverse group of professionals within the swine industry, members of the US NPB and Animal Science and Animal Welfare Committees were recruited based on their on-farm experience and knowledge related to swine euthanasia and welfare. These committees were comprised of individuals involved in the industry and included swine producers, caretakers, veterinarians, industry representatives, academic professionals, and processing plant personnel. The Animal Welfare Committee contributed to the development of the US CSIA; as such, the members of the committee were expected to have the most insight into appropriate euthanasia timelines selected as audit guidelines. The Animal Science Committee was selected to increase the sample size and because most of its members are experts in the field of swine physiology.

Objective 1: Survey

An internet-based survey was created following the principles of the Tailored Design Method (Dillman *et al* 2009) using the Qualtrics Research Suite 2015 online software platform. The survey instrument was independently reviewed by six of the co-authors who are experts in swine production and survey methodology to ensure content validity. These authors have worked extensively in both the US and Australian swine industries, published national surveys related to pig husbandry and euthanasia, and/or

investigated ethical decision-making in agricultural fields. The survey was pre-tested with members of The Ohio State University Welfare and Behavior Lab to assess functionality and approximate completion time (15–20 min). The survey instrument can be found in the Appendix (see supplementary material to papers published in *Animal Welfare* on the UFAW website: <http://www.ufaw.org.uk/t-ufaw-journal/supplementary-material>).

Potential respondents (n = 63) were recruited in January 2016 using email listservs provided by NPB and consisted of members of both the Animal Science and Animal Welfare Committees. Respondents were contacted via email from the Qualtrics Survey Mailer and provided with a consent form and link to the survey. In most cases, the members of these committees were located in geographically separate areas of the country and were not expected to communicate with one another regarding the survey. Additionally, because respondents remained anonymous and could complete as much of the survey as they were comfortable answering, in accordance with IRB protocol, concern regarding response bias was minimal. Non-completion rates for the survey were not anticipated to be large due to the estimated completion time and the committees' interest in furthering animal welfare research for the betterment of the US swine industry. A reminder email was sent one and two weeks after the initial email to non-responders. To avoid discussion among respondents which could have altered respondents' answers, the survey was open for a total of three consecutive weeks and closed the day before the Unified Research Review meeting (February 15, 2016) — a gathering of NPB committee members to review research proposals and discuss industry updates. To ensure anonymity, no identifying information was collected by the Qualtrics platform in connection with the data.

The survey consisted of three parts. Part 1 collected demographic information. Part 2 asked participants to consider euthanasia decisions related to 26 selected illnesses and injury conditions. Respondents were asked to assign each illness and/or injury condition a 'euthanasia score' regarding the timeliness of euthanasia. The 'euthanasia score' presented five discrete choices organised in a unipolar matrix question design: euthanase immediately (score 1), treat and euthanase on-farm within 12 h if no improvement (score 2), treat and euthanase on-farm within 24 h if no improvement (score 3), treat and euthanase on-farm within 48 h if no improvement (score 4), and do not euthanase and re-evaluate if condition worsens or cull (score 5). Based on CSIA guidelines, 48 h is the maximum length of time allowable to see improvement in a pig's condition (NPB 2017). After this time, euthanasia is warranted if the condition does not improve or worsens. Thus, the survey was designed on this specific framework, to most closely match the current 2017 CSIA guidelines. In addition, respondents were provided an open-ended question to add additional comments or clinical signs with a corresponding euthanasia score. Part 3 asked respondents to rank the top five most common reasons for euthanasia over three production stages: breeding stock (sows and boars), pre-weaning piglets, and non-breeding stock (nursery and grower/finisher pigs).

Table 1 Questions utilised in a focus group discussion on timely euthanasia in the US swine industry.

Number	Question text
1	What types of decision-making tools are currently used on farms to assist in deciding when to euthanase a pig, and how are they used?
2	What factors are considered and how are decision-making tools developed by individual farms?
3	What is the biggest factor for why euthanasia would be delayed or not performed on your farm or farms you have visited?
4	Would a standardised decision-making tool be positive or negative for the US swine industry?
5	What types of euthanasia-specific training should be provided? How often should euthanasia-specific training be provided?
6	What characteristics of a decision-making tool maximise the ease of use and acceptability of the tool on farm?

Rankings for each provided clinical sign were averaged to yield an average ranking. Similar to part 2, opportunity was given for respondents to add additional clinical signs and provide a corresponding ranking for each. The clinical signs list was randomised to eliminate order bias.

Objective 2: Focus groups

The second objective was to identify barriers to timely euthanasia and considerations for decision-making using focus group discussions. Members of the NPB Animal Welfare Committee, in attendance at the February 2016 Winter Unified Research Review meeting, were recruited to participate in two focus group discussions using a purposive sampling approach (Morgan 1998). This sampling method was important in the present study because it reduced bias in the results by the direct selection of swine welfare industry leaders for whom euthanasia decision-making and caretaker training are well-understood topics. Using convenience or self-selected samples from other NPB committees may have resulted in bias because participants may not have had the knowledge to comment regarding on-farm euthanasia. Focus groups were selected for this particular objective because they allowed participants to freely express their own opinions and generate ideas from interactions with others (Pivetti 2007). Demographic forms provided before the discussions asked participants to identify their gender, number of years engaged in the swine industry, and current role in the swine industry. Participants were assigned an identifying number linked to their demographic form, and moderators and participants identified themselves throughout the discussions by number to maintain separation of identifying information. Groups were randomly assigned without regard to any of the demographic variables, and discussions were moderated by two CITI-trained (Collaborative Institutional Training Initiative) animal science academic professionals. Both scripts consisted of six open-ended questions accompanied by a series of follow-up questions which were used to expand more deeply upon a comment made by a participant or encourage discussion. Questions were developed to directly ask participants about current challenges and possible solutions to failures of timely euthanasia on-farm. The focus group script and questions were reviewed and modified by all authors. Main questions are summarised in Table 1. Each focus group lasted for an average of 80 min, and discussions were audio-recorded.

