The Effects of Ractopamine on Behavior and Physiology of Finishing Pigs

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Introduction

The feed additive ractopamine, a beta-adrenergic agonist, acts as a repartitioning agent, promoting lean tissue deposition in market-weight pigs (Watkins et al., 1990; Crome et al., 1996). It has been the focus of widespread research over the last 20 years and has been shown to give substantial improvements in average daily gain, feed conversion efficiency, dressing percent and carcass lean content (Watkins et al., 1990; Gu et al., 1991a,b; Uttaro et al., 1993; Crome et al., 1996). Its usage may also confer environmental benefits such as reduced manure volume, decreased ammonia and volatile fatty acids emissions from slurry (Sutton et al., 2001). It was formally approved for use in swine in the US in 1999, and subsequently, a number of other countries.

Research has also shown that the production advantages of ractopamine are relatively brief. Performance measures peak and then decline (Bark et al., 1992; Williams et al., 1994) with the greatest response occurring during the first 14 days (Williams et al., 1994). In recent studies, pigs fed a constant level of ractopamine had slower growth rates and poorer feed conversion efficiency than control pigs by the fifth week on test (Herr et al., 2002a, 2002b). At a cellular level, the change in response may be due to a combination of down regulation of the ß-adrenergic receptors and ractopamine's partial agonist activity (Liu et al., 1994; Mills, 2001). The little behavioral research carried out to date has confirmed that after 6 weeks of being fed ractopamine, pigs spent more time lying down and less time walking (Schaefer et al., 1992), but there was no evidence of decreased joint soundness and there is no scientific evidence of behavioral or physiological responses to stress. As global usage increases, it is important that these concerns are addressed. The objectives of this study, therefore, were to examine the behavior and physiology of market-weight pigs during the conventional ractopamine administration period and in response to stressors encountered during routine handling, weighing and during transport.

Materials and Methods

Animals, Housing and Husbandry. A total of 72 gilts were used, offspring of Newsham XL terminal sires on Newsham US parent gilts. They were blocked by weight into two rows of twelve adjacent pens separated by a central corridor in the same wing of the Purdue University Swine Evaluation Unit. Each pen (6 × 10 ft) housed 3 pigs and had fully-slatted floors, a single drinker, and a single-space feeder. Both water and feed were available ad libitum. The pens were randomly assigned within block to one of two treatments, when they had reached an average bodyweight of 188.5 lb, for the four weeks prior to slaughter; 1) finishing feed plus ractopamine (9 g/ton –19.2% CP), 2) finishing feed alone (19.2% CP).

All pigs were weighed individually on a weekly basis to monitor growth performance and pen feed intakes were recorded also weekly to determine feed intakes and feed efficiencies. At the end of the four week trial period, pigs were loaded onto a flat-bed truck and transported to the slaughter facility at the Purdue University West Lafayette campus – a distance of approximately 10 miles. At the abattoir facility, they were off-loaded and held in lairage for up to one hour prior to slaughter.

Behavior. Behavior of gilts in twelve of the pens (six per treatment) was recorded using ceiling-mounted cameras (Panasonic WV-CD110AE, Matsushita Electric Industrial Co. Ltd., Japan) attached to time-lapse video-recorders (Panasonic AG6720A, Matsushita Electric Industrial Co. Ltd., Japan) over a 22 hour period, once a week during each of the 4 weeks. The 22 hour period avoided the 2 hours during which daily husbandry routines such as refilling feed hoppers and cleaning were carried out, as these could vary in the amount of disturbance that different pens were subject to, depending on their position in the barn. The video data were analyzed using a scan sampling technique, with behavior (specifically activity, alertness and feeding), location and posture of each pig in a pen recorded every 5 minutes. Data from each pig were then combined to give a behavioral time budget with each pen as an experimental unit. Also once a week, over the four weeks, pigs were subjected to a behavioral disturbance test where, when lying, all pigs in a pen were made to stand and the time taken for them to return to lying down was recorded.

