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

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Behavior and handling of physically and immunologically castrated market pigs on farm and going to market[1]

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ABSTRACT: Physical castration is a common management practice on commercial swine farms in the United States 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 the 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 were 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 before 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 was also quantified. Before 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

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INTRODUCTION

Physical castration is a common management practice on commercial swine farms in the United States. Castration is performed primarily to reduce the accumulation of boar taint compounds, aggressive behavior in postpubertal 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 have been 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

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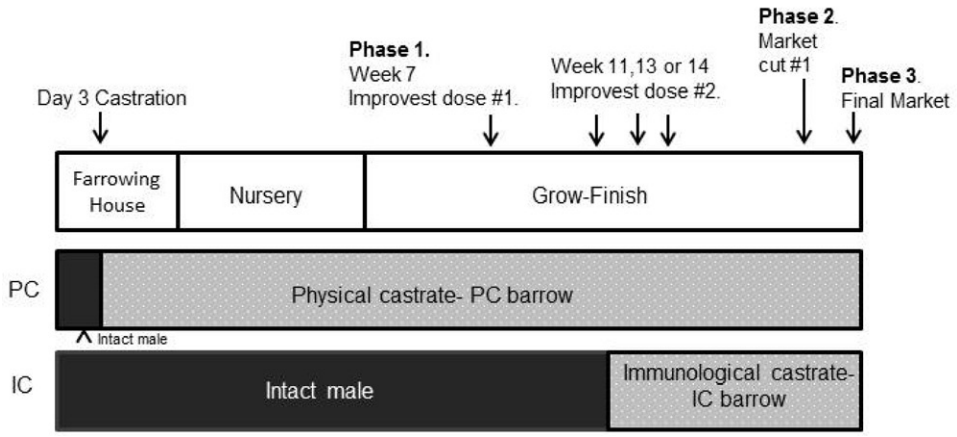

Figure 1. Experimental timeline of present study. Physical castration (PC) was performed at 3 d of age, whereas immunological castration (IC) injections were given at 7 wk and then again at 11, 13, or 14 wk of age.

handle male pigs at the farm and at the plant has not been assessed. Will the immunologically castrated (**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 (Cronin et al., 2003). Therefore, the objectives of this study were to evaluate the effects of immunological castration on behaviors, such as human-pig interactions and aggressiveness, feeding, social, mounting, and lying behaviors, as well as behavior during loading and unloading.

MATERIALS AND METHODS

This work was reviewed and approved by the Texas Tech University Animal Care and Use Committee (FASS, 2010) before the study began.

General Description

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 were 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 (Fig. 1). In the preimmunization period (phase 1; 6 wk into the grower-finisher period), one-half of the male pigs were physically castrated (**PC**) at 3 d of age (remaining males remained intact during this phase). The postimmunization 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). Last, the final marketing phase (phase 3) was 4 to 8 wk after the second immunization and before 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.

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: Preimmunization

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.

Table 1. Definitions of behaviors of pigs during in-home-pen observations at each of 3 time points[1]

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 recumbency or sitting
Social	Nonaggressive social behavior such as licking or touching
Mounting	One animal mounting another
Aggression	Biting or pushing

[1]Data were collected as counts, converted to percentages, and transformed before analyses.

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 were 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. Immunocastrated 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: Postimmunization

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: Postimmunization 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 because of 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 ex-

pressed 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 AND DISCUSSION

Phase 1: Preimmunization

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 being social was similar ($P \geq 0.57$) between intact and PC males. A single peak in aggression among PC barrows occurred around 1700 h, whereas intact males showed increased aggression from 1400 to 1800 h (treatment × time, $P < 0.001$; Fig. 2). Furthermore, intact males rested more at 1200 h, and lying behavior was greatest in PC barrows at 1500 h (treatment × time, $P = 0.031$; Fig. 3).

Phase 1: Preimmunization 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.

Table 2. Comparison of the behavior, pig-human interactions, and mortality of physically castrated barrows (PC) and intact males during the preimmunization phase (phase 1)[1]

				P-values[2]	
Item	Barrow	Intact male	SE	Treatment	Treatment × time
No. of pens[3]	12	12	—	—	—
Behavior, %					
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]Values are expressed as percentage of time engaged in each behavior averaged over 24 h.

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

[3]Each pen contained 23 to 24 pigs.

