Journal of Animal Science, 2021, Vol. 99, No. 5, 1–8

doi:10.1093/jas/skab110
Advance Access publication April 4, 2021
Received: 5 October 2020 and **Accepted:** 5 April 2021
Animal Health and Well Being

ANIMAL HEALTH AND WELL BEING

Time budgets of group-housed pigs in relation to social aggression and production

Carly I. O´Malley,[†,1,2] Juan P. Steibel,[†,‡] Ronald O. Bates,[†] Catherine W. Ernst,[†] and Janice M. Siegford[†]

[†]Department of Animal Science, Michigan State University, East Lansing, MI 48824, USA, [‡]Department of Fisheries and Wildlife, Michigan State University, East Lansing, MI 48824, USA

[1]This author completed the work at Michigan State University but is currently with Charles River Laboratories, 251 Ballardvale St, Wilmington, MA 01887, USA.
[2]Corresponding author: carly.o´malley@crl.com

ORCiD number: 0000-0002-1000-3147 (J. M. Siegford).

Abstract

Commercial producers house growing pigs by sex and weight to allow for efficient use of resources and provide pigs the welfare benefits of interacting with their conspecifics and more freedom of movement. However, the introduction of unfamiliar pigs can cause increased aggression for 24 to 48 h as pigs establish social relationships. To address this issue, a better understanding of pig behavior is needed. The objectives of this study were to quantify time budgets of pigs following introduction into a new social group and how these changed over time and to investigate how social aggression influences the overall time budgets and production parameters. A total of 257 grow-finish Yorkshire barrows across 20 pens were introduced into new social groups at 10 wk of age (~23 kg) and observed for aggression and time budgets of behavior at four periods: immediately after introduction and 3, 6, and 9 wk later. Pigs were observed for the duration of total aggression and initiated aggression (s) for 9 h after introduction and for 4 h at 3, 6, and 9 wk later. Time budgets were created by scan sampling inactive, movement, ingestion, social, and exploration behaviors every 2 min for 4 h in the afternoon and summarizing the proportion of time each behavior was performed by period. The least square means of each behavior were compared across time points. Pigs spent most of their time inactive. In general, the greatest change in pig behavior was observed between introduction and week 3 ($P < 0.003$), with gradual changes throughout the study period as pigs became more inactive (week 3 vs. week 6: $P = 0.209$; week 6 vs. week 9: $P = 0.007$) and spent less time on other behaviors. Pigs' nonaggressive behavior and production parameters were compared with aggression using generalized linear mixed models. The time pigs spent on nonaggressive behaviors was negatively related to aggression ($P < 0.045$) with few exceptions. Initiated aggression after introduction was negatively related to loin muscle area ($P = 0.003$). These results show how finishing pigs spend their time in commercial facilities and indicate that behavior continues to change for up to 9 wk after introduction into a new social group. Efforts to reduce chronic levels of aggression should focus on promoting nonaggressive behaviors, such as exploration and movement, after the initial fighting that occurs immediately after introduction has waned, and should be implemented for up to 9 wk after introduction into new social groups.

Key words: aggression, behavior, group housing, pigs, production, time budgets

Introduction

Consumers are increasingly concerned with the sustainability of agricultural practices, including the welfare of livestock, leading to a demand for welfare-friendly products (Broom, 2010; Velarde et al., 2015). Naturalness is considered a key component of good welfare, with intensive production systems, often viewed negatively in this regard by consumers (Velarde et al., 2015; Thorslund et al., 2017; Hemsworth, 2018). Within the United States, a major change is occurring in the pig industry as producers transition gestating sows to group-housing systems in response to concerns from consumers about sows' inability to perform natural behaviors in gestation stalls (Tonsor et al., 2009; Hemsworth, 2018). In response to public concerns over animal welfare, 10 states have passed legislation banning the use of gestation stalls, and over 60 major food companies have pledged to purchase only crate-free pork products, with these mandates requiring producers to transition away from gestation crates by 2022 (Andrews, 2014). However, as of 2018, only 24% of U.S. producers have phased out gestation crates, and those who have done so have invested large sums of money and faced challenges in training personnel to manage group-housed pigs safely and effectively (Pairis-Garcia, 2018). Thus, although group housing addresses some welfare concerns raised by consumers related to allowing more natural social behaviors, this comes with its own set of challenges.

