An investigation of sow interaction with ice blocks on a farm with group-housed sows fed by electronic sow feeders

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Summary

More gestating sows are being housed in pens where it is challenging to implement controlled exposure to pathogens for disease control ("feedback"). Ice blocks provide a possible vehicle for feedback material in pen gestation. Ice blocks were placed once weekly for 6 consecutive weeks in a pen of approximately 130 sows to test whether sows would interact with the blocks of ice. Sows were housed in a large, dynamic pre-implantation group fed with electronic sow feeders. Each ice block was video-recorded for 1 hour. All sows that contacted it were identified. The number of sows, their duration of contact, and amount of aggression were coded from the video. Median number of sows that interacted with the ice was 94, and increasing the number of ice blocks from two to four per pen increased the median number of sows to contact the ice and the median duration of an individual sow's contact with the ice, and decreased the amount of aggression at each block. Our findings suggest ice blocks are a convenient vehicle for controlled exposure of feedback material to gestating sows housed in large pens. However, additional studies are needed to validate pathogen exposure with this method.

Keywords: swine, ice, controlled exposure, group housing, behavior

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Resumen - Una investigación sobre la interacción de hembras con bloques de hielo en una granja con hembras alojadas en grupos alimentadas con comederos electrónicos

Cada vez, se están alojando más hembras gestantes en corrales donde es difícil implementar una exposición controlada a patógenos para el control de enfermedades ("retroalimentación"). Los bloques de hielo proveen un posible vehículo para material de retroalimentación en el corral de gestación. Los bloques de hielo se colocaron una vez por semana durante 6 semanas consecutivas en un corral de aproximadamente 130 hembras para probar si las hembras interactuarían con los bloques de hielo. Las hembras se alojaron en grupos grandes, dinámicos de preimplantación alimentados con comederos electrónicos. Cada bloque de hielo fue video grabado por 1 hora. Todas las hembras que tuvieron contacto con él fueron identificadas. El número de hembras, la duración del contacto, y la cantidad de agresión fueron identificados en el video. El número mediano de hembras que interactuaron con el hielo fue de 94, y el incremento del número de bloques de hielo de dos a cuatro por corral, incrementó el número mediano de hembras que hicieron contacto con el hielo y la duración mediana del contacto de la hembra individual con el hielo, y la disminuyó la agresión hacia cada bloque. Nuestros hallazgos sugieren que los bloques de hielo son un vehículo conveniente para la exposición controlada de material de retroalimentación para las hembras gestantes alojadas en corrales grandes. Sin embargo, se necesitan estudios adicionales para validar la exposición patógena con este método.

Résumé - Étude sur l'interaction entre des truies et des blocs de glace sur une ferme avec des truies logées en groupe et nourries avec des distributeurs électroniques de nourriture

Plus de truies gestantes sont logées dans des parcs représentant ainsi un défi pour mettre en place des mesures permettant de maitriser l'exposition à des agents pathogènes pour le contrôle des maladies ("rétroaction"). Des blocs de glace fournissent un véhicule possible pour du matériel de rétroaction dans les parcs de gestation. Les blocs de glace ont été placés une fois par semaine pour 6 semaines consécutives dans un parc d'environ 130 truies pour tester si les truies interagiraient avec les blocs de glace. Les truies étaient hébergées dans un grand groupe dynamique pré-implantation et nourries avec un distributeur électronique d'aliments pour truies. Chaque bloc de glace était enregistré par vidéo pendant 1 heure. Toutes les truies qui sont entrées en contact avec le bloc étaient identifiées. Le nombre de truies, la durée du contact, et la quantité d'agressions étaient codés à partir de la vidéo. Le nombre médian de truies qui ont interagit avec la glace était de 94, et en augmentant le nombre de blocs de glace de deux à quatre par enclos on augmenta le nombre médian de truies venant en contact avec la glace et la durée médiane qu'une truie était en contact avec la glace, et on diminua le nombre d'agressions à chaque bloc. Nos trouvailles suggèrent que des blocs de glace sont un véhicule acceptable pour contrôler l'exposition à du matériel de rétroaction de truies gestantes logées dans des grands enclos. Toutefois, des études supplémentaires sont requises pour valider l'exposition à des agents pathogènes avec cette méthode.

