Behavior and handling of physically- and immunologically-castrated market pigs on farm and going to market

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ABSTRACT: Physical castration is a common management practice on commercial swine farms in the U.S. to reduce the incidence of boar taint and aggressive behavior. One alternative to physical castration (**PC**) is to immunologically castrate (**IC**) male pigs by blocking gonadotropin releasing factor (**GnRF**), thereby reducing levels of LH, FSH, testosterone and androstenone. The objectives of this study were to evaluate the effects of IC on pig behavior, human-pig interactions, and handling during and after transport. Pigs were given the first immunization at wk 7 of the grower-finisher period, and second immunizations (given at wk 11, 13, or 14 of the grower-finisher period). Behaviors of PC and IC barrows were sampled at 3 time points after entering finishing at 9 wk of age: 7 wk prior to first injection, 16 wk (after immunization was complete) into finishing, and 1 d before marketing (16 to 19 wk into finishing). Handling during loading and unloading of trailers going to market were also quantified. Prior to the first injection, intact males showed increased aggression ($P = 0.014$) and mounting ($P = 0.048$), whereas PC barrows spent more ($P = 0.003$) time feeding than intact males. There were treatment × time interactions for lying ($P = 0.018$), aggression ($P < 0.001$), and standing ($P = 0.009$) behaviors. Few differences were observed in pig-human interactions between PC and IC barrows, with IC and PC approaching people in the same amount of time, but IC barrows were more ($P < 0.001$) aggressive in chewing and rubbing on the test person's pant leg and boots. When handling and loading for processing in the home barn, PC barrows were more ($P < 0.05$) vocal than IC barrows. Fewer dead and down pigs were observed among IC (0%) compared with PC barrows (1.17%). Immunological castration may result in similar or improved animal welfare compared to the stress of physical castration without pain relief.

Key words: behavior, castration, handling, immunocastration, pigs

INTRODUCTION

Physical castration is a common management practice on commercial swine farms in the U.S. Castration is performed primarily to reduce the accumulation of boar taint compounds, aggressive behavior in post-pubertal male pigs, and undesirable pregnancy at slaughter. Androstenone and related steroids, along with skatole, are responsible for the boar taint that is often offensive to pork consumers (Lundström and Zamaratskaia, 2006). The industry markets pigs at BW well past the onset of puberty; therefore, male pigs are typically castrated physically at less than 5 d of age to prevent boar taint.

Physical castration causes pain and distress, (McGlone and Hellman, 1988; Prunier et al., 2005; Sutherland et al., 2010) which can lead to greater mortality and morbidity rates. Attempts to reduce the pain and distress by use of local or general anesthetics were insufficient to date (McGlone et al., 1993; Sutherland et al., 2010; Rault and Lay, 2011). Immunological castration yields a carcass without boar taint and may improve pig welfare by reducing the stress of physical castration (Bonneau et al., 1994; Dunshea et al., 2001; Metz et al., 2002; Jaros et al., 2005; Zamaratskaia et al., 2008).

Immunological castration changes the behavior of male pigs (Baumgartner et al. 2010; Fábrega et al. 2010; Pauly et al. 2009), but the safety of those who handle male pigs at the farm and at the plant has not been assessed. Will the IC barrows act more like barrows or boars in their aggressive and feeding behaviors? Cronin et al. (2003) found that IC barrows spent more time at feeders and spent less time displaying sexual and aggressive behavior than the boars (Cornin et al. 2003). Therefore, the objectives of this study were to evaluate the effects of

immunological castration on behaviors, such as human-pig interactions, aggressiveness, feeding, social, mounting, and lying behaviors, as well as behavior during loading and unloading.

MATERIALS AND METHODS

General

Crossbred pigs (PIC, Inc., Hendersonville, TN) were born the same week, transferred to a nursery for approximately 7 wk, and then moved to the test grow-finish barns in pens of 24 pigs each. Pigs remained in the finishing barn for 16 to 19 wk (23 to 26 wk of age) before transport to slaughter. Pigs were fed corn-soybean meal diets formulated to exceed NRC (1998) requirements of pigs. Pigs had *ad libitum* access to feed and water. Round feeders allowed 4 pigs to eat simultaneously, and 2 water nipples were present in each pen.

Pigs were in 2 adjacent barns containing 48 pens/barn, and initially stocked with 2,304 pigs. Treatments were applied to 96 pens of pigs. Mortality during the finish phase resulted in 21 to 24 pigs/pen during behavioral observations. All behavioral observations were adjusted to a common number of pigs/pen (see statistics section for more detail). Each pen was 3.7 × 4.6 m (allowing approximately 0.71 m^2/pig of floor space) with slatted floors and metal bar dividers between adjacent pens, which is representative of commercial swine farms.