Group housing already presents major welfare concerns for pigs at other production stages, such as grow-finisher (Marchant-Forde and Marchant-Forde, 2005). Pigs at this stage are often housed with pigs of the same sex and similar weight to create uniform groups for efficient resource use (Turner et al., 2010). Unfamiliar pigs fight intensely for 24 to 28 h as they work to establish a social hierarchy following introduction into a new social group, after which lower levels of aggression are typically seen (Meese and Ewbank, 1973). Chronic high levels of aggression can occur in some social groups and contribute to disruptions to growth rate and immune function (Marchant-Forde and Marchant-Forde, 2005). Recent survey data from North American pig producers found that about half of the respondents attempted to minimize aggression when introducing pigs using a variety of techniques such as mixing pigs into a new pen or using a specified mixing pen, mixing pigs at night, using odor-masking agents, providing enrichment at mixing, or socializing piglets before weaning (Ison et al., 2018). Many of these interventions, such as mixing at night, have been shown to merely delay aggression rather than reduce it (Marchant-Forde and Marchant-Forde, 2005). Producers who did not actively attempt to minimize aggression may not perceive aggression at mixing as a top priority despite it being a major welfare concern in the industry (Camerlink and Turner, 2017), meaning that social aggression is still a prevalent welfare issue that needs realistic and implementable solutions.

To address this issue, a better understanding of what constitutes successful group housing is needed so that researchers and producers can work to promote successful social groups. The objectives of this study were to quantify the behavioral profiles of group-housed grow-finish pigs to better understand how pigs in typical U.S. commercial facilities spend their time following introduction into a new social group and pen and to examine how social aggression influences the overall time budgets and production parameters, including growth rate, backfat thickness, and loin muscle area. It was hypothesized that the time budgets of pigs immediately after being introduced would be different than the time budgets of pigs 3, 6, and 9 wk after introduction, with pigs spending more time on aggression and explorative behaviors immediately after introduction than pigs in more stable social groups. It was also hypothesized that pens of pigs that displayed more aggression would have different behavioral time budgets at all time points as a result of unstable social relationships and that pens with more aggression will negatively impact production parameters as a result of chronic stress.

Materials and Methods

All animal protocols were approved by the Institutional Animal Care and Use Committee (Animal Use Form number 01/14-003-00).

Study population and housing

The animals used in this study were housed at the Michigan State University Swine Teaching and Research Center (East Lansing, MI, USA). Pigs were moved into grow-finisher rooms at 10 wk of age (approximately 23 kg) and housed in 4.83 × 2.44 m slatted concrete floor pens. Pigs could consume feed ad libitum with commercial feed formulated for the age and weight of the animals (NRC, 2012) and had ad libitum access to water using nipple with cup water systems. The grow-finish rooms had incandescent light bulbs and received 8 h of full light and 16 h of half-light per day.

A total of 257 purebred Yorkshire castrated males (barrows) were observed across four replicates. The barrows were housed in 20 pens, with 9 to 15 pigs per pen with pigs of similar weights to minimize variation. Barrows from 3 to 5 nursery pens were moved into grow-finish pens with 2 to 5 familiar barrows. The rest of the barrows were unfamiliar to them. At 6 wk after mixing, stable groups of barrows were moved into a different pen in the same room as a way to assess social stability as part of a different experiment. The new pens had the same configuration and resources as the barrows' original pens.

Video recording and observations

Pigs were video recorded by Clinton Electronics VF540 Bullet Cameras installed on the ceiling above each pen. These cameras were connected to a digital video recorder (Geovision 1480A) that was set up to record video events for 24 h immediately after mixing and again for 24 h 3, 6, and 9 wk later.

Pigs were given a unique mark on their backs using nontoxic markers for the purpose of identifying individual animals. Trained observers recorded aggressive behaviors including reciprocal fighting, attacks, pressing, and head knocks using all-occurrence sampling for 9 h after introduction to a new social group, including 5 h immediately after introduction and 4 h the following morning, and 4 h in the afternoon at wk 3, 6, and 9 after introduction. At week 6, pigs were relocated to a new pen within the same room—and data were collected after this move. Recording started prior to pigs being moved to ensure that behaviors were captured immediately upon entry to the pen. Pigs were moved into new pens in less than 10 min. The pens had the same resources and layout as the original pen, and pigs remained in the same social groups. Behaviors included in the time budgets were observed by trained individuals using the ethogram in Table 1. All pigs were observed using focal-animal scan sampling every 2 min for 4 h in the afternoon, when the pigs were generally active, for each of the four time periods (immediately after mixing and 3, 6, and 9 wk later).