Recordings were used to transcribe *verbatim* both discussions which resulted in a total length of 74 double-spaced pages. Scripts were independently analysed by two of the authors for repeated themes and key concepts. Questions were analysed both independently and as they related to other questions, and key quotes were extracted for illustrative purposes. Content analysis was performed using the techniques of Coffey and Atkinson (1996) and Braun and Clarke (2006). Those ideas which were discussed by both groups and which could be explained by multiple smaller key points were categorised as main themes. Within each main theme, several sub-themes were identified which may or may not have been discussed by both groups and which could be further expanded upon by examples provided by participants.

Results

Objective 1: Survey

Part 1: Demographics

A total of 63 committee members were contacted, and 37 responses were recorded, yielding a response rate of 59%; six respondents did not complete the survey (Table 2). In the 'current role in the swine industry' question, ten identified as swine producers (three farrow-to-finish; three sow; three nursery or grower/finisher; one farrow-to-finish and boar stud). Respondents who indicated 'other' (n = 6) categorised themselves as a nutritionist, animal care co-ordinator, animal welfare director, consultant, member of an allied industry, and state animal health official. For those who had previously or currently work with pigs (n = 24), the number of directly managed animals ranged from four to 200,000 for sow producers, 1,000 to 5,000,000 for nursery and grower/finisher producers, and 15 to 7,500 for boar stud producers. Overall, 51.4% of respondents had previously received euthanasia-specific training.

Part 2: Euthanasia scores

In part 2 of the survey, respondents were asked to consider the potential impact of an individual pig's conditions on its ability to function biologically, minimise negative mental states, and perform behaviours which allowed the pig to cope. 'Euthanasia scores' were used to denote five different euthanasia time-points. Respondents' choices were a reflection of when they believed compromised pigs should be

Table 2 Respondents' demographic information collected in a survey on timely euthanasia in the US swine industry.

Variable	n	Respondents (%)
<i>National Pork Board committee affiliation</i>		
Animal welfare	20	54.1
Animal science	15	40.5
Other or did not respond	2	5.4
<i>Current role in the swine industry</i>		
Veterinarian	3	8.1
Academia animal scientist	8	21.6
Swine researcher in industry	4	10.8
Swine producer (operation owner)*	10	27.0
Swine farm stockperson (non-owner)*	1	2.7
Pork packer†	4	10.8
Industry representative	0	0
Other	6	16.2
Did not respond	1	2.7
<i>Education level</i>		
High school diploma/GED‡	2	5.4
Associate's degree/Certificate	1	2.7
Bachelor's degree	9	24.3
Graduate degree (eg MS, MBA, PhD)	17	45.9
Professional degree (eg DVM)	5	13.5
Did not respond	3	8.1
<i>History of euthanasia-specific training</i>		
Yes	19	51.4
No	11	29.7
Did not respond	7	18.9

* In this paper, the term 'stockperson' is synonymous with 'caretaker' and denotes a farm employee whose daily responsibilities include hands-on care of pigs.

† Pork packer refers to personnel working in a pig processing plant or abattoir.

‡ GED: General Educational Development Test is a US equivalency test taken to demonstrate mastery of high school-level academic skills. Not all percentages sum to 100 due to rounding errors.

euthanased based on their clinical signs. During the analysis, the 26 conditions were grouped into ten categories based upon their primary clinical signs: locomotory, gastrointestinal, integument, body condition, hernia, prolapse, respiratory, reproductive, neurological, and systemic conditions. This allowed for exploration of euthanasia scores across broader groupings of clinical signs. The results in Table 3 are presented

as number of respondents and the corresponding percentage for each euthanasia score by individual condition and category. Five respondents provided additional conditions which warranted immediate euthanasia (score 1); these included umbilical hernias which touch the ground; tail-biting which has led to necrosis around the anus; flank-biting which has led to deep, open wounds; emaciated piglets which cannot access feed and water; and piglets which weigh less than 0.68 kg at birth. One respondent indicated that pigs unable to rise due to fatigue should be euthanased on-farm within 12 h (score 2).

The locomotory category contained the greatest percentage of respondents who believed immediate euthanasia (score 1) was warranted, followed by the prolapse, hernia, body condition, neurological, systemic conditions, and respiratory categories. No respondents indicated that conditions in the integument, gastrointestinal, and reproductive categories warranted immediate euthanasia.

Figure 1 presents the cumulative distribution of euthanasia scores for each clinical sign included in part 2. Clinical signs are ranked in descending order based upon the percentage of respondents who indicated 'euthanase immediately' first. Figure 1 can be found in the supplementary material to papers published in *Animal Welfare* on the UFAW website: <http://www.ufaw.org.uk/t-ufaw-journal/supplementary-material>.

Part 3: Rankings of reasons for on-farm euthanasia

Table 4 summarises the average rankings for reasons for on-farm euthanasia for each clinical sign by production stage. In the open-ended question allowing provision to supply additional comments, one respondent identified ulcers and paleness/weakness as the fifth and fourth most common reasons for euthanasia in both breeding and non-breeding stock, respectively. For pre-weaning piglets, one respondent indicated that surviving after being laid on was the most common reason for euthanasia while another indicated this was the second most common reason. Two other respondents noted that being unthrifty or of low bodyweight was the second most common reason, while another noted that piglets with broken limbs should be euthanased but did not provide a corresponding ranking.