This study was divided into 3 phases (Figure 1). The pre-immunization period (Phase 1; 6 wk into the grower-finisher period) was where half of the male pigs were physically castrated (PC) at 3 d of age (remaining males remained intact during this phase). The post-immunization period (Phase 2; wk 16 during the grower-finisher period) occurred after the first (given at wk 7 of the grower-finisher period) and second immunizations (given at wk 11, 13, or 14 of the grower-finisher period) with Improvest (Pfizer Animal Health, New York, NY). Lastly, the final

marketing phase (Phase 3) was 4 to 8 wk after the second immunization and prior to marketing after the 19-wk grower-finisher period. Pigs were scheduled to go to market in 2 "cuts." At 16 wk into the grower-finisher period, the 3 heaviest pigs were removed from each pen, weighed, loaded onto trucks, and taken to slaughter, leaving 17 to 21 pigs/pen for the remainder of the study. At this time, pens of pigs were in 1 of the 4 treatments: PC barrows and IC barrows who received their second immunization at wk 11, 13, or 14 of the grower-finisher period.

This work was reviewed and approved by the Texas Tech University Animal Care and Use Committee before the study began. All behavioral observations were taken by Texas Tech personnel; no data were collected by Pfizer or the commercial producer. Observers were blind to the treatment groups; however, it was clear to the observers which pens contained intact males and which contained castrated males.

Phase 1 – Pre-immunization

Phase 1 began 6 wk after pigs arrived in the grow-finish site. During this phase, 12 pens of PC barrows and 12 pens of intact males were observed over a 24-h period. Observers used a scan-sampling method to record behavior (Table 1) in each pen every 12 min for 24 h. Two observers walked from pen to pen recording the number of pigs that expressed each mutually-exclusive behavior. To prevent distracting the pigs, observers recorded pig behavior from the aisle, but not in front of the target pen. After a short period of time, the pigs' behavior was not influenced by the researchers walking up and down the aisle. Data were converted to a percentage of pigs expressing each behavior over time, and summarized by hour over the 24-h observation period. The number of pigs in each pen was counted and the percentage mortality was calculated on 12 pens of PC barrows and 36 pens of intact males, which were assigned

randomly to 1 of 3 IC treatments applied later in the grower-finisher period. During this time, a researcher walked the pen from the aisle to the far wall and back to the aisle to simulate a routine health check by a worker, while an observer recorded the number of pigs coming in contact with the simulated worker.

A fear test, as modified by Gonyou and Stricklin (1998), was used to assess pig fear. During this test, a person walked into the pen and stood against a fence. An observer in the aisle recorded the time (s) until a pig came within 1 m of the test person and the time for any pig to come into contact with the person. Pigs were allowed to briefly interact with the test person and an aggressiveness score was recorded on a 5-point scale, with 1 indicating touching the observer and 5 indicating pigs aggressively biting/chewing on the observer's boots or coveralls.

Immunization treatment groups

One week after the in-pen behavior and human-pig interaction data were collected, all intact males received their first immunization at 7 wk into the grower-finisher period, whereas IC barrows received the second immunization at either 4, 6, or 7 wk later. Dosing and administration procedures followed the product labeling. Treatments were randomly assigned to pens; thus, all of the pigs in a pen were on the same treatment. However, PC barrows received no immunization or injection.

Phase 2 – Post-immunization

Pen behavior data (Table 1) were collected at 16 wk into the grower-finisher period as previously described for Phase 1. In this phase, an observer recorded data in each pen over 24 h,

with behavior data recorded for a total of 96 pens (n = 24 pens/treatment for PC barrows and IC barrows receiving their second immunizations at 11 and 14 wk of the grower-finisher period).

Phase 2 – Post-immunization handling and human-pig interaction

Human-pig interaction, mortality, and handling were evaluated from 12 pens of PC barrows and each immunization treatment group. At 16 wk into the grower-finisher period, and 1 d before the first pigs were removed, observers recorded the fear test and mortality as previously described for Phase 1. Observers also recorded the number of vocalizations (any vocal noise from the pigs), as well as the time from the scale to the barn door and the number of slips, falls, and vocalizations as pigs were moved up a 20° loading chute into a livestock trailer.

Phase 3 –Final Marketing

At the conclusion of the 19-wk grower-finisher period, all pigs were transported to slaughter. The day before the final marketing, observers recorded pig behavior (Table 1) over a 12-h observation period. The pigs in previous observations were predominantly lying down in the evening hours, so behaviors were recorded during the period from 0700 to 1900 on a total of 48 pens/treatment group. Observations were restricted to only 1 barn due to technical reasons. Because there were no slips, falls, or vocalizations recorded during Phase 2, these data were not collected at marketing.

At loading, pigs were mixed, and 6 trailers were loaded with PC and IC barrows (25 and 75% of the pigs on each trailer, respectively), whereas an additional 9 trailers were loaded with PC barrows and gilts that were not part of this experiment. The number of dead and downer pigs was recorded for each trailer. Data comparisons were between the PC barrows and IC barrows from within 6 trailers (n = 1,011 pigs). Information on rates of dead and down (nonambulatory,

not injured [NANI] and nonambulatory, injured [NAI]) pigs from among trailers containing PC barrows and gilts are provided only for general information and not for statistical comparison.

