Impact of feeders and drinker devices on pig performance, water use, and manure volume

Michael C. Brumm, MS, PhD; James M. Dahlquist, MS; Jill M. Heemstra, MS

Summary

Objective: To determine the impact of feeder and drinker designs on pig performance, water use, and manure volume.

Methods: Experiment One compared a wet/dry feeder to a dry feeder with wall-mounted nipple drinker. Experiment Two compared a swinging nipple drinker to a gate-mounted nipple, and Experiment Three compared a bowl drinker to the swinging drinker of Experiment Two. In all experiments, pigs were housed in pens of 20–24 pigs per pen in partially slatted, mechanically ventilated facilities.

Results: In Experiment One, water disappearance (L per pig per day) was 4.49 for the wet/dry feeder versus 6.06 for the dry feeder plus nipple drinker. In Experiment Two, water disappearance was 4.90 L per pig per day for the swinging drinker versus 5.50 for the gate-mounted drinker. In Experiment Three, water disappearance was 3.78 for the bowl versus 5.01 for the swinging drinker. Summer manure production in Experiment One was 4.96 L per pig per day for the wet-dry feeder versus 7.02 for the nipple drinker. Winter manure production was 3.96 L per pig per day for the swinging drinker versus 4.59 for the nipple drinker in Experiment Two.

Implications: These results document the wide range in water use and manure volume associated with feeder and drinker devices installed in swine facilities. They also suggest lower amounts of total water use and manure volume than those currently cited in the literature or used by regulatory officials.

Keywords: swine, water intake, feeder, manure

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The importance of water availability to growing-finishing pigs is often cited in publications dealing with swine nutrition.[1–4] Some have recommended maximum stocking densities and minimum delivery rates (L per minute) for nipple drinking devices.[2] Some have estimated total manure production, including wasted drinking water, based on the use of nipple drinkers and include water wastage from these drinkers.[5] Other studies fail to mention the impact of water delivery devices on total manure volume.[6–8]

The objective of this study was to conduct a series of experiments to examine the impact of alternative water delivery devices on pig performance, water use, and manure production.

Materials and methods

Housing

In each of three experiments, pigs were housed in two similar, mechanically ventilated, partially slatted finishing facilities at the University of Nebraska's Northeast Research and Extension Center near Concord, Nebraska. Each facility had six 3.7-m × 4.6-m (12.1 ft × 15.1 ft) pens with 50% of the pen area slatted. There were 24 pigs per pen in Experiments One and Two (0.70 m^2 [7.5 ft^2] per pig) and 20 pigs per pen in Experiment Three (0.84 m^2 [9.0 ft^2] per pig). Pen size was not adjusted in the event of pig death or removal for poor performance.

In Experiments One and Three, summer cooling was provided to all pens of pigs within a facility by means of a thermostatically controlled drip system with intermittent dripping initiated at 27°C (80.6°F). Water used for cooling was not metered, but the same system serviced all pens within a building with one control and a similar setup in each pen.

Manure system

The manure system in each facility was a shallow pit (depth = 1.2 m [3.9 ft]) drained periodically into a lagoon (i.e., a pull-plug system). The pens on the north or south side of a center aisle had a common pit and pull-plug system. Feeder and drinker treatments were assigned to either the north or south side of the aisle so manure production could be estimated from manure depth in the common pit for each feeder or waterer type.

Water disappearance (animal intake and waste) was measured for each feeder or drinker type in each facility by water meters installed in the water delivery line corresponding to the manure pit location. Manure production was estimated by recording the manure depth in each pit prior to removal of the pull-plug.