Table 1. Ethogram of the behaviors recorded (adapted from Bolhuis et al., 2005) using scan sampling every 2 min for four consecutive hours in the afternoon

Behavior	Description
Inactive	Lying on floor, sitting, kneeling, or standing without performing any other behavior in the ethogram
Movement	Walking, trotting, running, scampering, or changing postures without performing any other behavior in the ethogram
Ingestion	Eating or drinking, interacting with feeder or waterer
Social	Touching or sniffing pen-mate; mounting pen-mate; pushing pen-mate out of feeder space; performing any manipulative behavior, such as belly nosing, nibbling, or suckling pen-mate
Aggression	Fighting, biting, head knocks, pressing, retreating from attack, or withdrawal
Exploration	Nosing, chewing, or otherwise manipulating floor or pen fixtures

Production traits

Pigs were weighed prior to introduction into grow-finish pens and again prior to slaughter. The growth rate (kg/d) was calculated using these two weights divided by the number of days between weights. Backfat thickness (cm) and loin muscle area (cm^2) were measured using B-mode ultrasound (Aloka SSd-500V, Hitachi Aloka Medical America, Inc., Wallingford, CT).

Statistical analyses

The experimental unit was the individual pig within pen. Aggressive behaviors were summarized into total duration of aggression (s) and total duration of initiated aggression (s). The total duration of aggression was the sum of all bouts of aggression that individual pigs were involved in, regardless of who initiated the interaction or the direction of the interaction. Initiated aggression included any behavior where there was a clear initiator of the aggressive interaction, as well as any one-sided aggressive interactions and totaled only for the individual pig that was the initiator.

Time budgets were calculated by taking the proportion of time pigs spent performing each behavior at each time point. Time budgets were compared between time points using least square means with time point as a fixed effect and pen as a random effect. The response variable was the proportion of behavior, which was arcsine square-root transformed for normality. Normality was assessed by visual inspection of Q–Q. plots. Tukey's honestly significant difference test was used to obtain adjusted *P*-values.

To assess the relationship between time budgets and aggression, Gaussian linear mixed models were fitted for each time point and for each measure of aggression, including total aggression (s) and total initiated aggression (s). The response variable was aggression ($\log_{10}$ + 1 transformed for normality, which was determined by visual inspection of quantile-quantile plots). Fixed effects included the proportion of time spent on inactivity, movement, ingestion, social behavior, and exploration, and pen was a random effect.

To assess the relationship between aggression and production traits, Gaussian linear mixed models were fitted for each production trait for each measure of aggression (total and initiated) and period. The response variables were the production traits, which were checked for normality by visual inspection of quantile-quantile plots. Fixed effects included the measures of aggression (scaled), and random effect was pen.

Data analyses were completed using R (Version 1.0.136, R Core Team, 2016; Vienna, Austria). Packages used included: xlsx (Dragulescu and Arendt, 2018), psych (Revelle, 2017), lmerTest (Kuznetsova et al., 2017), and car (Fox and Weisberg, 2011).

Results

Pig time budgets and how time budgets changed over time (i.e., immediately after introduction and 3, 6, and 9 later) are depicted in Figure 1. In general, the most drastic change in pig behavior was observed between introduction and week 3 ($P < 0.003$). Pigs' behavior continued to change throughout week 9 as the pigs became more inactive (week 3 vs. week 6: $P = 0.209$; week 6 vs. week 9: $P = 0.007$) and spent less time on other behaviors, such as aggression, exploration, and movement.

Time spent on nonaggressive behaviors of interest was compared with time spent in total aggression (Table 2) and total initiated aggression (Table 3) at all time points. The time pigs spent on nonaggressive behaviors was negatively related to the total duration of aggression ($P < 0.045$). This was also true for total initiated aggression, with few exceptions (i.e., social behavior at introduction: $P = 0.063$ and movement at week 6: $P = 0.087$).

The total duration of aggression and total initiated aggression at all time points were compared with the production variables of growth rate, backfat thickness, and loin muscle area taken prior to slaughter (Table 4). Loin muscle area was negatively related to total initiated aggression after introduction ($P = 0.003$). There were no other relationships between aggression and the measured production variables.