More sows are being housed in groups, and both legislative initiatives and market forces suggest that the number of group-housed sows will only increase in the future. Producers and

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veterinarians that work with loose-housed sows face different challenges from those that house sows in gestation stalls. For example, the control of some diseases is proving to be more challenging in loose-housed sows than in sows in gestation stalls. In particular, protection against endemic enteric diseases of swine is usually achieved by inducing herd immunity following uniform exposure of healthy sows to the pathogen via a controlled exposure to infected biological material. This process is commonly called "feedback" and is used routinely in the acclimatization of gilts. It increases colostral antibodies to common pathogens such as rotavirus[1] and *Clostridium perfringens*.[2] Another common use for feedback is to help develop whole-herd immunity to a newly introduced enteric pathogen such as transmissible gastroenteritis virus (TGEV).[3] These feedback programs are readily implemented in conventional gestation barns where sows are constrained by a gestation stall to a single physical location, and it is easy to ascertain if the animal has been exposed. In contrast, the ability to induce whole-herd immunity via feedback in loose-housed sows is much more challenging, as sows are free to move around and exposure is harder to achieve and confirm.

The shortcomings of feedback in loose-housed sows is even more problematic on farms that use electronic sow feeders (ESFs), as the facilities are not designed to simultaneously feed all sows in the herd. These challenges have come to the forefront in the last 2 years with the emergence of a new and more pathogenic enteric virus in the US sow herd, porcine epidemic diarrhea virus (PEDV). The acute and severe death loss associated with this disease demands a solution to enteric pathogen control in loose-housed sows. There is little that has been done investigating feedback in electronic sow-feeding facilities. A micro-doser that dispenses small amounts into each ration has been used effectively to dispense fecal material into gilt rations.[4] However, this method has its limitations, as it requires additional equipment and controlling electronics that may not be available for all systems. Ice blocks have been investigated previously as sources of environmental enrichment in pigs,[5] and motivated us to consider ice as a possible vehicle for controlled exposure in pen gestation. Other research suggests that most currently known enteric pathogens of swine can be frozen and still be viable.[6-9] Ice, therefore, could provide a convenient and effective vehicle for controlled exposure of pathogens to pen-gestating sows if sufficient numbers of sows interact with the ice blocks before they melt. This case report documents how the sows in a research herd interacted with ice blocks and supports further study of ice blocks as a means of pathogen exposure.

Case description

Routine animal care and experimental procedures were conducted under a protocol that was approved by the University of Pennsylvania IACUC.

Study farm

The farm used was the swine research and teaching facility at the University of Pennsylvania School of Veterinary Medicine. The 130 gestating sows were housed in a single large dynamic pre-implantation pen and fed by two ESFs (Compident VII; Schauer Agrotronics, Prambachkirchen, Austria), with gilts housed in a separate pen (Figure 1). The ESF stations turned on at midnight and by 4 PM the feeding cycle was completed and the feeders closed. Sows were placed in the pen 1 to 3 days post breeding and removed 1 to 7 days before farrowing. Therefore, 92% of the population in the dynamic pen remained unchanged every week when 10 sows were moved to farrowing. The result of these movements is that over the 6 weeks, of the case report, half of the sows would have been resident sows for the entire 6 weeks, and the other half of the population consisted of animals that had been introduced or were only in the pen for part of the study and then were moved to farrowing.