Objective 2: Focus groups

Each focus group consisted of nine participants for a total of 18 participants in the study. Group 1 consisted of five males and four females and included one clinical veterinarian, two academia veterinarians, one academia animal scientist, two swine operation owners, and three pork processors, all of whom had at least five years of experience in the swine industry. Group 2 consisted of six males and three females and included one clinical veterinarian, four swine operation owners, one animal care co-ordinator, one allied industry representative, one veterinarian and operation owner, and one animal welfare manager. Seven participants in Group 2 had more than ten years of experience in the swine industry.

The coding of data resulted in three to five sub-themes within each of four main themes. Two of the four themes focused on barriers to euthanasia while the other two focused upon caretaker training and decision tools. For the purpose of this study, only the two themes addressing

Table 3 Response number and corresponding percentages for euthanasia scores assigned within ten categories in a survey on timely euthanasia in the US swine industry.

Category	Specific clinical sign	Euthanasia score n (%)				
		1	2	3	4	5
Locomotory	Fractured limb	28 (90.3)	0 (0)	0 (0)	2 (6.5)	1 (3.2)
	Severely lame	6 (20.0)	5 (16.7)	4 (13.3)	11 (36.7)	4 (13.3)
	Non-ambulatory	19 (61.3)	1 (3.2)	4 (12.9)	7 (22.6)	0 (0)
Cumulative		53 (57.6)	6 (6.5)	8 (8.7)	22 (21.7)	5 (5.4)
Hernia	Umbilical	7 (22.6)	0 (0)	3 (9.7)	4 (12.9)	17 (54.8)
	Scrotal	7 (22.6)	0 (0)	4 (12.9)	4 (12.9)	16 (51.6)
	Perforated	26 (86.7)	0 (0)	1 (3.3)	2 (6.7)	1 (3.3)
Cumulative		40 (43.5)	0 (0)	8 (8.7)	10 (10.9)	34 (37.0)
Prolapse	Vaginal	14 (46.7)	2 (6.7)	6 (20.0)	4 (13.3)	4 (13.3)
	Rectal	8 (25.8)	2 (6.5)	7 (22.6)	10 (32.3)	4 (12.9)
	Uterine	23 (74.2)	2 (6.5)	3 (9.7)	1 (3.2)	2 (6.5)
	Penile	13 (41.9)	2 (6.5)	4 (12.9)	5 (16.1)	7 (22.6)
Cumulative		58 (47.2)	8 (6.5)	20 (16.3)	20 (16.3)	17 (13.8)
Gastrointestinal	Severe diarrhoea	0 (0)	0 (0)	3 (10.0)	11 (36.7)	16 (53.3)
	Bloody diarrhoea	0 (0)	1 (3.3)	4 (13.3)	8 (26.7)	17 (56.7)
	Vomiting	0 (0)	0 (0)	0 (0)	7 (23.3)	23 (76.7)
Cumulative		0 (0)	1 (1.1)	7 (7.8)	26 (28.9)	56 (62.2)
Integument	Skin injuries	0 (0)	0 (0)	0 (0)	3 (9.7)	28 (90.3)
Respiratory	Open-mouth breathing	0 (0)	2 (6.7)	3 (10.0)	2 (6.7)	23 (76.7)
	Thumping	2 (6.5)	0 (0)	2 (6.5)	9 (29.0)	18 (58.1)
	Shallow, rapid breathing	1 (3.2)	1 (3.2)	3 (9.7)	7 (22.6)	19 (61.3)
	Cough	0 (0)	0 (0)	0 (0)	8 (25.8)	23 (74.2)
Cumulative		3 (2.4)	3 (2.4)	8 (6.5)	26 (21.1)	83 (67.5)
Reproductive	Dystocia	0 (0)	2 (6.5)	4 (12.9)	2 (6.5)	23 (74.2)
	Mastitis-Metritis-Agalactia	0 (0)	0 (0)	1 (3.2)	6 (19.4)	24 (77.4)
Cumulative		0 (0)	2 (3.2)	5 (8.1)	8 (12.9)	47 (75.8)
Neurological	Convulsions	7 (23.3)	3 (10.0)	5 (16.7)	8 (26.7)	7 (23.3)
	Circling or inco-ordination	5 (16.1)	3 (9.7)	8 (25.8)	11 (35.5)	4 (12.9)
	Nystagmus or head tilt	3 (9.7)	2 (6.5)	6 (19.4)	13 (41.9)	7 (22.6)
Cumulative		15 (16.3)	8 (8.7)	19 (20.7)	32 (34.8)	18 (19.6)
Systemic conditions	Septicaemia	3 (9.7)	6 (19.4)	3 (9.7)	13 (41.9)	6 (19.4)
	Extremely weak	6 (9.4)	5 (16.1)	4 (12.9)	14 (45.2)	2 (6.5)
Cumulative		9 (14.5)	11 (17.7)	7 (11.3)	27 (43.5)	8 (12.9)
Body condition	Dramatic weight loss or BCS 1	6 (19.4)	1 (3.2)	3 (9.7)	14 (45.2)	7 (22.6)

Score 1: Euthanase immediately.

Score 2: Treat and euthanase on-farm within 12 h if no improvement.

Score 3: Treat and euthanase on-farm within 24 h if no improvement.

Score 4: Treat and euthanase on-farm within 48 h if no improvement.

Score 5: Do not euthanase and re-evaluate if condition worsens or cull.

Further explanation for each specific clinical sign can be found in the full survey provided in the Appendix (<http://www.ufaw.org.uk/t-ufaw-journal/supplementary-material>).

Respondents could only select one euthanasia score for each clinical sign. Not all percentages sum to 100 due to rounding error, and not all participants submitted a euthanasia score for each clinical sign.

Table 4 Average ranking of reasons for on-farm euthanasia in a survey on timely euthanasia in the US swine industry.