Discussion

Group-housing systems can improve pig welfare through interactions with conspecifics and the ability to display more natural behaviors, but these systems also present a welfare concern due to aggression seen between pigs as they establish social relationships. As producers work to address this issue, understanding how pig behavior changes over time following the introduction into new social groups is important for designing interventions that reduce conflict and improve productivity. For this study, the objectives were to assess and compare the time budgets of group-housed grow-finisher pigs that were introduced into a new social group at 10 wk of age (approximately 23 kg), and 3, 6, and 9 wk after introduction, and to investigate the relationship between nonaggressive behaviors and aggression and between aggression and production parameters.

Under seminatural conditions, pigs are diurnal and are active and exploratory during the day. Sub-adult pigs, similar to the ages of pigs observed in this study, have been observed to forage for approximately 75% of their active period (Stolba and Wood-Gush, 1989). It has been reported that pigs in commercial settings spend about 80% of their time inactive, 10% on ingestion, and 10% on other behaviors (Pond and Mersmann, 2001). In the 3, 6, and 9 wk after introduction to new social groups, the behavioral patterns seen in our population were similar, suggesting that the behavior of pigs in this study is representative of pigs in typical U.S. commercial facilities, although one limitation of this

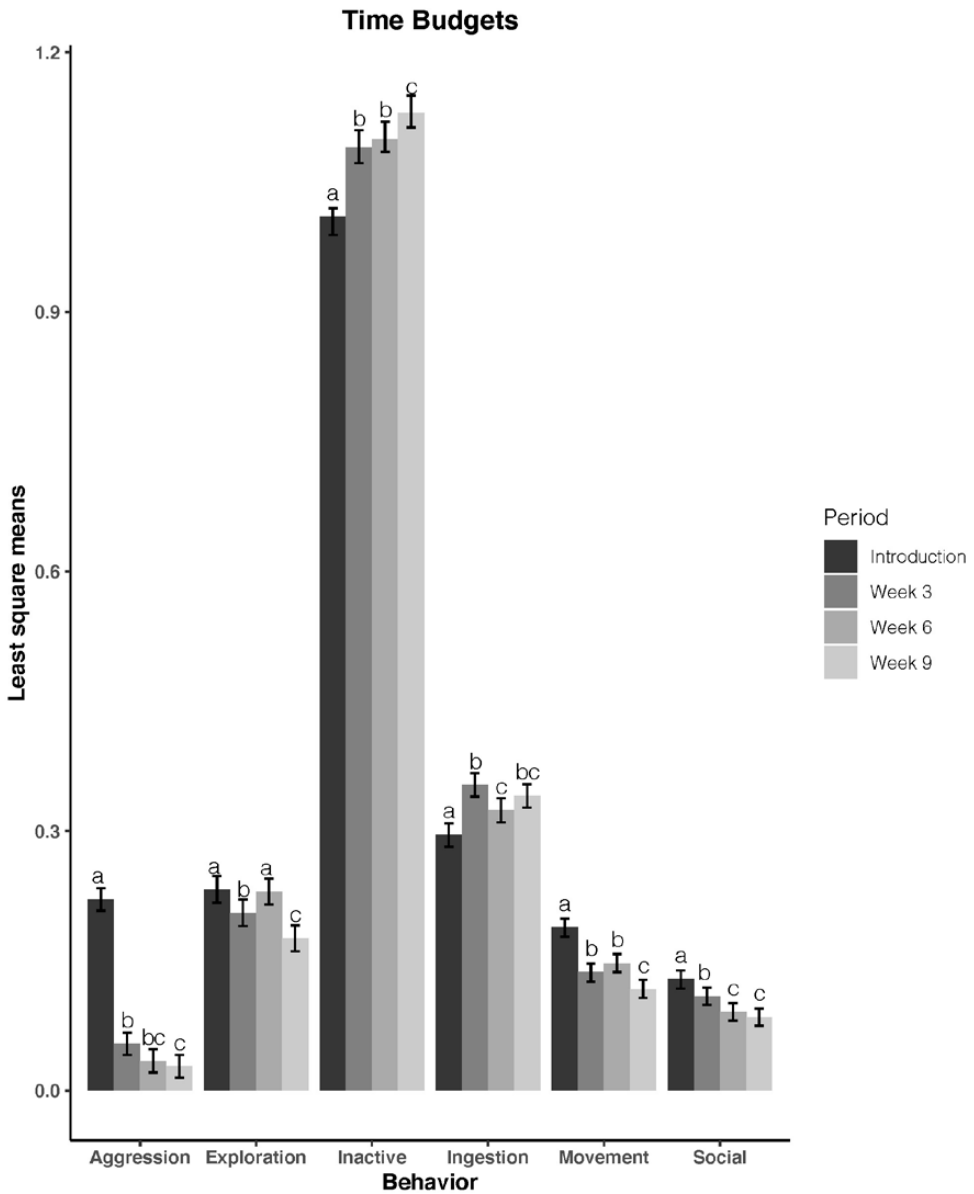

Figure 1. Least square means of the proportion of time pigs spent on each behavior for finishing pigs compared over four time points (immediately after introduction into a new social group at the start of the grow-finish stage [10 wk of age] [Introduction] and 3, 6, and 9 wk after introduction). Error bars represent the 95% confidence interval of the least square mean. Bars with different letters are statistically different from each other ($P < 0.05$, Tukey HSD adjusted).

study is that only castrated males were observed. We found that pigs spent most of their time inactive, with ingestion as the next most performed behavior at 3, 6, and 9 wk after they were placed into finishing groups. We hypothesized that the time budgets of pigs immediately after being introduced would be different than the time budgets of pigs 3, 6, and 9 wk after introduction and that pigs would spend more time on aggression and exploration immediately after introduction than in later time periods, and this was indeed the case. Pigs' behavior immediately after introduction was