Ice blocks

Ice blocks were made by placing 9.5-liter plastic storage bags (Hefty; Lake Forest, Illinois) of water in a standard chest freezer. Bags were 35.6 cm wide by 39.4 cm tall and generated an ice block of a similar size. Ice-block integrity was improved by the use of non-aerated water and the addition of chopped straw to the water prior to freezing. Originally, ice blocks were made without these additions and placed in a pen that was not to be used for the actual investigation. The blocks routinely broke either before placement in the pen or shortly afterwards. In order to video record the ice block for an hour it had to stay intact, so chopped straw and non-aerated water were explored as ways to increase the strength of the blocks. With these additions, the blocks stayed whole for long enough to test them in the sow pen. Test ice blocks lasted at least 1 hour and 20 minutes. Therefore, to standardize the duration of data collection, a 1-hour interval was chosen for video recording.

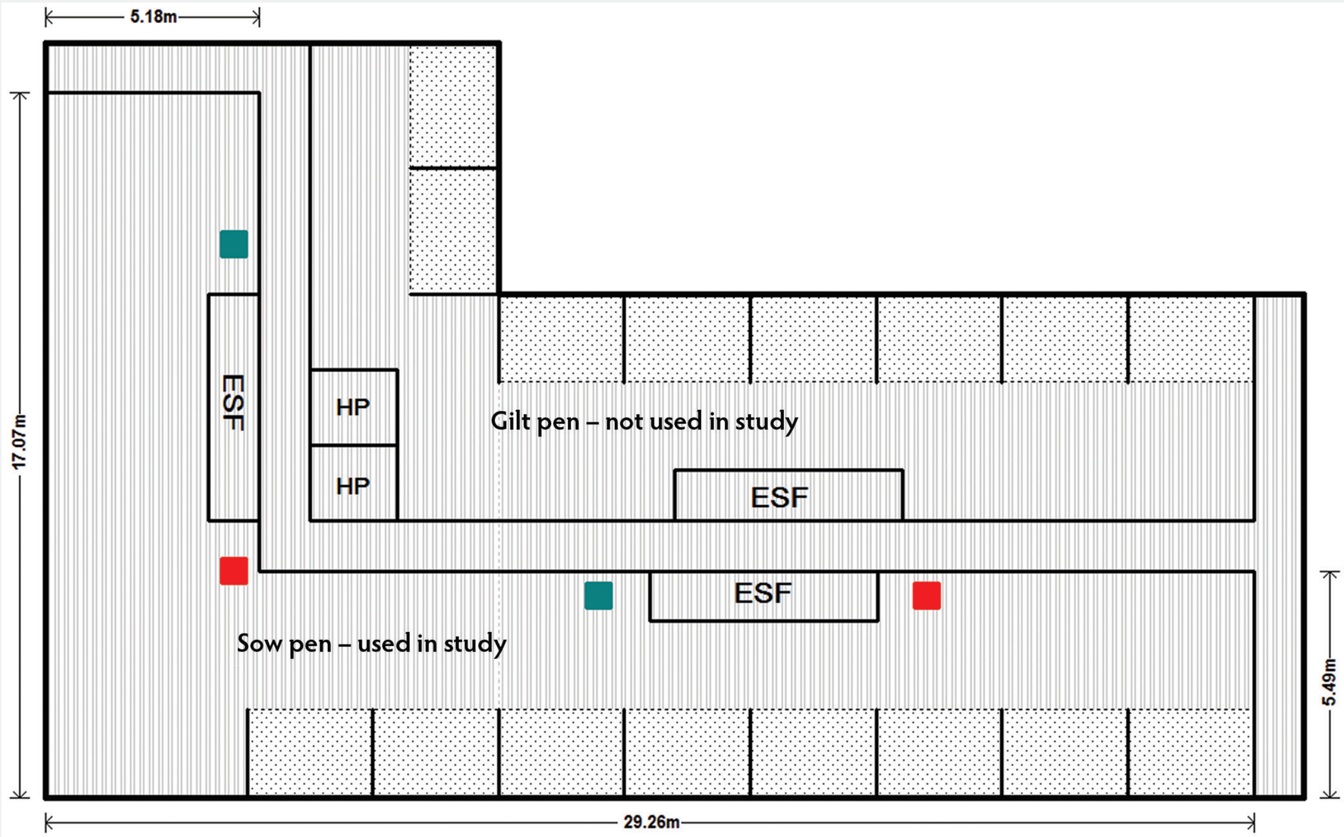
Sow interaction with the ice block

Once a week for 6 weeks at 9 AM on a weekday, either two or four ice blocks were placed in the sow pen directly on the slats. On weeks 1, 3, and 6, four ice blocks were placed in the pen, one 1 to 2 meters from the entrance of each feeder and one 1 to 2 meters from the exit of each feeder, and on weeks 2, 4, and 5, two ice blocks were introduced and placed at each of the feeder entrances at the distances described for weeks 1, 3, and 6. (Figure 1; Table 1). At 9 AM, the ESF stations were still in use and sows in the pen were active. In order to be able to identify the individual sows that interacted with the ice, and follow the ice as it was pushed around the pen, each ice block was filmed by a single observer 0.5 to 1.0 meter from the ice block with a hand-held video camera (Handycam; Sony, New York, New York). The observer stood outside the pen when possible, but entered the pen to follow the ice block or inspect sow identification tags. For 1 hour following placement of the ice in the pen, the observer filmed the ice block and verbally identified the sows as they contacted the ice by calling out their unique identification numbers. This information was then available in the audio portion of the video recording. The ice was repositioned to its starting location if it was lodged in a corner for more than 5 minutes.

Analysis