Production stage	Reason for euthanasia	Average ranking*
Breeding stock	Non-ambulatory or severely weak	1.4
	Severe lameness (non-weight-bearing on one limb)	2.4
	Prolapse	3.2
	Respiratory disease	3.3
	Reproductive disease	3.5
	Dramatic weight loss or BCS I	3.5
	Systemic disease	3.9
	Skin injuries	4.9
	Gastrointestinal disease	5.0
Pre-weaning piglets	Starve-outs or BCS I	1.7
	Non-ambulatory or severely weak	2.1
	Severe lameness (non-weight-bearing on one limb)	3.3
	Respiratory disease	3.3
	Hernias (umbilical or scrotal)	3.6
	Gastrointestinal disease	4.0
	Skin injuries (eg facial injuries, leg abrasions)	4.1
Non-breeding stock	Systemic disease	4.1
	Non-ambulatory or severely weak	1.7
	Severe lameness (non-weight-bearing on one limb)	2.7
	Dramatic weight loss or BCS I	3.2
	Systemic disease	3.4
	Respiratory disease	3.4
	Prolapse (necrotic)	3.5
	Hernias (umbilical or scrotal)	3.6
	Gastrointestinal disease	3.8
Skin injuries	4.3	

* Average ranking determined by computing a simple arithmetic mean of all ranked responses for each clinical sign. Further explanation for each specific clinical sign can be found in the full survey provided in the Appendix (<http://www.ufaw.org.uk/t-ufaw-journal/supplementary-material>).

barriers to euthanasia will be presented (Table 5). These themes were largely derived from discussion associated with Question 3 (Table 1). Quotes are accompanied by the group number (ie, G1 = Group 1), participant number (ie, P1 = Participant 1), and the participant's role in the swine industry as indicated on the demographic form.

Theme 1: Considerations in euthanasia decisions

Participants acknowledged several external factors exist which influence the decision to euthanase. These factors were generally based on the importance of risk analysis of performing euthanasia as it relates to potential impacts on overall herd health, public perception of animal care, and the pig's likelihood of recovery. Several participants highlighted these ideas:

When we're thinking about risk related to euthanasia, it's sort of a two-sided sword, having animals there that should be euthanased but weren't, is a risk for people seeing that and then condemning you for your inaction. Likewise, euthanasing things is just not a pretty sight, and it's not a pleasant experience for anybody, so that becomes a risk (G2, P7, producer).

We recently had an incident where an auditor said there were two piglets that were not timely euthanased. To this day, the auditor says timely euthanasia was a failure, and the producer is adamant that it was not a problem. So perception of timely euthanasia is always going to be a challenge (G1, P3, pork processor).

Timeliness of euthanasia is all in the eye of the beholder, and no matter how many rules, regulations, matrices that you put out there, you are never going to satisfy everyone's definition of timely euthanasia (G1, P7, pork processor).

As a biological system, it [a compromised pig] doesn't always fit the cookie-cutter protocols (G2, P5, veterinarian and producer).

Theme 2: Barriers to timely euthanasia

Participants in both groups described thoroughly how logistical, economic, emotional, and cultural barriers play a significant role in timely euthanasia decision-making. The difficulty in detecting and monitoring compromised pigs; physical location and condition of equipment; and removing and disposing of carcasses were all indicated as common factors delaying the process. Euthanasia methods may also result in delayed euthanasia as one participant described that caretakers may wait until enough pigs are collected to fill the carbon dioxide chamber, or the caretaker moves all pigs at once to a central euthanasia location. The lack of available and capable personnel, particularly on weekends and holidays, and where company representatives are the only personnel authorised to euthanase was also discussed as a contributing factor for delaying euthanasia. Additionally, two participants provided examples of competing priorities indicating that for some producers, euthanasia is not considered a top priority:

I think it's 'breed and feed' first and then 'inspect, treat, and euthanase' (G1, P9, producer).

There is a disease flowing around called 'cornitis,' I call it. So in the spring and the fall, the value to that person, to his time, is not to be in the barn euthanasing pigs.

They will take care of dying themselves, and I gotta get a crop in the ground (G2, P7, producer).

One of the most significant reasons for delaying euthanasia mentioned by nearly all participants is the economic value tied to pig loss. According to participants, both 'per-head' payment systems which compensate producers based on

final pig numbers and the economic investment in breeding and grower/finisher pigs may encourage delayed decision-making. For pork processors, any system which rewards producers for shipping more pigs is problematic, and feedback to producers is an essential component to reducing the number of compromised pigs leaving the farm:

So sometimes if we receive an animal in the plant that we believe should've been euthanased, we counsel that producer that you have spent the same amount of money feeding and paying for the animal but are now going to be paid a reduced price on that animal (G1, P3, pork processor).

We have, in our system, the decision to cull or the decision to euthanase, and ultimately it comes down to [an] economic decision (G2, P6, animal care co-ordinator).

An additional significant barrier explored by participants was the emotional effects felt by caretakers when euthanasia is viewed as a failure to provide adequate or sufficient care. Participants emphasised that caretakers are tasked with caring for pigs to the best of their ability, and asking caretakers to euthanase pigs is difficult because of their hope that additional treatment may allow the pig to heal, despite the length and success of past treatment. It was also noted that caretakers, by avoiding euthanasia duties themselves, relegate the task to a higher authority on-farm, thus transferring the responsibility and perpetuating farm-wide systemic emotional strain. Furthermore, the emotional impact on caretakers of performing mass euthanasia in response to disease outbreak was discussed:

Your job is to keep pigs alive and care for them well. The end-of-life decision is not one that really flows well with that mentality. So you're asking people to make [a big statement], essentially say, 'I failed' (G2, P7, producer).

I know that I've encountered some people with the mentality of 'I can save them all,' and they may have the best of intentions. They just continue trying to treat and improve the condition of the animal (G1, P3, pork processor).