Carcass measures

Carcass lean estimates were collected on individually identified pigs by employees of SiouxPreme Packing Co.; Sioux Center, Iowa using total body electrical conductivity (TOBEC). Data were reported by the slaughter house as carcass percentage lean containing 5% fat. Lean gain containing 5% fat was calculated using the procedures suggested by the National Pork Producers Council (NPPC).[9]

Experiment One

Both a winter and summer trial using crossbred (Duroc × [Yorkshire-Landrace × Duroc]) feeder pigs were conducted. Pigs were allocated at arrival on the basis of sex and arrival weight outcome groups in a

MCB, JMD, JMH: University of Nebraska, Haskell Agricultural Laboratory, Concord, Nebraska 68728

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balanced design to pens equipped with one of the following two experimental treatments:

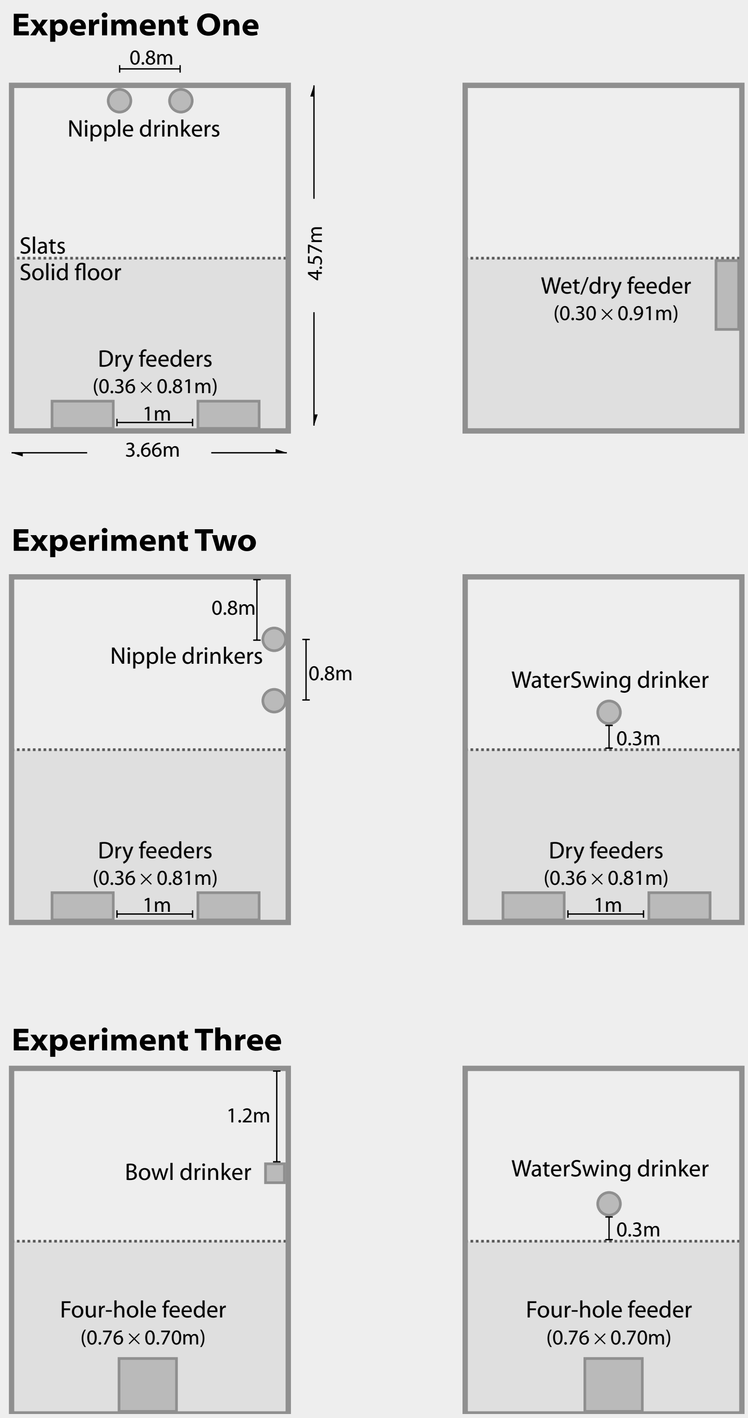
- a Crystal Springs® wet/dry feeding system (GroMaster, Inc.; Omaha, Nebraska). The Crystal Springs® feeder provided two feeding spaces for 24 pigs and a single nipple drinker in the feed trough. No other drinking water source was provided. Water pressure to the feeders was adjusted to 69 kPa (10 psi); or
- a traditional system of dry feeders and nipple drinkers: two three-hole stainless steel feeders (Marting Manufacturing Co.; Britt, Iowa). The feeders were separated by 1 m (3.3 feet) so pig access to all six feeder holes was not restricted. There were two nipple drinkers provided on the wall opposite the feeders over the slatted portion of the pens (Figure 1). The nipple drinkers were 0.8 m (32 inches) apart and 0.5 m (20 inches) above the slats. Water pressure to these drinkers was 240 kPa (35 psi).