All pigs were weighed five times - once at the start of the trial and once at the end of each week of treatment. Weighing was carried out in the central corridor by 2 handlers. The same pair of handlers carried out the weighing on Weeks 0, 1 and 3, but on Weeks 2 and 4, one of the pair of handlers was different. A number of measures were taken over the weighing process. These included;

1. Number of pigs exiting the home pen voluntarily
2. Time taken for each individual pig to exit the home pen
3. Time taken to get the pig into the weighing crate, from the first contact with board handler until the crate gate was shut
4. Number of pats, hand pushes and knee pushes needed to get the pig into weighing crate
5. Time taken to get the pig out of the weighing crate, from the crate gate opening until the pigs front feet were out of the crate
6. Number of pats, slaps and hand pushes needed to get the pig out of the weighing crate
7. Time taken to get all 3 pigs back into the home pen, from the first contact with a handler until the pen gate was shut

Heart Rate. Heart-rate responses to unfamiliar human presence were measured in all pigs once during the 4th week of the trial. Twelve pens of pigs were recorded on each of two afternoons. The human entered each pen and fitted each of the three pigs with a Polar Vantage NV (Polar Electro Oy, Kempele, Finland) heart rate monitor (see methodology in Marchant et al., 1995), which was set to record and store successive interbeat intervals. Once the last pig's monitor had been fitted, all monitors were started and the experimenter then knelt in one corner of the pen and interacted with the pigs for 10 min. from the time that the last monitor in the pen was started.

The data were displayed in graphical and numerical form using Polar Precision Performance Analysis Software (Version 2.1, Polar Electro Oy, Finland) and analyzed to determine mean heart rate every 1 min over the 10 min period, in beats per minute (bpm), with each pen as an experimental unit.

Heart rate was also measured during transportation to the campus slaughter facility. Transportation took place on four separate mornings, with 18 pigs being transported per day from 12 of the pens. Due to equipment constraints, the heart rate of only 8 pigs could be recorded each day. Thus a total of 32 pigs were recorded, with at least one pig recorded from each of the 24 pens.

Circulating hormone concentrations. Blood samples were taken from a single pig in each pen once during the 4th week of the trial. Twelve pigs had blood samples taken on each of two mornings, on days different to the heart rate recording. An additional post-slaughter blood sample was taken from the same pigs during exsanguinations and this was analyzed for cortisol concentrations only. Norepinephrine and epinephrine were measured in duplicate using high performance liquid chromatography with electrochemical detection. Plasma cortisol was measured in quadruplicate using a competitive binding radioimmunoassay kit (GammaCoat, DiaSorin).

Statistical analysis. The experimental was a repeated measure design with repeated measurements of animals (main units) over time (subunits). Behavior and heart rate data were analyzed using the repeated option of Proc GLM of SAS. (Sas Inst. Inc, Cary, NC). Diet treatment, time and time by treatment interactions were included in the model. Students T-tests were used to compare the hormone concentrations of the pigs, with treatment as the between-subjects factor. The data were transformed as appropriate when the assumption of normality was not fulfilled (Sokal and Rohlf, 1981). As the behavioral time budget data were expressed as proportions of total time, these data were transformed using arcsine-root transformation.

Results

Behavior. During weeks 1 and 2, pigs fed ractopamine spent more time active, more time alert, more time lying in sternal recumbency and spent less time lying in lateral recumbency (Table 1). They also spent more time at the feeder in week 1. There were no differences in time budgets in any of the behaviors measured during weeks 3 and 4. Overall, RAC pigs spent more time active, feeding and lying sternally and less time lying laterally. Following behavioral disturbance, pigs on ractopamine took longer to settle down than control pigs, but only during weeks 1 and 2 (Table 1).