But our personnel that work in the farrowing house, they're subconsciously selected because of their caring nature for the sow and the piglets, and to tell them to euthanase is very difficult for them to do. I don't know the answer to that one (G1, P2, academia veterinarian).

They [caretakers] just cannot emotionally wrap themselves around euthanasing one more animal (G1, P8, producer).

A final barrier to timely euthanasia discussed by participants was the role that farm culture and accountability play in influencing the timeliness of euthanasia. Farm culture was explained as the degree to which caretakers and managers allow one another to delay timely euthanasia decisions while accountability reflected the idea that farm managers or upper management should expect caretakers to perform euthanasia when needed. Within Group 1, farm culture was indicated as a key driver determining caretakers' willingness to euthanase as it influences expectations of performance in situations where oversight is not always present:

Table 5 Coded themes and sub-themes identified in a focus group analysis on timely euthanasia in the US swine industry.

Theme	Main themes	Sub-themes
1	Considerations in euthanasia decisions	Health status of animal and herd Public perception and risk analysis Caretakers' perception of ability to recover
2	Barriers to timely euthanasia	Logistical challenges Balancing competing priorities Economic considerations Emotional strain on caretakers Farm culture and accountability

...I think one of the key things I see just goes back to the culture and expectations... Most of us don't walk out of a barn if it's out of food or water. However, there's several sites where we walk out of and there's pigs that need to be euthanased or caretakers walked out. So it's just that kind of mindset that I think we need to work on still (G2, P6, animal care co-ordinator).

The culture of an operation really drives appropriate procedures and handling and interactions with animals, especially at times when oversight isn't always present which is typically the case. [...] If the culture's set appropriately, then that's where the best decision-making can happen (G2, P3, allied industry representative).

Barn culture is really a big deal (G2, P9, producer).

[Euthanasia] is a highly dispersed decision occurring millions of times a day across our swine farms, and it really needs a community sense of discipline with each other to keep on doing it correctly (G1, P9, academia veterinarian).

Similarly, participants in Group 1 emphasised the importance of holding caretakers accountable for performing euthanasia regardless of their personal feelings toward the act. In general, participants felt strongly that the expectations both from management and peers as regards to how timely decisions are made, greatly influence how caretakers act on-farm:

Caretakers are perfectly capable of identifying which animals need to be euthanased, but they are very often not willing to take on the responsibility (G1, P8, producer).

Overall, participants expressed the sentiment that timely euthanasia is a complex issue fraught with challenges to reducing the incidence of the problem on-farm. The act of performing euthanasia was described as aversive, and participants noted that the competent caretaker feels the need to provide care to sustain the life of the pig. One participant opined:

I would argue if you have someone that likes doing euthanasia you probably need to fire them (G1, P8, producer).

Table 6 Timely euthanasia criteria of the 2017 US Common Swine Industry Audit.

Pigs which have not improved after two days of intensive care or which have no prospect for improvement
Severely injured or non-ambulatory* pigs with the inability to recover
Any non-ambulatory pig with a body condition score of 1
Pigs with hernias which touch the ground while standing, cause difficulty walking, and are ulcerated; or pigs with perforated or ulcerated hernias which are also necrotic
Pigs with uterine prolapses or untreated, necrotic prolapses

* A pig is classified as non-ambulatory if it cannot rise or if it can stand with support but cannot bear weight on two legs.

Despite significant challenges that producers and caretakers still face, some participants acknowledged that significant progress has been made in the swine industry regarding timely euthanasia decisions. Many agreed that opportunity still exists for improvement:

The progress in the industry over the last 5–10 years is amazing. It's getting better. We have weaknesses, but at least the industry is attempting to address them. I'm pleased with that. [...] In general, I would say we're not very good as an industry with timely euthanasia (G1, P2, academia veterinarian).

Discussion

The objective of this study was to identify possible avenues which influence decision-making and performance of euthanasia on-farm with the goal of reducing negative welfare outcomes on swine farms. Additionally, the study was intended to explore the opinions of US swine industry leaders regarding appropriate euthanasia time-lines, similar to the survey methodology of sampling an expert panel utilised in previous studies (Rodenburg *et al* 2008; Jensen *et al* 2012a).

Under the 2017 CSIA euthanasia criteria (Table 6), an automatic audit failure will result if any compromised pig is present during an audit. Though it was not expected that all respondents be in agreement with all examples regarding euthanasia timelines as measured in Part 2 of the survey (euthanasia scores), the lack of consensus on several of the specific conditions was unexpected. Approximately one-third of respondents (38.7%) indicated that a pig which is 'non-weight bearing on two or more legs' (one of the CSIA definitions of a non-ambulatory animal) should not be euthanased immediately (score 1). Non-ambulatory pigs represent both a welfare concern on-farm, because likelihood of recovery is often poor, as well as a public perception risk, as explained by one producer who described this idea as a 'two-sided sword' (G2, P7). However, it should be noted that other clinical conditions, including neurological deficits and acute stress, can result in non-ambulatory pigs which retain the ability to recover. In this study, no qualifiers were used to further define non-ambulatory or the potential for recovery, so opportunities to draw conclusions for this specific condition are limited. Results for the conditions 'uterine prolapse' and 'perforated hernia' were unexpected and showed that only 74.2 and 86.7% of respondents, respectively, assigned score 1, indicating the

need for immediate euthanasia. Though widespread education may help improve consensus amongst industry leaders in some of the more critical euthanasia categories already defined by the CSIA, in other clinical conditions' categories, there was more consensus towards not euthanasing (score 5). This was particularly evident for those categories — gastrointestinal, integument, respiratory, and reproductive — which included conditions that are often associated with a greater potential for recovery and which may not present as much of a dilemma for caretakers in deciding on a euthanasia timeline. The wide distribution of euthanasia scores in both the neurological and systemic conditions' categories may be an indication that these conditions are not as commonly identified or diagnosed and that they can be associated with both severe and mild clinical signs. Thus, making euthanasia decisions on very broadly defined clinical signs may have contributed to the variability of responses and lack of consensus among respondents. Supporting this idea, one veterinarian and producer (G2, P5) described how assuming standardised responses — 'cookie-cutter protocols' — to compromised pigs may not result in the best outcomes due to the inherent biological variability between individual animals.