different than their behavior 3, 6, and 9 wk later; in particular, pigs spent more time on aggression and exploration immediately after introduction to their new social groups compared with later time points. However, at week 6, exploration occupied a similar proportion of time as at introduction into new social groups. In week 6, pigs were moved to a new pen, which likely explains the increased levels of exploration seen at this time point. Pigs are most aggressive in the first 48 h after introduction to unfamiliar pigs, but once pigs have established social relationships, aggression sharply declines (Meese and Ewbank, 1973). Not surprisingly, pigs in our study were also most aggressive immediately after introduction to a new social group, with relatively low amounts of aggression seen in the following weeks. For the nonaggressive behaviors assessed, the proportion of time pigs spent on each continued to change through week 9 as pigs generally spent more time inactive and ingesting and less time on other behaviors. These changes in behavior may reflect developmental changes in the pigs as they grow from piglets to subadults and their growth approaches market weight. However, it should be noted that this study only observed castrated males (i.e., barrows). Gilts reaching puberty may show different changes in behavior over time. In addition to the biological changes that the pigs are experiencing,

Table 2. Nonaggressive behaviors (analyzed as the proportion of time for each behavior over a 4-h observation period with scan sampling every 2 min), at each time point, were compared with the total duration of aggression (s)[1]

Aggression (s)	Period	Behavior	Slope	SE	$F_{(1, 8)}$	P-value
Total aggression	Introduction	Inactive	−3.144	0.334	86.766	<0.001
		Movement	−4.596	1.039	19.137	<0.001
		Ingestion	−3.931	0.512	57.915	<0.001
		Social	−3.708	1.182	9.666	0.002
		Exploration	−5.687	0.651	75.280	<0.001
	3 wk	Inactive	−10.565	2.003	27.575	<0.001
		Movement	−9.058	2.259	15.946	<0.001
		Ingestion	−8.572	2.055	17.253	<0.001
		Social	−7.717	2.404	10.240	0.002
		Exploration	−8.852	2.039	18.695	<0.001
	6 wk	Inactive	−9.014	2.583	12.026	0.001
		Movement	−5.631	2.778	4.070	0.045
		Ingestion	−6.585	2.641	6.657	0.011
		Social	−9.020	2.972	9.117	0.003
		Exploration	−8.182	2.683	9.178	0.003
	9 wk	Inactive	−12.381	3.588	−11.839	0.001
		Movement	−11.020	3.895	−7.969	0.005
		Ingestion	−9.940	3.619	−7.503	0.007
		Social	−8.195	3.735	−4.791	0.029
		Exploration	−10.085	3.696	−7.400	0.007

[1]Aggression variables were $\log_{10} + 1$ transformed for normality. Pigs were observed immediately after introduction to a new social group and 3, 6, and 9 wk later.