At the start of the trial, there were no differences in behavioral responses to handling. However, over the next 4 weeks, on average, 51% fewer pigs fed ractopamine exited the home pen voluntarily compared with control pigs. Ractopamine-fed pigs also took 136% longer to be removed from the home pen, 83% longer to handle into the weighing scale and needed 52% more pats, slaps and pushes from the handler to enter the scales (Figure 1). There was no significant effect of the handling team on behavioral responses to handling and thus RAC pigs were more difficult to handle regardless of the familiarity of the handlers. There also appeared to be no habituation to the procedure, in as much as none of the measures of handling decreased over time.

Heart rate. In response to the presence of the experimenter, at the end of week 4, pigs fed ractopamine had higher mean heart rates overall during the test (144.6 ± 3.2 bpm vs. 136.4 ± 2.7 bpm, $P < 0.05$). When separated into 1 min periods, heart rate showed similar temporal patterns and was initially not different between the two treatments (Figure 2). However, it became and remained significantly different from 3 min. onwards (Figure 2). During transport, pigs fed ractopamine had similar mean heart rates overall ($P > 0.1$), When separated into 2-min periods, heart rate showed similar temporal patterns and was not different between treatments when heart rate was highest during loading and unloading (Figure 3).

Hormones. At the end of week 4, pigs fed ractopamine had increased circulating concentrations of epinephrine (253.0 ± 55.0 vs. 101.5 ± 15.0 pg/mL; $P < 0.05$) and norepinephrine (991 ± 150 vs. 480 ± 58 pg/mL; $P < 0.01$) than control pigs. Circulating cortisol concentrations did not differ between treatments either before or after transport. There was also no significant difference between treatments in percentage change in cortisol levels from baseline, in response to transportation.

Discussion and Conclusions

The results indicate that ractopamine did affect the behavior and physiology of finishing pigs in this study. In terms of time budget differences, pigs fed ractopamine were more active and alert, spent more time in sternal recumbency and less time in lateral recumbency than control pigs. They also tended to take longer to settle after disturbance. These results confirm the anecdotal reports of increased activity in ractopamine-fed pigs and appear to counter the results of the only other study carried out on ractopamine-fed pigs (Schaefer et al., 1992), which noted only that pigs on ractopamine were less active.

However, the different timings of behavioral observations between this study and the previous study means that these results are not necessarily in conflict. In this study, the pigs were observed from the time that ractopamine was fed over 4 weeks up to slaughter. Schaefer et al. (1992) observed the pigs after they had been on ractopamine for between 5 and 6 weeks. From our results, the effects of behavioral time budgets were relatively short-lasting and had all but disappeared by the 3rd week, with only very few differences during week 4. It is also known that the production benefits of feeding pigs a constant level of ractopamine is minimized by the fifth week on test (Herr et al., 2001a,b) and that at a cellular level, there is down regulation of the ß-adrenergic receptors (Liu et al., 1994; Mills, 2001). Therefore, it is probable that the observations carried out in the previous study (Schaefer et al., 1992) occurred at the wrong time in order to answer the questions that were posed.

The behavioral responses to handling also indicate that as well as being more active, pigs fed ractopamine are generally more difficult to handle. They were less likely to exit the pen without being forced out, they took longer and needed more physical interactions by the handler to get into the weighing scale. These differences became apparent very quickly after feeding of ractopamine had started and, unlike the time budget differences, they continued over the entire 4-week period. This result may have serious implications for the well-being of market-weight pigs at the point of slaughter, as well as financial implications in terms of time input and meat quality. Pigs that are difficult to load and unload during transportation to the slaughterhouse are more likely to be subject to rough handling (Geverink et al., 1998) and thus, interactions with the handler may escalate, with pats becoming slaps, knee pushes becoming kicks and perhaps even culminating in the use of electric prods. The worst case scenario may be an increase in pigs dying in transit or in subsequent lairage.

Ractopamine appears to chronically elevate heart rate compared to control-fed pigs. It has been shown that chronic administration of other beta-agonists results in a shift of intrinsic autonomic balance towards sympathetic dominance (Jartti et al., 1998) resulting in elevated basal heart rate. Chronic administration of ractopamine over this 4-week period does not appear to affect cardiac responses to external stimuli, such as those encountered during handling.