Phase 2: Postimmunization

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

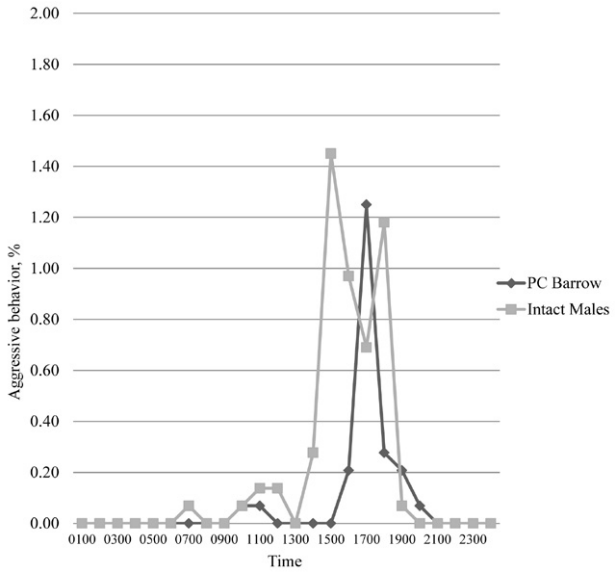

Figure 2. Aggressive behavior toward other pigs of physically castrated (PC) pigs and intact males during the preinjection phase (phase 1). At 15 wk, intact males showed nearly a 2-fold increase in aggression from 1400 to 1800 h, whereas PC barrows only showed increased aggression around 1700 h (treatment × time; $P = 0.01$; pooled SE = 0.134).

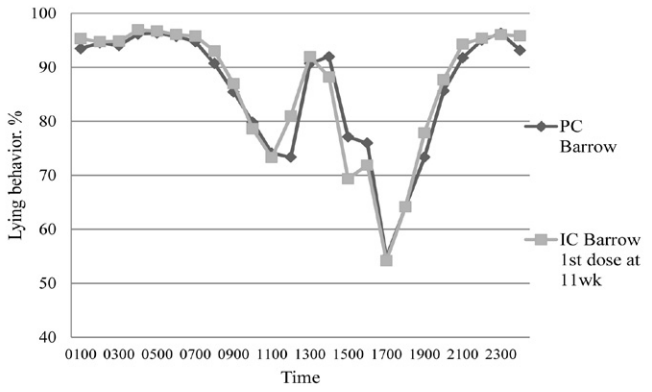

Figure 3. Lying behavior of physically castrated (PC) barrows compared to boars after first immunocastration injection (phase 2). Boars rested more at 1200 h, whereas PC barrows spent more time lying down at 1500 h (treatment × time; $P = 0.03$; pooled SE = 1.58).

behavior varied considerably among the treatment groups over a 24-h observation period, with no discernible pattern.

Phase 2: Postimmunization 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 toward the observer than IC barrows, regardless of when they received their second immunization.

Feeding, drinking, standing, social, aggressive, and mounting behaviors of pigs in their home pens were similar ($P \geq 0.09$) among castration treatments (Table 6). Feeding behavior was also not different between IC and PC pigs after the second immunization (Fig. 4).

When pigs were being loaded and unloaded at 15 wk into the grower-finisher period, IC pigs immunized at both 11 and 13 wk vocalized less ($P = 0.004$) than PC pigs in the home pen (Table 7).

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

Item	Barrows	Boars	SE	*P*-value
No. of pens	12	36		
Walking the pens				
No. of pigs in contact	0.25	0.25	0.086	1.00
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]Scores are as follows: 1 = touching observer to 5 = pig aggressively biting chewing on observer's boots or coveralls.

Table 4. Comparison of pig behavior during the postimmunization 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

		Second immunization				*P*-value[1]	
Item	PC barrow	wk 11	wk 13	wk 14	SE	Trt	Trt × time
No. of pens[2]	24	24	24	24			
Behavior, %							
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

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

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

[2]Each pen contained 21 to 24 pigs.

Phase 3: Final Marketing

There was, however, a treatment × time interaction for lying behavior ($P < 0.001$), but no discernible pattern could be identified (Fig. 5).

For the 6 trailers of PC and IC barrows (n = 1,011 total pigs), there were dead-on-arrival and NANI pigs 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 nonsignificant difference may be of biological relevance to the swine industry.

Table 5. Comparison of the pig-human interaction and mortality rate during the postimmunization 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

		Immunologically castrated barrows				
Item	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]Scores are as follows: 1 = touching observer to 5 = pig aggressively biting/chewing on observer's boots or coveralls.