It should be acknowledged that this biological variability can also influence the appearance and severity of certain disease conditions which are not acute in nature. Under the CSIA, a compromised pig is given two days to respond to treatment before euthanasia is warranted. This time allowance and the nature of disease processes specifically in the body condition as well as the neurological and systemic conditions' categories may explain why the greatest percentage of respondents indicated score 4 ('treat and euthanase on-farm within 48 h if no improvement'). Therefore, caretakers must be keenly observant of pig behaviour in these cases to ensure continued feed and water intake, yet also understand that these types of conditions may require a significant amount of time to resolve depending on the underlying pathology. Variation was also noted for the condition 'fractured limb' in which 3.2% of respondents provided score 5, 6.5% indicated score 4, and 90.3% indicated score 1. However, this may be because fractured limbs present very differently depending upon the location and severity of the condition. Despite established guidelines, it is evident that there is still a lack of understanding and agreement amongst industry leaders regarding

euthanasia timeline standards. Thus, opportunities may exist for more thorough descriptions of guidelines within training programmes and audit standards. These results are demonstrative of the need for further evaluation of communication efforts and training from scientists, veterinarians, and other animal welfare experts to guide timely on-farm euthanasia decision-making.

An understanding of the most common reasons for on-farm euthanasia can help ensure the most relevant caretaker training programmes and thus allow caretakers to be more conscious when pigs present with certain 'high-risk' clinical signs. Given that 'non-ambulatory' and 'severely lame' were among the top three most common reasons for euthanasia for all three production stages, it may be prudent for producers to cautiously evaluate lame animals and make euthanasia decisions before lame animals become non-ambulatory. Few studies have identified reasons for removal from the herd specifically by humane euthanasia, but it has been found that sows may be euthanased because of rectal and uterine prolapses, respiratory disease (Sanz *et al* 2007), shoulder ulcers (Jensen *et al* 2012b), mastitis (Engblom *et al* 2007), and digestive disorders (Christensen *et al* 1995) while grower/finisher pigs may be euthanased as a result of respiratory and gastrointestinal diseases, locomotory problems including fractures (Straw *et al* 1983), systemic infections, hernias, and integument injuries (Baumann & Bilkei 2002). It is interesting to note that for pre-weaning piglets, the most common reason for on-farm euthanasia was 'starve-outs or poor body condition score (BCS 1)'. Since natural swine death is normally greatest in the first few days after birth (Kerr & Cameron 1995; Roehe & Kalm 2000; Velarde *et al* 2015), producers may elect to euthanase piglets below a certain weight threshold without holistically evaluating the piglet's body condition and health status. Reflecting this sentiment, one respondent, an 'academia animal scientist,' indicated that piglets less than 0.68 kg at birth should be euthanased immediately without any qualifying statements regarding the piglet's condition aside from the low birth weight. The present study has ranked the relative frequency of common conditions in necessitating euthanasia which may be helpful in ensuring that euthanasia-specific training ensures caretakers' competency in addressing pigs which are possible euthanasia candidates based on their clinical presentation. This information also helped inform the selection of relevant case studies for the development of the euthanasia-specific training programme (Mullins *et al* in press).

Focus group participants both confirmed that caretakers face significant and numerous obstacles related to timely decision-making and highlighted possible avenues for future research. Though participants acknowledged the importance of considering economic and logistical challenges associated with making timely decisions, they also noted that these obstacles are often highly specific to individual farms based on numerous factors including, but not limited to, facility design, methods of euthanasia, pig production stage, interactions with upper management, and number of employees. However, focus group participants identified that most care-

takers tasked with performing euthanasia face similar emotional challenges. This emotional strain is not unique to caretakers of swine. Commonly termed 'compassion fatigue', Joinson (1992) was one of the first to describe the distress experienced by those in human nursing positions, but the term has since been used to describe the direct emotional effects of euthanasing animals (Scotney *et al* 2015). Arluke (1994) introduced a similar concept, the caring-killing paradox, which describes how animal shelter caregivers must sometimes euthanase the same animals for which they have been providing care. As noted by participants, caretakers are often selected for their positions because they demonstrate a motivation to save, raise, and heal pigs in their care:

But our personnel that work in the farrowing house, they're subconsciously selected because of their caring nature for the sow and the piglets... (G1, P2, academia veterinarian).

Therefore, when caretakers are asked to euthanase compromised pigs, some see this as a failure to provide adequate care (Blackwell 2004). It may thus be appropriate to consider that the same mental conflict associated with having to euthanase healthy shelter animals occurs in swine farm caretakers as well. Disease outbreaks can further magnify the emotional strain on caretakers when mass depopulation of farms is necessary. To illustrate, one participant recognised the emotional breaking point which some caretakers faced during the large-scale euthanasia of piglets during the US Porcine Epidemic Diarrhea Virus (PEDv) outbreak which began in May 2013. One participant described caretakers as being unable to:

.....emotionally wrap themselves around euthanasing one more animal (G1, P8, producer).

Similar negative psychological impacts have been noted with previous mass outbreaks and depopulations associated with Foot and Mouth Disease in the UK and Johne's disease in Australia (Hall *et al* 2004; Mort *et al* 2008). The results of the present study suggest that both compassion fatigue and the caring-killing paradox are likely important factors driving euthanasia decisions on swine farms.