Pigs fed ractopamine also had greater concentrations of epinephrine and norepinephrine, when measured during the 4th week of administration. This increase in epinephrine and norepinephrine could be responsible for the increase in heart rates and activity of the pigs fed ractopamine.

Implications

Pigs fed ractopamine were more difficult to handle and had elevated heart rates and catecholamine levels after 4 weeks of administration. Pigs that are more difficult to move are more likely to be subjected to rough handling and increased stress during transportation, implying reduced welfare, increased workload for the handlers and, potentially, poorer meat quality. Further research is needed to determine why ractopamine-fed pigs are more difficult to handle and to elucidate ways to ameliorate adverse behavioral responses to handling, in order to prevent widespread reduction in finishing pig well-being and unnecessary costs to the industry.

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Table 1. Mean proportion of time spent in various behaviors and postures by finishing pigs on ractopamine -added (9 g/ton) or control diets

				P-value		
Behavior	**Ractopamine**	**Control**	**Pooled SEM**	**Trt**	**Time**	**Trt ´ Time**
Active (proportion of time)						
Week 1	0.252	0.194	0.013	*		
Week 2	0.240	0.185	0.010	***		
Week 3	0.201	0.190	0.007	-		
Week 4	0.200	0.182	0.009	-		
Overall	0.223	0.188	0.010	**	*	-
Alert (proportion of time)						
Week 1	0.041	0.022	0.005	†		
Week 2	0.042	0.023	0.005	*		
Week 3	0.035	0.031	0.003	-		
Week 4	0.029	0.026	0.004	-		
Overall	0.037	0.026	0.004	-	-	-
Feeding (proportion of time)						
Week 1	0.060	0.045	0.003	**		
Week 2	0.058	0.052	0.002	-		
Week 3	0.049	0.042	0.003	-		
Week 4	0.048	0.044	0.002	-		
Overall	0.054	0.046	0.003	*	*	-
Lying sternally (proportion of time)						
Week 1	0.282	0.209	0.018	*		
Week 2	0.293	0.198	0.021	*		
Week 3	0.264	0.219	0.016	-		
Week 4	0.237	0.216	0.014	-		
Overall	0.269	0.211	0.017	*	-	-
Lying laterally (proportion of time)						
Week 1	0.552	0.650	0.019	**		
Week 2	0.577	0.680	0.022	*		
Week 3	0.605	0.659	0.017	-		
Week 4	0.635	0.669	0.015	-		
Overall	0.592	0.665	0.018	**	†	-
Time to lie down, s						
Week 1	413	214	49	*		
Week 2	684	289	109	†		
Week 3	277	311	37	-		
Week 4	541	531	74	-		
Overall	479	336	67	-	*	-

†P < 0.1, * P < 0.05, ** P < 0.01, *** P < 0.001.