The video was analyzed using the Noldus Observer XT v 11 software (Noldus Information Technology Inc, Leesburg, Virginia), and the ethogram included both the continuous behavior of sows contacting the ice and the point behavior of aggressive events. Contact with the ice was defined as the nose or the mouth of the sow touching the ice for more than 3 seconds. Aggressive events were defined as a sow biting or head butting another sow. From the initial coding of the behavior data, additional variables were calculated. The identity of individual sows was recorded and allowed calculating, for each replicate, the total number of unique sows contacting the ice or initiating an aggressive event. Sows exhibited multiple contacts with

Figure 1: Schematic of gestation area on the study farm and placement of ice blocks. Sows were housed separately from gilts and small parity-one sows. The flooring was totally slatted except for several 2.1 × 3.1-meter sleeping areas in each pen that had raised, solid concrete bases (stippled areas). The gestation area included two 1.8 × 2.1-meter hospital pens (HPs). The behavioral observations were carried out in only the sow pen. Sows were fed via two electronic sow feeding stations (ESFs). On observation days 2, 4, and 5, an ice block was placed 1 to 2 meters from the entrance of each ESF station (red boxes) for a total of two blocks in the pen. On days 1, 3, and 6, an additional ice block was placed 1 to 2 meters from the exit of the ESF station (green boxes) for a total of four blocks in the pen. Sow behavior was recorded by a single observer 0.5 to 1.0 meter from the ice block with a hand-held video camera (Handycam; Sony, New York, New York).



the ice blocks and thus the total duration of contact with the ice was calculated as the sum of the duration of each sow's individual different contacts with the ice. Number of aggressive events per sow was the sum of individual aggressive events initiated by a given sow. Also tallied was the number of aggressive events per ice block. Since the ice was placed in the pen on consecutive weeks, and the individual sows were identified, it was possible to calculate the total number of unique sows that contacted the ice during two consecutive exposure periods (Table 1). Feed order is saved daily by the ESF computer (Topo; Schauer Agrotronics, Prambachkirchen, Austria). A feed rank was calculated for each sow using the average of her place in the eating order of the sows in the pen for the week prior to each filming session. Statistical analysis was performed with STATA v 13.1 (STATACorp LP, College Station, Texas). Pen-level data (number of sows interacting with ice block) was not normally distributed and was therefore analyzed using a Mann Whitney rank sum test. Ice-block level data (total duration of ice contact and aggressive events) were normally distributed and were analyzed with a two-way Student *t* test. Correlations were tested using point bi-serial and Spearman's correlations. A value of $P < .05$ was considered statistically significant.