Statistical Analyses

Data were collected as counts or the number of pigs expressing each mutually-exclusive behavior in each pen. Data were converted to percentages of time/h that pigs expressed each behavior, subjected to square root-arcsine transformation, and analyzed using the GLM procedure of SAS (SAS Inst., Inc., Cary, NC). The experimental design was a completely random design, with a split-plot over time (time being each hour of day) and pen was the experimental unit. Pigs were housed in 2 adjacent barns, but no barn ($P \geq 0.10$) or barn × treatment ($P \geq 0.10$) effects were observed, so, barn was removed from the model. Data were analyzed separately for each phase. In Phase 1, there were 2 treatments (intact males vs. PC barrows), whereas, in phases 2 and 3, there were 4 treatments (PC barrow and IC barrows immunized with the second immunization at 11, 13, or 14 wk into the grower-finisher period). Least squares means were separated using the PDIFF option of SAS. Planned behavioral comparisons included treatment comparisons at each time point. Handling and mortality data were analyzed with the pen as the experimental unit (no split plot). In this qualitative data set, there were 6 trailers with PC barrows and IC barrows.

RESULTS

Phase 1 – Pre-immunization

Before immunization, PC barrows spent 15.8% more ($P = 0.005$) time feeding than intact males (Table 2). Levels of aggressive behavior were very low. However, intact males spent more ($P = 0.011$) time engaged in aggressive interactions than PC barrows. Intact males also

spent more ($P = 0.05$) time mounting compared to PC barrows; otherwise, the proportion of time spent drinking, standing, and social was similar ($P \geq 0.57$) between intact and PC males. A single peak in aggression among PC barrows occurred around 1700, whereas intact males showed increased aggression from 1400 to 1800 (treatment × time, $P < 0.001$; Figure 2). Furthermore, intact males rested more at 1200 and lying behavior was greatest in PC barrows at 1500 (treatment × time, $P = 0.031$; Figure 3).

Phase 1 – Pre-immunization human-pig interaction and mortality

When the test person walked the pen, the same ($P = 1.00$) number of pigs in each treatment interacted with the person on average (Table 3). Pigs in each treatment approached the human in the same short period of time (Table 3). Moreover, there was no difference between PC and intact males for the amount of time a pig came within 1 m ($P = 0.61$) and directly in contact with the observer ($P = 0.24$), or in aggressiveness scores ($P = 0.29$). Likewise, mortality rate did not ($P = 0.83$) differ during Phase 1 between PC and intact males.

Phase 2 – Post-immunization

After the second immunization, observers recorded the behavior of PC barrows and IC barrows in each of the 3 immunization treatment groups (Table 4). Neither the main effect of castration treatment ($P \geq 0.10$), nor the interactive effect of castration treatment and observation time ($P \geq 0.29$), affected drinking, aggressive, mounting, standing, and social behaviors after the second immunization (Table 4). Even though there was a treatment × time interaction ($P = 0.024$) for feeding behavior, this particular behavior varied considerably among the treatment groups over a 24-h observation period, with no discernible pattern.

Phase 2 – Post-immunization handling and human-pig interaction

There was no ($P = 0.61$) difference in the time to come within 1 m of the observer walking the pens, nor in the time to interact with the observer during the fear test ($P \geq 0.26$) among the 4 treatments (Table 5). However, PC barrows were less ($P = 0.007$) aggressive towards the observer than IC barrows, regardless of when they received their second immunization.

Phase 3 –Final Marketing

Feeding, drinking, standing, social, aggressive, and mounting behavior of pigs in their home pens were similar ($P \geq 0.09$) among castration treatments (Table 7). There was, however, a treatment × time interaction for lying behavior ($P < 0.001$), but no discernible pattern could be identified (Figure 5).

For the 6 trailers of PC and IC barrows (n = 1,011 total pigs), there were dead-on-arrival and NANI among PC barrows but not among IC barrows (Table 8). For comparison purpose, 9 trailers of PC barrows and gilts (contemporary in age and from identical, adjacent buildings) also had dead and down pigs (Table 8). Because the mean and SD for IC barrows was 0, statistical analysis was not possible; however, this non-significant difference may be of biological relevance to the swine industry.

DISCUSSION

Baseline behavior data were collected before immunizations (Table 2). Pigs were about 6 wk into the grower-finisher period (about 15 wk of age), which was before full onset of puberty. Yet, at this age, typical intact male behaviors were being expressed, including aggression and mounting. Although intact males expressed more than a 2-fold increase in aggression and mounting, the percentage time spent in aggressive and mounting behaviors was far less than 1%.

Moreover, neither intact males nor PC barrows were aggressive towards people; therefore, PC barrows and boars had the same interactive intensity towards humans before the first immunization.

Even though young males and castrates may eat at about the same rate, intact peri-pubertal males were reported to spend less time feeding than castrated males (Cronin et al. 2003). Indeed, in the present study, intact males spent less time with their head in the feeder than PC barrows (Table 2). The primary reason that barrows grow faster than boars in the finishing phase is because the barrows have an increase in motivation to feed compared with boars in late finishing (Pauly, et al., 2009).