Table 3. Nonaggressive behaviors (analyzed as the proportion of time for each behavior over a 4-h observation period with scan sampling every 2 min) at each time point were compared with the total duration of initiated aggression (s)[1]

Aggression (s)	Period	Behavior	Slope	SE	$F_{(1, 8)}$	P-value
Total initiated aggression	Introduction	Inactive	−2.047	0.413	24.388	<0.001
		Movement	−3.027	1.283	5.517	0.019
		Ingestion	−2.648	0.628	17.653	<0.001
		Social	−2.725	1.451	3.499	0.063
		Exploration	−4.511	0.796	31.959	<0.001
	3 wk	Inactive	−11.059	2.483	19.559	<0.001
		Movement	−9.459	2.803	11.244	0.001
		Ingestion	−8.505	2.546	11.002	0.001
		Social	−9.105	2.989	9.189	0.003
		Exploration	−8.992	2.528	12.483	<0.001
	6 wk	Inactive	−9.443	3.282	8.087	0.005
		Movement	−6.155	3.548	2.954	0.087
		Ingestion	−7.195	3.355	4.493	0.035
		Social	−9.890	3.792	6.670	0.010
		Exploration	−9.051	3.406	6.894	0.009
	9 wk	Inactive	−11.419	4.013	8.027	0.005
		Movement	−12.188	4.359	7.759	0.006
		Ingestion	−8.713	4.045	4.597	0.033
		Social	−8.928	4.181	4.526	0.034
		Exploration	−10.018	4.132	5.825	0.017

[1]Aggression variables were $\log_{10} + 1$ transformed for normality. Pigs were observed immediately after introduction to a new social group and 3, 6, and 9 wk later.

another possible explanation for these behavioral changes is that it can take up to 9 wk for pigs to fully settle into their new social group. Previous reports show that skin lesions resulting from aggressive interactions can remain at an elevated level for several weeks after introduction, and that chronic aggression may persist for several months following introduction (Turner et al., 2013), supporting the explanation that new social groups may take time to fully integrate.

To date, little research has looked into the relationship between aggression and other behaviors that comprise a pig's daily time budget. Our second hypothesis was that pens of pigs that displayed more aggression would have different nonaggressive behavioral time budgets at all time points due to unstable social groups and disruptions to resting, eating, and exploration. The total duration of aggression was negatively related to pigs' nonaggressive behaviors through

Table 4. Total aggression (s) and total initiated aggression (s) recorded using all-occurrence sampling for four continuous hours in the afternoon at four time points (immediately after introduction and 3, 6, and 9 wk later) were compared with the production traits taken prior to slaughter[1]

Period	Production variable	Aggression, s	Slope	SE	$F_{(1, 4)}$	P-value
Introduction	Growth rate, kg/d	Total	–0.001	0.005	0.014	0.906
		Initiated	0.003	0.005	0.708	0.401
	Backfat thickness, cm	Total	0.034	0.024	1.963	0.162
		Initiated	0.042	0.024	2.884	0.091
	Loin muscle area, cm^2	Total	–0.294	0.297	0.964	0.327
		Initiated	–0.885	0.293	8.976	0.003
3 wk	Growth rate, kg/d	Total	0.001	0.005	0.018	0.893
		Initiated	0.003	0.004	0.358	0.550
	Backfat thickness, cm	Total	–0.021	0.024	0.748	0.388
		Initiated	0.002	0.023	0.005	0.943
	Loin muscle area, cm^2	Total	–0.429	0.294	2.075	0.151
		Initiated	–0.328	0.282	1.333	0.249
6 wk	Growth rate, kg/d	Total	–0.004	0.005	0.722	0.397
		Initiated	–0.004	0.005	0.634	0.427
	Backfat thickness, cm	Total	–0.021	0.028	0.548	0.459
		Initiated	–0.012	0.026	0.209	0.647
	Loin muscle area, cm^2	Total	0.011	0.340	0.001	0.975
		Initiated	–0.033	0.321	0.010	0.919
9 wk	Growth rate, kg/d	Total	–0.003	0.005	0.337	0.562
		Initiated	–0.002	0.005	0.184	0.668
	Backfat thickness, cm	Total	–0.027	0.029	0.809	0.369
		Initiated	–0.029	0.028	1.139	0.287
	Loin muscle area, cm^2	Total	–0.467	0.355	1.695	0.194
		Initiated	–0.148	0.338	0.191	0.662

[1]Production traits included growth rate, backfat thickness, and loin muscle area.