Description of findings

Number of sows contacting the ice block

The median number of individual sows in the pen that contacted one of the ice blocks during an individual filming session (number of sows to contact the ice) was 94 and ranged from 76 to 106 sows or 58% to 82% of the sows in the pen (Table 1). On days with two blocks in the pen, a median number of 79 unique sows contacted one of the blocks, and on days where there were four blocks, the median number of sows was 105 (Figure 2). The number of contacts on two-block days compared to four-block days was significantly different ($P < .05$). Whether a sow contacted the ice was not correlated with her feed rank. There also was no significant effect of replicate on the number of sows to contact the ice.

To better understand how the ice blocks might be used under field conditions, the data from each 2 consecutive days of ice placement were combined and the number of unique animals that contacted the ice block was determined (Table 1). This analysis revealed

Table 1: Sow interactions with ice blocks in one pen in a loose-housing gestation facility*

Week	Pen inventory	No. of ice blocks	No. of sows contacted	2-day tally of unique sows	Weeks tallied
1	128	4	105	NA	NA
2	130	2	79	125	1, 2
3	130	4	101	116	2, 3
4	128	2	87	125	3, 4
5	132	2	76	116	4, 5
6	131	4	106	121	5, 6

* Sows were fed using electronic sow feeders. Ice blocks were placed once weekly for 6 consecutive weeks. Each ice block was video-recorded for 1 hour, and all sows that contacted it were identified. For each week, the inventory in the dynamic pen (number of sows), the number of ice blocks that were placed in the pen, the number of sows that contacted the ice, and the weekly observations combined to give a 2-day tally are shown.

NA = not applicable.

that the median number of unique animals to interact with the ice was 120 (Figure 2), or more than 90% of the pen per two consecutive weekly opportunities.

Duration of contact

The median total duration of time that individual sows contacted the ice was 93 seconds on days when there were two blocks, and 147 seconds when there were four blocks. This difference was statistically significant ($P < .001$).

Number of aggressive events

The number of sows that initiated aggressive events was not altered by the presence of two blocks (12.8 ± 1.8 sows; mean ± standard error) compared to four blocks (10.3 ± .78 sows). However, when there were only two blocks in the pen, sows were more aggressive than when there were four blocks in the pen, as the mean number of aggressive events on each block was higher when there were two blocks (68 ± 7.2) than when there were four blocks (46.2 ± 3.9) ($P < .05$). On 5 of the 6 days of observation, there was a correlation ($P < .05$) between a sow having a higher feed rank and initiating aggressive events.

Discussion

Sows that are housed in pens are still susceptible to enteric disease, and producers that use pen gestation, especially those with electronic sow feeders where all the sows do not eat at the same time, are looking for methods to administer feedback material. If ice is going to be used for pathogen control, then it is important to verify that sows will interact with the ice block in order to have the opportunity to become exposed. This case report shows that when ice was placed in the pen on two consecutive time points 1 week apart, over 90% of the sows in this large dynamic pen contacted the ice. Using four blocks instead of two blocks increased the number of sows to touch the ice, as well as increasing the duration of contact by individual sows and decreasing aggression at the ice block. Social hierarchy influenced aggression at the ice block, as animals with higher social status (animals that ate earlier during the feeding cycle)[10] were more likely to initiate aggression. However, social hierarchy did not impact contact with the ice block, as there was no correlation between feed rank and access to the block. Thus, in this dynamic pen, and given the protocol that was used here, there appeared to be enough time and material for even animals of lower social status to gain access to the ice block.

Another consideration is that a focal sampling technique was used in order to capture the individual identities of the animals contacting the ice. We cannot be sure what impact, if any, the human observer had on the number of animals to contact the ice. There is the possibility that human presence drew animals to the ice block or that human presence scared some animals away from the block. These animals had been well habituated to human presence by frequent contact with humans working in the facility, as well as being observed in the pen where they were housed. These two factors are considered the available best practices to help mitigate the presence of humans during data collection if using a camera and a remote observer is not a possibility.[11] For this study, a remote observer and unattended camera was not an option, as it would have precluded both following the ice block as it was pushed around the pen and capture of individual sow identities.