Results from the present study agree with those of Cronin et al. (2003), who demonstrated that PC barrows ate more, and fought and mounted less, than intact males. At 15 wk of age (6 wk into finishing), the intact males were behaving like peri-pubertal males compared to the castrated males. Pig mortality was not different between barrows and boars, but for percentage mortality to be accurately assessed in boars and barrows, a different experimental design would be required and a very large sample size. After the second immunization, intact males that had been immunized began behaving more like PC barrows than boars in their home pens. Immunized males' feeding behavior increased (Figure 4) and aggressive behaviors decreased to the level of barrows (Table 4). Even though IC barrows were more aggressive towards an experimenter standing in the pen than PC barrows (Table 5), this difference was small, and "aggressiveness" may not be the best term to describe this pig-human interaction. Pigs were not necessarily biting the experimenter; rather, they chewed on the observer's boots and clothes. This behavior could actually be the result of the IC males less fearful or more inquisitive

towards people and, therefore, more willing to approach and investigate. The time for the pig-human contact did not differ between IC and PC barrows; so, the primary difference was the intensity of pig behavior towards a person in their pen.

When a worker entered the test pens to select the 3 heaviest pigs, PC barrows vocalized more than IC barrows. Vocalization at this point in the production cycle may be common because the pens had heavy-weight pigs and more numbers, or mass, of pigs/floor space. Interestingly, PC barrows vocalized more than IC barrows when they were being "cut" from the test pens (Table 6). This finding supports the idea that there may be an endocrine explanation for increased vocalizations among finishing pigs (Schrader et al., 1998). Certainly, the PC and IC barrows have quite different endocrine profiles. Vocalization is thought to be a sign of stress in pigs (Rushen and Ladewig, 1991; White et al., 1995; Schrader, 1998), and this finding leads to the speculation that PC barrows have increased responsiveness to a stressor than IC barrows – a hypothesis that is testable in future studies.

On the day before slaughter, PC and IC barrows displayed similar behavioral profiles after the second immunization until slaughter. Both treatment groups had similar levels of feeding, aggression, and mounting behaviors. Basically from shortly after the second immunization to slaughter, the IC barrows showed similar behavioral profiles to physically castrated pigs.

Data on the rates of dead and down (NANI and/or NAI) pigs were quite striking (Table 8). No dead or down pigs were observed among IC pigs, whereas the dead and down rate was about 1% of pigs among PC barrows. Interestingly, a study at the University of Illinois had a similar finding (F. McKeith, personal communication). Normally, with dead and down data, one needs a very large sample size. However, when a treatment group has a mean of zero with no

variation (as was the case for IC barrows) – one can only conclude that IC lowered the rate of dead and down pigs in our study. Larger-scaled field replication is required to confirm this effect.

Activists and some consumers want to know if there are viable alternatives to PC without anesthetics. Physical castration without pain relief is a growing animal welfare issue (Thun et al., 2006). The logical choices available in the U.S. at this time to attempt to improve animal welfare of the castrated pig are: 1) PC without pain relief; 2) PC with pain relief; 3) genetic selection for low boar taint; or 4) IC.

McGlone and Hellman (1988) first reported that PC of piglets caused pain-induced behavioral changes. Since then, the painful effects of PC have been replicated by our laboratory (McGlone et al., 1993) and another (White et al., 1995). Recent attempts to relieve the pain include use of local or general anesthetics or analgesics. None of the drugs, gases, or methods completely relieved all of the behavioral or physiological signs of stress associated with PC (McGlone and Hellman, 1988; Sutherland et al., 2010, 2012). Pharmacological methods to reduce pain are further complicated by the lengthy approval process required by the FDA, or other governmental entities, before these analgesics can be used in food animals. Enough is known about the genetics of boar taint to know that selection for lower levels of boar taint. Selection against levels of boar taint may be feasible; however, genetic lines with low levels of boar taint are not presently available on commercial farms. Furthermore, the reproductive side effects of selecting against boar taint are not understood.

Immunological castration eliminates the animal welfare issue of PC, but new issues arise. However, intact males were a little more aggressive (or overly “interactive”) towards each other before the second immunization and, IC barrows received 2 immunizations, which may pose a

welfare issue, but, depending on health status, pigs may receive many immunizations throughout their lives which has not been a serious welfare issue in the past. The relative aversiveness of 2 immunizations compared to PC is largely unknown, but immunization is likely to be less negative than PC with or without pain relief. Producer and consumer attitude can be negative against any new technology, which might make it difficult to implement hormonal immunization into a routine management practice.

CONCLUSIONS

Castration of pigs largely eliminates boar taint, but, at the same time causes acute pain and performance changes, including depressed feed efficiency (Sutherland et al., 2012). Prior to immunization, intact male pigs showed an increase in aggression and mounting of each other compared to PC barrows. Yet, after the second immunization, PC and IC barrows displayed similar levels of behavior, and IC barrows exhibited more curious interactions with people in their pen. Immunologically castrated pigs vocalized less and had numerically fewer dead and down pigs than PC barrows. Handling pigs while loading onto the livestock trailers and handling coming off the trailers showed no issues with pig behavior or pig-human interactions. Behavioral or handling issues were not identified among IC and PC barrows, especially towards the end of the grower-finisher period. IC may be a viable alternative to PC (without pain relief), and may result in improved animal well-being when compared to PC, but a complete animal welfare assessment would include both improvements and detriments in pig welfare generated by any alternative to PC.

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Table 1. Definitions of behaviors of pigs during in-home-pen observations at each of three time points. Data were collected as counts, converted to percentages and transformed prior to analyses.