Broadening the scope of emotional obstacles from an individual to a farm level, participants emphasised that farm culture may play a large role in determining ultimate caretaker behaviour related to euthanasia decisions. Though individual-level emotional challenges may serve as the primary individual barrier towards performing euthanasia, a positive farm culture which is established and maintained by caring management personnel who prioritise employee well-being, may help ensure that those responsible for euthanasia are comfortable with the task. This culture may offer the required emotional support to individuals while also establishing expectations related to performance of caretaker duties. As explained by an animal care coordinator (G2, P6), decision-making ultimately "...just goes back to the culture and expectations..." The revelation that widespread social interactions within the farm amongst caretakers and management personnel influence performance expectations highlights an area for further research.

To complement efforts to encourage a more supportive farm culture, research to identify and characterise caretakers' specific internal motivations related to performing euthanasia may help induce behaviour change on an individual level. Following established principles of modifying swine caretaker behaviour demonstrated by others (Hemsworth *et al* 1994; Coleman *et al* 2000) may offer an opportunity to target caretakers' underlying beliefs and attitudes, thereby encouraging timely decision-making. Opportunities to establish and/or improve accountability procedures for caretakers, an important dimension of farm culture, should also be investigated.

Despite novel findings, this study had several limitations. In the survey, the generalised clinical conditions left room for ambiguity with regards to previous history of disease or injury, severity of clinical signs, pig production stage, the caretaker's past experience with similar situations, and availability of intensive veterinary treatment. Thus, it is likely that respondents would assign different euthanasia scores given additional information. Furthermore, separating euthanasia score 5 into two options — re-evaluate the pig at a later time-point or cull the pig — may have revealed differences in a pig's ultimate disposition. Additionally, the exclusion of caretakers from the focus group samples due to the make-up of the NPB committees eliminated the potentially valuable insight these individuals may have added describing the specific challenges they face regarding euthanasia decision-making and appropriate euthanasia time-lines. To draw more robust conclusions regarding impediments associated with euthanasia decision-making, the addition of caretakers to future research samples is imperative. Despite these limitations, this study presents a unique opportunity to understand how industry leadership views the importance of animal welfare and has revealed both the seriousness with which the US swine industry views timely euthanasia as well as possible avenues for future novel research.

Animal welfare implications

Further investigation of the apparent knowledge discrepancy between US swine industry euthanasia guidelines and industry leaders' understanding of those guidelines can improve quality of swine care on-farm by caretakers. Furthermore, fostering a supportive farm culture which emphasises making timely and humane euthanasia decisions may offer a novel avenue through which timely decision-making can be encouraged.

Conclusion

This multimodal study sought to determine swine euthanasia criteria and the most common reasons for euthanasia from swine industry experts. Furthermore, obstacles to timely euthanasia were discussed by swine welfare experts. The results of this study suggest that there is a lack of understanding or acceptance of national audit guidelines by industry leaders, which may highlight an area for future education and clarification of industry standards.

Additionally, an exploration of how different clinical signs impact euthanasia timeline decisions provided a unique perspective on how these signs can be incorporated as humane endpoints. Perhaps most notable in the focus group discussions was the finding that farm culture and caretaker accountability play an important — if not the most significant — role in determining the willingness of caretakers to euthanase a compromised pig immediately, when needed.

Acknowledgements

The authors would like to acknowledge the National Pork Board committee members who participated in this research. Funding was provided by the National Pork Checkoff.

References

- Arluke A** 1994 Managing emotions in an animal shelter. In: Manning A and Serpell J (eds) *Animals and Human Society: Changing Perspectives* pp 145-165. Routledge: New York, USA
- AVMA** 2013 *AVMA Guidelines for the Euthanasia of Animals, 2013 Edition*. American Veterinary Medical Association: Schaumburg, USA
- Baumann B and Bilkei G** 2002 Emergency-culling and mortality in growing/fattening pigs in a large Hungarian 'farrow-to-finish' production unit. *Deutsche Tierärztliche Wochenschrift* 109: 26-33
- Blackwell TE** 2004 Production practices and well-being: swine. In: Benson GJ and Rollin BE (eds) *The Well-Being of Farm Animals* pp 241-269. Blackwell Publishing: Oxford, UK. <https://doi.org/10.1002/9780470344859.ch12>
- Braun V and Clarke V** 2006 Using thematic analysis in psychology. *Qualitative Research in Psychology* 3: 77-101. <https://doi.org/10.1191/1478088706qp063oa>
- Christensen G, Vraa-Andersen L and Mousing J** 1995 Causes of mortality among sows in Danish pig herds. *Veterinary Record* 137: 395-399. <https://doi.org/10.1136/vr.137.16.395>
- Coffey A and Atkinson P** 1996 *Making Sense of Qualitative Data: Complementary Research Strategies* pp 26-53. Sage Publications Inc: Thousand Oaks, USA
- Coleman GJ, Hemsworth PH, Hay M and Cox M** 2000 Modifying stockperson attitudes and behaviour towards pigs at a large commercial farm. *Applied Animal Behaviour Science* 66: 11-20. [https://doi.org/10.1016/S0168-1591\(99\)00073-8](https://doi.org/10.1016/S0168-1591(99)00073-8)
- Dillman DA, Smyth JD and Christian LM** 2009 *Internet, Mail, and Mixed-Mode Surveys: The Tailored Design Method*. John Wiley & Sons Inc: Hoboken, USA
- Engblom L, Lundeheim N, Dalin A and Andersson K** 2007 Sow removal in Swedish commercial herds. *Livestock Science* 106: 76-86. <https://doi.org/10.1016/j.livsci.2006.07.002>
- Fraser D, Duncan IJH, Edwards SA, Grandin T, Gregory NG, Guyonnet V, Hemsworth PH, Huertas SM, Huzzey JM, Mellor DJ, Mench JA, Špinka M and Whay HR** 2013 General principles for the welfare of animals in production systems: the underlying science and its application. *The Veterinary Journal* 198: 19-27. <https://doi.org/10.1016/j.tvjl.2013.06.028>
- Gemus-Benjamin M, Kramer S, Bratton A and Conklin T** 2015 A perspective of stockpersons and the humane euthanasia of swine. *MSU Pork Quarterly* 20(1): 1-6
- Hall MJ, Ng A, Ursano RJ, Holloway H, Fullerton C and Casper J** 2004 Psychological impact of the animal-human bond in disaster preparedness and response. *Journal of Psychiatric Practice* 10: 368-374. <https://doi.org/10.1097/00131746-200411000-00005>