These findings suggest that the use of ice as a vehicle for pathogen exposure in loose-housed sows warrants follow-up study on a larger scale with pathogens that are of interest to producers and veterinarians. It is likely that the exact duration of contact time with the ice block required to successfully expose a sow to a pathogen will depend upon both the infectivity and concentration of the specific pathogen. In most current feedback programs, the exact concentration of pathogen in the exposure material is often poorly understood. Unlike sows in gestation stalls, loose-housed sows are at much greater risk for lateral transmission of pathogens used for controlled exposure between sows, and thus 100% exposure to the ice blocks may not be required to achieve good herd immunity. It should also be noted that the possibility for lateral transmission has the potential to confound subsequent studies designed to understand the impact of ice exposure and development of immunity in individual animals. In this case, gestating sows were housed in a large dynamic pen and fed via ESF. Several other types of pen gestation are in use, and additional studies would be required to understand how sows in other types of loose housing interact with ice blocks.

Implications

- Under conditions similar to those in this study, over 50% of loose-housed sows in a given pen may interact with an ice block over the course of an hour. More ice blocks would be expected to increase the number of sows contacting the ice and the duration of contact, and decrease the amount of aggression.
- On the basis of the outcome of this study, ice has the potential to be a convenient vehicle for exposing sows to on-farm pathogens, but further study is warranted to better understand how effective pathogen exposure will be using this method.

Conflict of interest

None reported.

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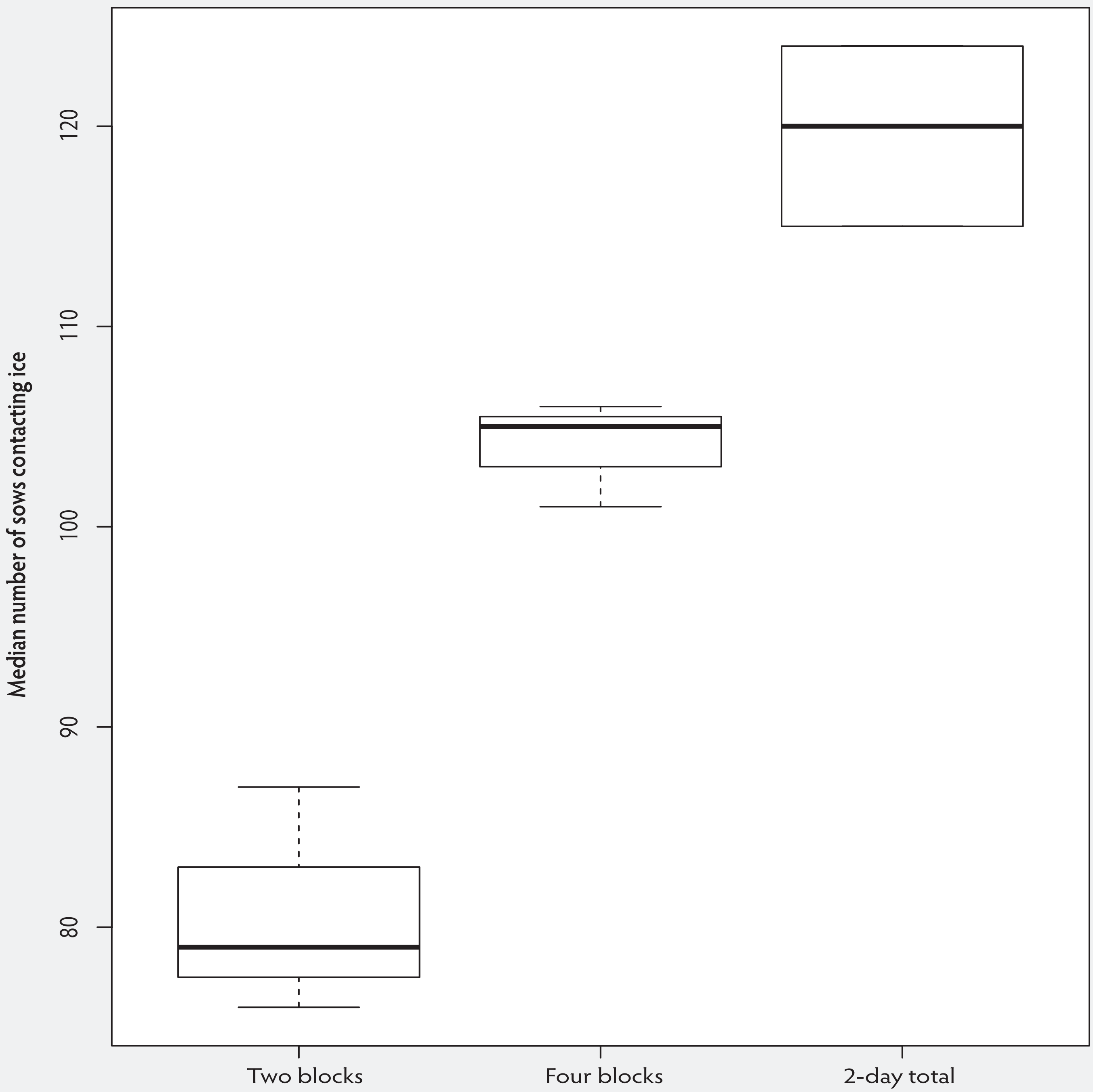
Figure 2: Boxplot of the median number of sows that contacted an ice block on days where there were two blocks (n = 3), compared to days where there were four blocks (n = 3), as well as the 2-day total of unique sows to interact with the blocks (study described in Figure 1 and Table 1).