Behavior	Definition
Feeding	Head in the feeder, eating
Drinking	Mouth on nipple waterer, drinking
Standing/walking	Standing still or walking
Lying	Not standing; lying in sternal or lateral recumbancy or sitting
Social	Non-aggressive social behavior such as licking or touching
Mounting	One animal mounting another
Aggression	Biting or pushing

Table 2. Comparison of the behavior, pig-human interactions, and mortality of physically castrated barrows (PC) and intact males during the pre-immunization phase (Phase 1). Values are expressed as percentage of time engaged in each behavior averaged over 24 h

				P-values[1]	
Behavior, %	Barrow	Intact male	SE	Treatment	Treatment × time
No. of pens[2]	12	12	--	--	--
Feeding	5.71[a]	4.93	0.659	0.005	0.31
Drinking	0.54	0.50	0.195	0.57	0.81
Aggression	0.09	0.21	0.134	0.01	< 0.001
Mounting	0.03	0.07	0.063	0.05	0.26
Social	1.19	1.18	0.50	0.70	0.59
Standing	6.63	6.80	1.11	0.90	0.08
Lying	85.8	86.3	1.58	0.42	0.03

[1]Time effects ($P < 0.001$) for all behaviors.

[2]Each pen contained 23 to 24 pigs.

Table 3. Pig-human interactions at 6-wk into the grower-finisher period (Phase 1)

	Barrows	Boars	SE	*P*-value
No. of pens	12	36		
Walking the pens	0.25	0.25	0.086	1.00
Pigs in contact, no.				
Fear test				
Pig within 1 m of human, s	2.08	1.67	0.742	0.61
Pig in contact with human, s	7.42	4.92	1.19	0.29
Aggressiveness of pig-human interaction[1]	4.2	3.4	0.012	0.83

[1]1 = touching observer to 5 = pig aggressively biting chewing on observer's boots or coveralls.

Table 4. Comparison of pig behavior during the post-immunization phase (Phase 2) among physically castrated (PC) and intact males immunized first at 7 wk and again at either 11, 13, or 14 wk into the grower-finisher period

Behavior, %	PC barrow	Second immunization, wk			SE	*P*-value[1]	
		11	13	14		Trt	Trt × time
No. of pens[2]	24	24	24	24			
Feeding	4.69	4.79	4.96	4.75	0.444	0.26	0.02
Drinking	0.57	0.66	0.66	0.72	0.154	0.42	0.52
Aggression	0.013	0.02	0.017	0.02	0.030	0.10	0.74
Mounting	0.012	0.01	0.022	0.03	0.027	0.08	0.30
Social	0.53	0.35	0.43	0.40	0.150	0.93	0.29
Standing	5.20	4.91	4.68	4.85	0.692	0.20	0.42
Lying	85.5[a]	86.4[a]	85.1[b]	86.3[a]	0.928	<0.001	0.53

[ab]Within a row, least squares means lacking a common superscript letter differ, $P < 0.05$.

[1]Time effects ($P < 0.001$) for all behaviors.

[2]Each pen contained 21 to 24 pigs.

Table 5. Comparison of the pig-human interaction and mortality rate during the post-immunization phase (Phase 2) among physically castrated (PC) and intact males immunized first as 7 wk, and again at either 11, 13, or 14 wk, into the grower-finisher period

		IC barrows				
	Barrows	11 wk	13 wk	14 wk	SE	*P*-value
No. of pens[1]	12	12	12	12		
Fear test						
Pig within 1 m of human, s	2.9	2.2	1.5	2.3	0.74	0.61
Pig in contact with human, s	7.4	5.0	4.0	5.7	1.20	0.26
Aggressiveness of pig-human interaction[2]	2.6[a]	3.1[b]	3.0[b]	3.0[b]	0.09	0.01
Mortality, %	4.2	3.5	2.8	4.2	1.23	0.83

[1]Each pen contained 21 to 24 pigs.

[2] 1 = touching observer to 5 = pig aggressively biting/chewing on observer's boots or coveralls.

Table 6. Handling data for pigs being loaded and unloaded at 15 weeks into the grower-finisher period (Phase 2)

	Treatment group					
Measure	Barrow	11 wk	13 wk	14 wk[1]	SE	*P*-value
Number pens	12	12	12	--	--	--
Vocalizations in home pen, number	16.1[a]	8.2[b]	5.8[b]	--	2.1	0.004
Time from scale to barn door, s	64.8	72.7	69.5	--	5.3	0.58
Slips, falls and vocalizations[1]	0	0	0	--	--	--

[a,b] Means within a row with different superscripts differ, $P < 0.05$. A lower value means pigs were more fearful

[1] The handling was excellent and zero slips, falls or vocalizations were recorded in the chute entering the livestock trailer. With no variation, statistical analyses are not appropriate. Pigs immunized at 14 weeks into the grow-finish phase were not marketed at this time.