- Hemsworth PH, Coleman GJ and Barnett JL** 1994 Improving the attitude and behaviour of stockpersons towards pigs and the consequences on the behaviour and reproductive performance of commercial pigs. *Applied Animal Behaviour Science* 39: 349-362. [https://doi.org/10.1016/0168-1591\(94\)90168-6](https://doi.org/10.1016/0168-1591(94)90168-6)
- Jensen TB, Kristensen HH and Toft N** 2012a Quantifying the impact of lameness on welfare and profitability of finisher pigs using expert opinions. *Livestock Science* 149: 209-214. <https://doi.org/10.1016/j.livsci.2012.07.013>
- Jensen TB, Toft N, Bonde MK, Kongsted AG, Kristensen AR and Sørensen JT** 2012b Herd and sow-related risk factors for mortality in sows in group-housed systems. *Preventive Veterinary Medicine* 103: 31-37. <https://doi.org/10.1016/j.prevetmed.2011.09.009>
- Joinson C** 1992 Coping with compassion fatigue: burned out and burned up – has caring for others made you too tired to care for yourself? *Nursing* 22(4): 116-121
- Kerr JC and Cameron ND** 1995 Reproductive performance of pigs selected for components of efficient lean growth. *Animal Science* 60: 281-290. <https://doi.org/10.1017/S135772980008444>
- Morgan DL** 1998 *Planning Focus Groups: Focus Group Kit 2* pp 55-69. Sage Publications Inc: Thousand Oaks, USA. <https://doi.org/10.4135/9781483328171.n6>
- Morrow WEM, Meyer RE, Roberts J and Lascelles D** 2006 Financial and welfare implications of immediately euthanizing compromised nursery pigs. *Journal of Swine Health and Production* 14: 25-34
- Mort M, Baxter J, Bailey C and Convery I** 2008 Animal disease and human trauma: the psychosocial implications of the 2001 UK foot and mouth disease disaster. *Journal of Applied Animal Welfare Science* 11: 133-148. <https://doi.org/10.1080/10888700801925984>
- Morton DB** 1998 Suffering of animals. In: Bekoff M and Meaney CA (eds) *Encyclopedia of Animal Rights and Animal Welfare* pp 329-330. Greenwood Press: Westport, USA
- Mullins CR, Pairis-Garcia MD, Campler MR, Anthony R, Johnson AK, Coleman GJ and Rault J-L** The development of an interactive computer-based training program for timely and humane on-farm pig euthanasia. *Journal of Veterinary Medical Education*, in press
- National Pork Board (NPB)** 2008 *Timely Euthanasia: Well-Being and Financial Implications*. National Pork Board: Des Moines, USA
- National Pork Board (NPB)** 2017 *Common Swine Industry Audit: Instructions, Standards and Audit Tool*. National Pork Board: Des Moines, USA
- National Pork Board (NPB) and American Association of Swine Veterinarians (AASV)** 2008 *On-Farm Euthanasia of Swine: Recommendations for the Producer*. National Pork Board: Des Moines, USA
- Pivetti M** 2007 Natural and unnatural: activists' representations of animal biotechnology. *New Genetics and Society* 26(2): 137-157. <https://doi.org/10.1080/14636770701466840>
- Rodenburg TB, Tuytens FAM, de Reu K, Herman L, Zoons J and Sonck B** 2008 Welfare assessment of laying hens in furnished cages and non-cage systems: assimilating expert opinion. *Animal Welfare* 17: 355-361
- Roehe R and Kalm E** 2000 Estimation of genetic and environmental risk factors associated with pre-weaning mortality in piglets using generalized linear mixed models. *Journal of Animal Science* 70: 227-240. <https://doi.org/10.1017/S1357729800054692>
- Sanz M, Roberts JD, Perfumo CJ, Alvarez RM, Donovan T and Almond GW** 2007 Assessment of sow mortality in a large herd. *Journal of Swine Health and Production* 15(1): 30-36
- Scotney RL, McLaughlin D and Keates HL** 2015 A systematic review of the effects of euthanasia and occupational stress in personnel working with animals in animal shelters, veterinary clinics, and biomedical research facilities. *Journal of the American Veterinary Medical Association* 247(10): 1121-1130. <https://doi.org/10.2460/javma.247.10.1121>
- Straw BE, Neubauer GD and Leman AD** 1983 Factors affecting mortality in finishing pigs. *Journal of the American Veterinary Medical Association* 183(4): 452-455
- Turner P and Doonan G** 2010 Developing on-farm euthanasia plans. *The Canadian Veterinary Journal* 51(9): 1031-1034
- Velarde A, Fàbrega E, Blanco-Penedo I and Dalmau A** 2015 Animal welfare towards sustainability in pork meat production. *Meat Science* 109: 13-17. <https://doi.org/10.1016/j.meatsci.2015.05.010>