week 9 with few exceptions, suggesting that pigs that engage in more aggression do spend less time on other behaviors. This was also true for pigs that were more likely to initiate aggressive interactions. Our results suggest that interventions that promote behaviors other than aggression, after the initial aggression that occurs at introduction has waned, could be successful in decreasing time spent on aggression later on, potentially deterring chronic aggression. Provision of environmental enrichment, even simply scattering feed (Vermeer et al., 2017), can decrease aggressive interactions in group-housed pigs and promote exploratory behavior and growth (Schaefer et al., 1990; Beattie et al., 2000). However, efforts to reduce aggression immediately after introduction have largely been unsuccessful and may not actually be beneficial to social hierarchy formation and reduce aggressive behavior long term. Desire et al. (2015) previously observed that the presence of some increased aggression after introduction (as determined by skin lesion counts) was more beneficial for long-term social hierarchy stability, resulting in less chronic aggression compared with groups that did not have increased aggression immediately following mixing with new pigs. Pigs that avoid fighting after introduction are likely to have more skin lesions, indicative of aggression, 3 wk after introduction (Turner et al., 2017). Enrichment has not been shown to reduce aggression immediately after introduction, but ongoing aggressive interactions in the weeks following introduction are reduced in pigs provided enrichment compared with control groups in barren pens (Martin et al., 2015).

Pigs kept in groups have different feeding patterns compared with those housed individually, with fewer feeding bouts and consumption of more food at each bout (de Haer and Merks, 1992; Bornett et al., 2000). Stress caused by introduction into a new social group can lead to decreased food intake and disrupt growth (Pond and Mersmann, 2001), which led to our hypothesis that increased aggression would negatively impact production parameters. Immediately after introduction into a new social group, ingestion was lower than feeding behavior at 3, 6, and 9 wk later. Pigs that initiated more aggression after introduction had smaller loin muscle areas, but there were few other relationships with growth rate, loin muscle area, and backfat thickness. A negative relationship between aggression and loin muscle area (as estimated through genetic correlations with lesion scores) was reported by Wurtz et al. (2017), which represented the full population of pigs (n = 1,093, gilts and barrows) used in this study (n = 257, all barrows). However, Desire et al. (2015) did not find a relationship between aggression and loin muscle area. The negative effect of aggression on growth rate has been documented previously and is a concern in the pig industry as producers may introduce pigs into new social groups several times before slaughter (Camerlink and Turner, 2017; Peden et al., 2018). No relationship of aggression to backfat thickness was found either in the current study or when the full data set was examined (Wurtz et al., 2017) or in work by Desire et al. (2015) to estimate genetic correlations. However, previous studies have reported that group-housed pigs have slower growth and less backfat than pigs housed individually (de Haer and de Vries, 1993). Thus, issues associated with aggression in group-housed pigs could be addressed through breeding programs as well as through behavioral management (Peden et al., 2018).

Conclusions

In conclusion, the proportion of time pigs spent on different behaviors changed in the weeks following introduction into a new social group as they entered the grow-finish stage, likely reflecting biological development during this stage and acclimation to a new environment and social group. Pigs spent most of their time inactive with inactivity increasing through week 9, whereas pigs spent less time on other behaviors, such as aggression, exploration, and social behavior. Aggression was negatively related to nonaggressive behaviors in pigs' time budgets at all time points. There was a negative relationship between initiating aggression after introduction and loin muscle area measured at slaughter, but no other relationships between aggression and growth rate, backfat thickness, and loin muscle area were found. Only castrated male pigs were observed in this study, leaving a gap in knowledge about these relationships in female pigs. The results of this study suggest that interventions promoting nonaggressive behaviors should be provided after the initial aggression and continue throughout the grow-finish stage to reduce chronic levels of aggression.

Acknowledgments

This work was supported by the U.S. Department of Agriculture (USDA), National Institute of Food and Agriculture, Agriculture and Food Research Initiative Award grant [2014-68004-21952]. Additional support was provided by grants from the National Pork Board and the Rackham Research Endowment at Michigan State University to J. M. S. and collaborators. C. I. O. was partially supported by Food and Agricultural Sciences National Needs Graduate Fellowship from the USDA National Institute of Food and Agriculture Award grant [2012-38420-30199]. Support was provided to J. M. S. as an AgBioResearch-supported faculty member of Michigan State University by the National Institute of Food and Agriculture, USDA, Hatch projects 1002990 and 1010765. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Conflict of interest statement

The authors declare no real or perceived conflicts of interest.

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