Table 7. Comparison of pig behavior during the post-immunization phase (Phase 2) among physically castrated (PC) and intact males immunized first as 7 wk and again at either 11, 13, or 14 wk into the grower-finisher period

Behavior, %	PC barrow	Second immunization, wk			SE	*P*-value[1]	
		11	13	14		Trt	Trt × time
No. of pens[2]	12	12	12	12			
Feeding	7.3	7.3	7.2	6.6	0.177	0.24	0.12
Drinking	0.9	1.0	1.1	1.3	0.023	0.42	0.48
Aggression	0.0	0.0	0.0	0.1	0.006	0.14	0.68
Mounting	0.1	0.1	0.0	0.1	0.007	0.14	0.68
Social	1.0	1.1	1.2	1.0	0.017	0.94	0.73
Standing	5.0	3.9	5.4	4.5	0.230	0.20	0.34
Lying	85.5[a]	86.4[a]	85.1[b]	86.3[a]	0.009	<0.001	0.50

[ab]Within a row, least squares means lacking a common superscript letter differ, $P < 0.05$.

[1]Time effects ($P < 0.001$) for all behaviors.

[2]Each pen contained 21 to 24 pigs.

Table 8. Number of dead and down pigs[1] off trailers upon arrival at the slaughter plant

	PC barrow	IC barrow	Barrows & Gilts
No. of trailers	6		9
No. of pigs	1,011		1,454
Dead/killed upon arrival, %	0.50	0.00	0.00
NANI, %[2]	0.67	0.00	0.21
NAI, %[3]	0.00	0.00	0.21
Total dead & down, %	1.17	0.00	0.42

[1]Physically castrated (PC) and immunocastrated (IC) barrows.
[2]Non-ambulatory, non-injured.
[3]Non-ambulatory, injured.

Fig 1. Experimental timeline of present study. Physical castration (PC) was performed at 3 d of age, while immunological castration (IC) injections were given at 7 w, then again at 11, 13, or 14 w of age.

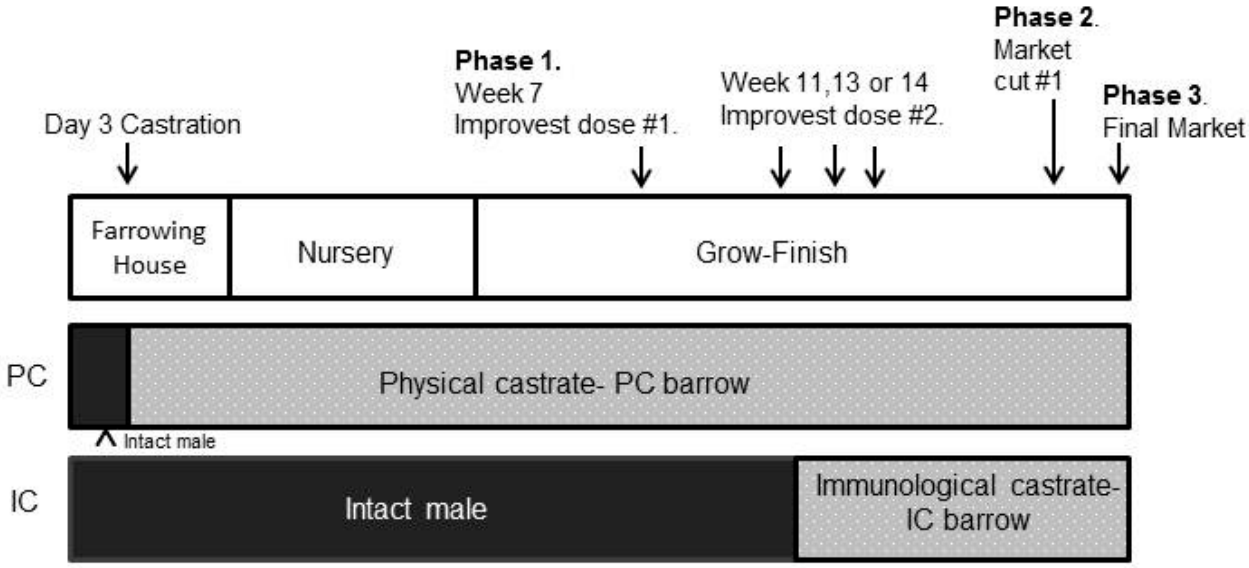

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Figure 1

Fig. 2. Aggressive behavior toward other pigs of physically castrated (PC) pigs and intact males during the pre-injection phase (Phase 1). At 15 w, intact males showed nearly a 2-fold increase in aggression from 1400 to 1800, while PC barrows only showed increased aggression around 1700. (Treatment × time; P= 0.01; SEp = 0.134).