Table 6. Comparison of pig behavior during the postimmunization 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

		Second immunization, wk				*P*-value[1]	
Item	PC barrow	11	13	14	SE	Trt	Trt × time
No. of pens[2]	12	12	12	12			
Behavior, %							
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. Trt = treatment.

[2]Each pen contained 21 to 24 pigs.

General 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 toward people; therefore, PC barrows and boars had the same interactive intensity toward humans before the first immunization.

Even though young males and castrates may eat at about the same rate, intact peripubertal 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 peripubertal 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 along with 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 (Fig. 4), and aggressive behaviors decreased to the level of barrows

Table 7. Handling data for pigs being loaded and unloaded at 15 wk into the grower-finisher period (phase 2)

	Treatment group					
Measure	Barrow	11 wk	13 wk	14 wk	SE	*P*-value
No. of 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 wk into the grower-finisher phase were not marketed at this time.

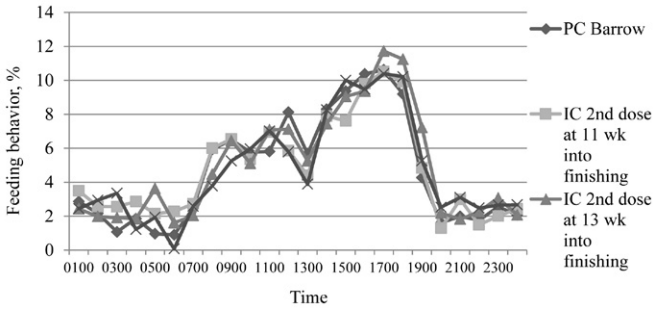

Figure 4. Feeding behavior of physically castrated (PC) barrows compared to immunologically castrated (IC) pigs during observation period 15 wk into grower-finisher period (phase 2). After the second immunization, IC males and PC barrows spent similar amounts of time engaged in feeding behavior (treatment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

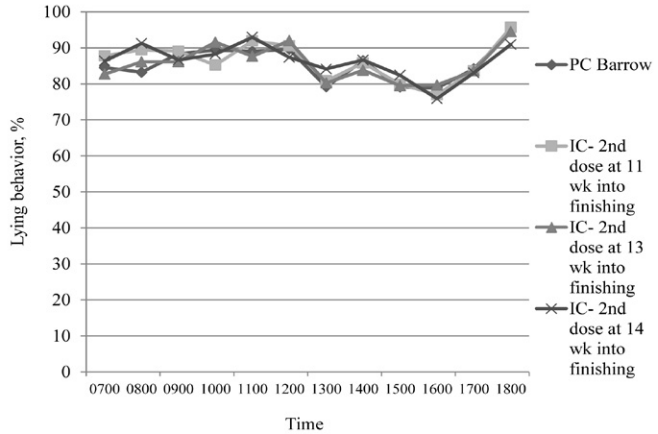

Figure 5. Lying behavior of physically castrated (PC) pigs and immunologically castrated (IC) males 19 wk into grower-finisher period (phase 3). The data showed a treatment × time interaction in lying behavior, but no discernible pattern could be established (treatment × time, $P < 0.001$; pooled SE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

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

Item	PC barrow	IC barrow	Barrows and Gilts
No. of trailers	6		9
No. of pigs	1,011		1,454
Dead/killed on 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 and down, %	1.17	0.00	0.42

[1]Physically castrated (PC) and immunocastrated (IC) barrows.

[2]Nonambulatory, noninjured.

[3]Nonambulatory, injured.

(Table 4). Even though IC barrows were more aggressive toward 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 being less fearful or more inquisitive toward people and therefore being 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 toward 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 higher 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 7). This finding supports the idea that there may be an endocrine explanation for increased vocalizations among finishing pigs (Schrader and Todt, 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 and Todt, 1998), and this finding leads to the speculation that PC barrows have increased responsiveness to a stressor than IC barrows: a hypothesis that can be tested 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, University of Illinois, Urbana-Champaign, personal communication). Normally, with dead and down data, one needs a very large sample size. However, when a treatment group has a mean of 0 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-scale 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 United States 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 one (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 select 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") toward 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 toward 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). Before immunization, intact male pigs showed an increase in aggression and mounting of each other compared to PC barrows. However, 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 toward the end of the grower-finisher period. Immunologically castration 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 need to include both improvements in and detriments to pig welfare generated by any alternative to PC.

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