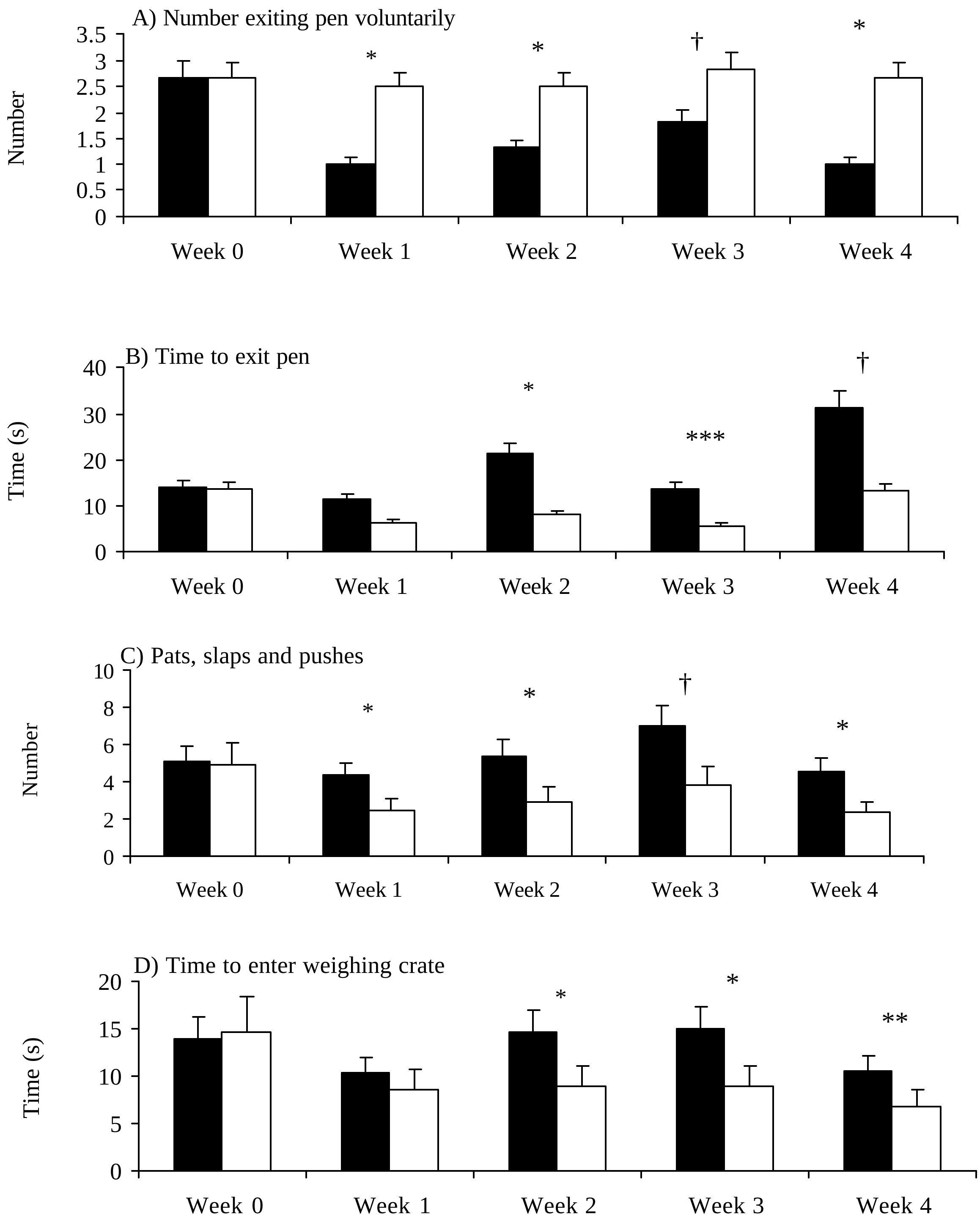

Figure 1. Measures of ease of handling during weighing for finishing pigs on control (?) or ractopamine-added (¦) diets. (†P < 0.1, *P < 0.05, **P < 0.01). A) Overall treatment effect P < 0.01, time effect P < 0.01; B) Overall treatment effect P < 0.05, time effect P < 0.001; C) Overall treatment effect P < 0.05, time effect P < 0.05; D) Overall treatment effect P < 0.05, time effect P < 0.01.