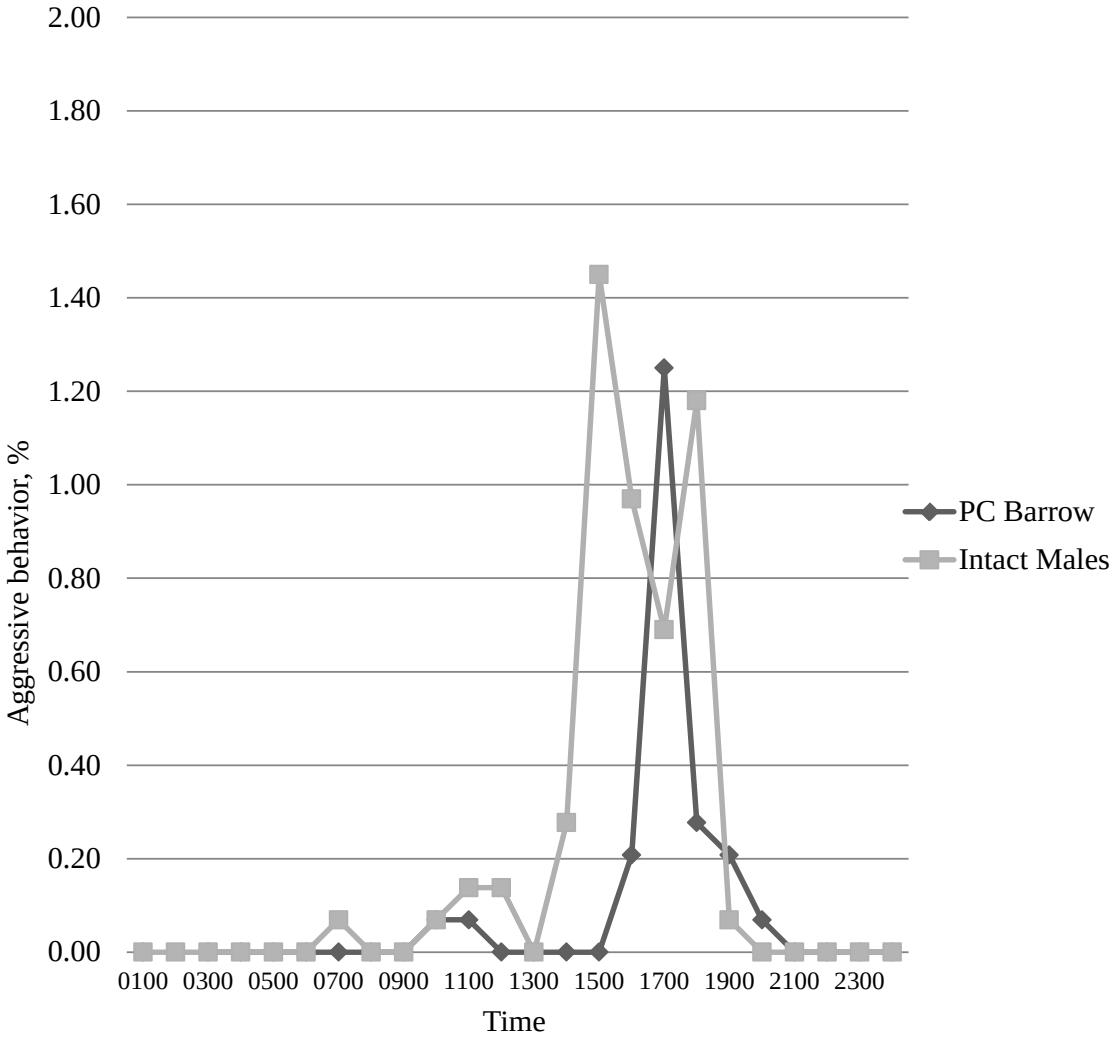

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Figure 2

Fig. 3. Lying behavior of physically castrated (PC) barrows compared to boars after 1st immunocastration injection. (Phase 2). Boars rested more at 1200, while PC barrows spent more time lying down at 1500 (Treatment × time; *P*= 0.03; SEp = 1.58)

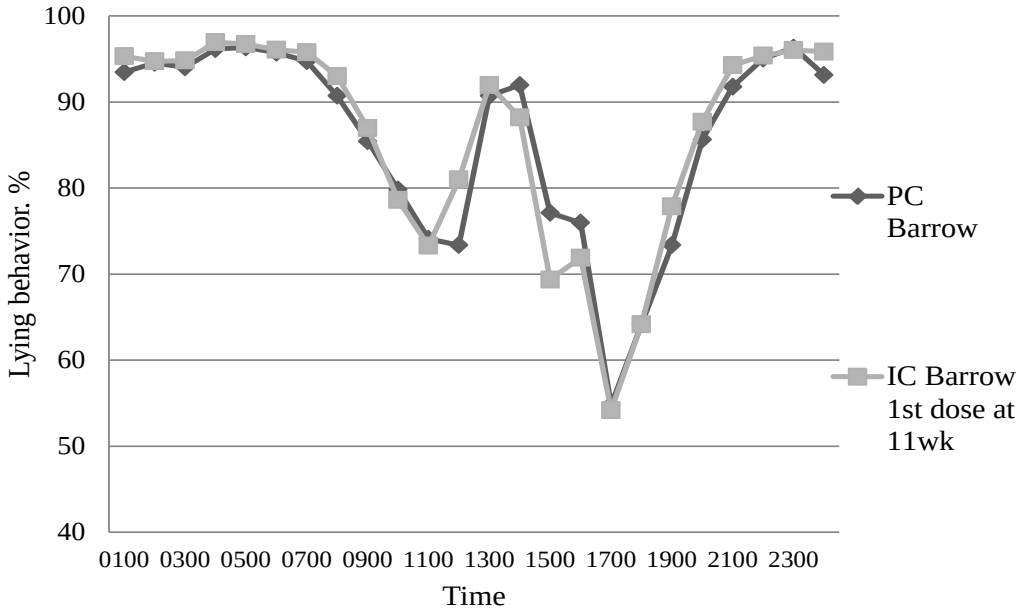

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Figure 3

Fig. 4. Feeding behavior of physically castrated (PC) barrows compared to immunologically castrated (IC) pigs during observation period 15 weeks into grower-finisher period (Phase 2). After the second immunization, IC males and PC barrows spent similar amounts of time engaged in feeding behavior (Treatment × time, $P = 0.02$; SEp = 0.444).