or the practice of veterinary medicine in their country or region.

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* Non-refereed references.

Conversion tables

Weights and measures conversions

Common (US)	Metric	To convert	Multiply by
1 oz	28.35 g	oz to g	28.4
1 lb (16 oz)	453.59 g	lb to kg	0.45
2.2 lb	1 kg	kg to lb	2.2
1 in	2.54 cm	in to cm	2.54
0.39 in	1 cm	cm to in	0.39
1 ft (12 in)	0.31 m	ft to m	0.3
3.28 ft	1 m	m to ft	3.28
1 mi	1.6 km	mi to km	1.6
0.62 mi	1 km	km to mi	0.62
1 in^2	6.45 cm^2	in^2 to cm^2	6.45
0.16 in^2	1 cm^2	cm^2 to in^2	0.16
1 ft^2	0.09 m^2	ft^2 to m^2	0.09
10.76 ft^2	1 m^2	m^2 to ft^2	10.8
1 ft^3	0.03 m^3	ft^3 to m^3	0.03
35.3 ft^3	1 m^3	m^3 to ft^3	35
1 gal (128 fl oz)	3.8 L	gal to L	3.8
0.264 gal	1 L	L to gal	0.26
1 qt (32 fl oz)	946.36 mL	qt to L	0.95
33.815 fl oz	1 L	L to qt	1.1

Temperature equivalents (approx)

°F	°C
32	0
50	10
60	15.5
61	16
65	18.3
70	21.1
75	23.8
80	26.6
82	28
85	29.4
90	32.2
102	38.8
103	39.4
104	40.0
105	40.5
106	41.1
212	100

$°F = (°C \times 9/5) + 32$
$°C = (°F - 32) \times 5/9$

Conversion chart, kg to lb (approx)

Pig size	Lb	Kg
Birth	3.3-4.4	1.5-2.0
Weaning	7.7	3.5
	11	5
	22	10
Nursery	33	15
	44	20
	55	25
	66	30
Grower	99	45
	110	50
	132	60
Finisher	198	90
	220	100
	231	105
	242	110
	253	115
Sow	300	135
	661	300
Boar	794	360
	800	363

1 tonne = 1000 kg
1 ppm = 0.0001% = 1 mg/kg = 1 g/tonne
1 ppm = 1 mg/L