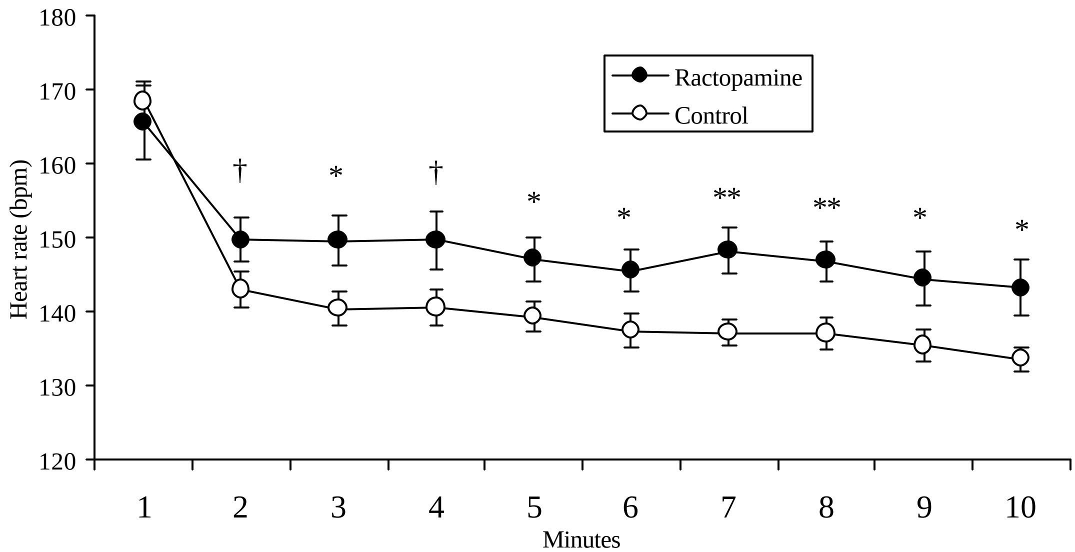

Figure 2. Mean±s.e. heart rate in beats per minute of finishing pigs during exposure to an unfamiliar human. (†P < 0.1, * P < 0.05, ** P < 0.01). Overall treatment effect P < 0.05, time effect P < 0.001.

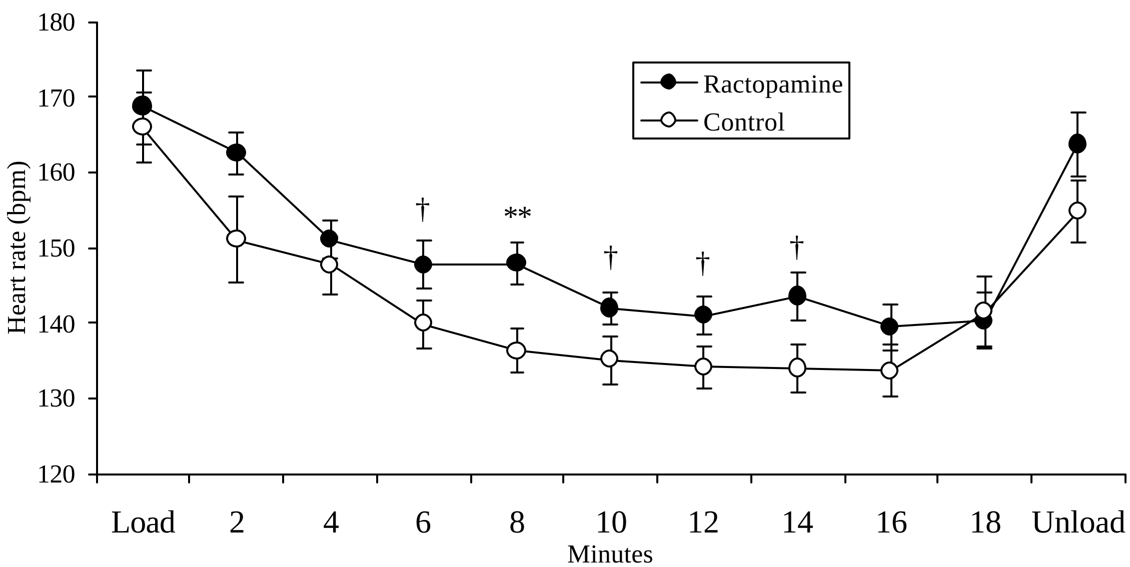

Figure 3. Mean±s.e. heart rate in beats per minute of finishing pigs during transport. (†P < 0.1, * P < 0.05, ** P < 0.01). Overall treatment effect *P* >0.1, time effect P< 0.001.