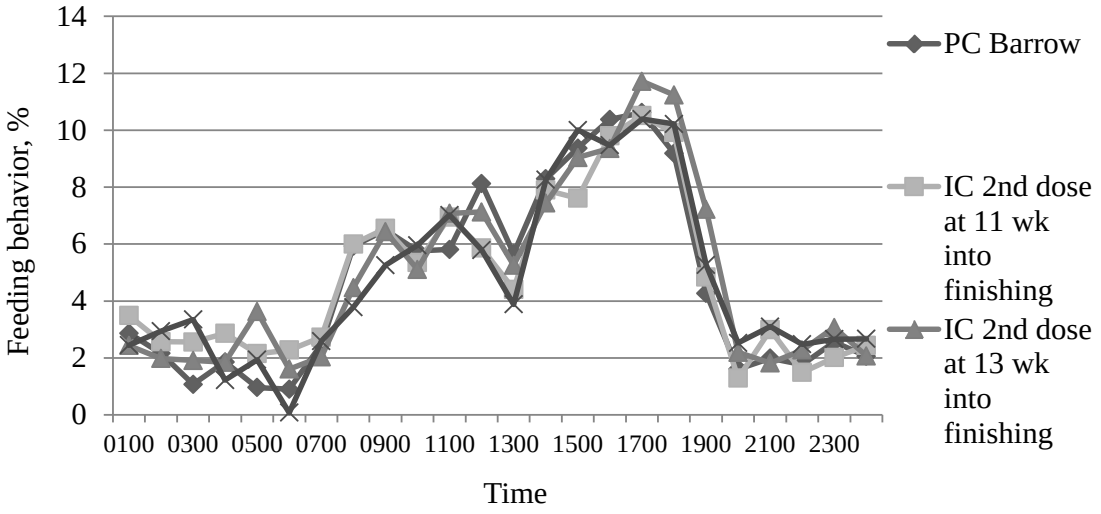

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Figure 4

Fig. 5. Lying behavior of physically castrated (PC) pigs and immunologically castrated (IC) males 19 weeks into grower-finisher period (Phase 3). The data showed a treatment × time interaction in lying behavior, but no discernible pattern could be established. (Treatment × time, $P < 0.001$; SEp = 0.009).

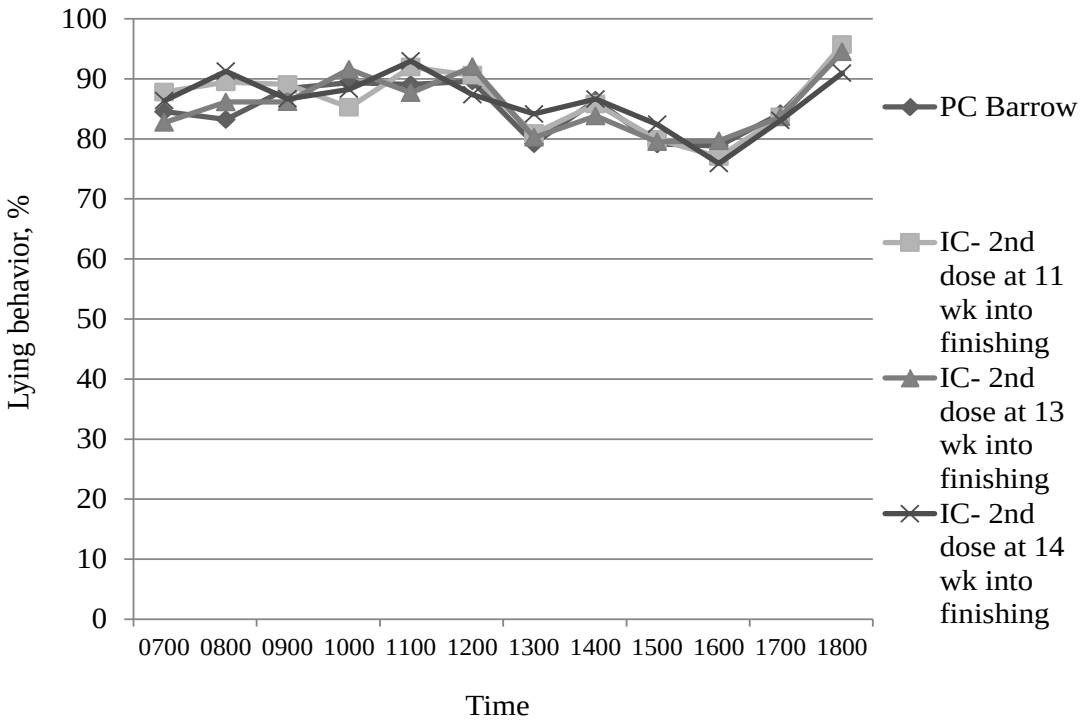

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Figure 5