Corn-soybean meal-based diets in meal form containing 3% added fat were formulated to provide

- 0.9% lysine from 18.6–40.9 kg (41–90 lb) bodyweight (BW),
- 0.8% lysine from 40.9–77.3 kg (90–170 lb) BW, and
- 0.7% lysine from 77.3 kg (170 lb) to slaughter.

Diets were switched on the week individual pens of pigs achieved the target weights. All diets contained 44 mg per kg tylosin.

Figure 1: Feeder and drinker locations for Experiments One, Two, and Three



Experiment Two

At arrival, crossbred (Line 326 × C15) pigs (PIC, Inc.; Franklin, Kentucky) were sorted by sex, with barrows in one facility and gilts in the other in this winter trial. Within sex (facility), pigs were randomly assigned on the basis of weight blocks in a balanced design to pens equipped with one of the following experimental treatments:

- the Trojan WaterSwing® (Ritchie Industries, Inc.; Conrad, Iowa). The WaterSwing® drinker consisted of opposing nipple drinkers attached to a delivery pipe, which was suspended from a chain anchored to the ceiling in the middle of the pen of pigs; or
- conventionally installed Trojan nipple drinkers. The conventional nipple drinkers were installed on the slotted portion of the pen partition over the slatted floor portion of the pen (Figure 1). The two conventional nipple drinkers were spaced 0.8 m (32 inches) apart to limit pig dominance activities.

Both drinker types were adjusted for height every 2–3 weeks to provide 5–10 cm (2–4 inches) of clearance between the shoulder of the pigs (while standing) and the bottom of the drinker. Water pressure to both drinker types was 200 kPa (30 psi).

Corn-soybean meal-based diets in meal form were formulated for each sex according to the University of Nebraska[2] recommendations for pigs of high lean-gain potential. All diets contained 44 mg per kg tylosin.

Experiment Three

In a summer trial, crossbred feeder pigs (PIC Line 326 × C15) were allocated at arrival on the basis of sex and arrival weight in a balanced design to mixed-sex pens equipped with one of the following experimental treatments:

- the Drik-O-Mat® bowl drinker (Farmweld, Inc.; Teutopolis, Illinois). A single bowl was fastened to the pen partition over the slatted floor portion of the pen 0.8 m (32 inches) from the rear wall of the pen with the bottom lip of the bowl 25 cm (10 inches) from the floor (Figure 1); or
- the WaterSwing® used in Experiment Two. The WaterSwing® was adjusted as in Experiment Two.

Water pressure to both drinker types was 240 kPa (35 psi).

A four-space feeder (Farmweld Wean-Finish, Farmweld Inc.; Teutopolis, Illinois) was provided with two spaces on each side of the feed hopper. The feeder was located perpendicular to the center aisle in the center of the pen partition along the aisle (Figure 1).

Corn–soybean meal-based diets in meal form containing 5% added fat were formulated to have the same lysine:calorie ratio as the gilt diets in Experiment Two. Diets contained 110 mg per kg tylosin except for days 20–38, when they contained 44 mg per kg tylosin.

Statistical analysis

The pen of pigs was the experimental unit for all pig performance criteria except death loss and pig removal. For water disappearance and manure volume, the side of the facility (north versus south) was the experimental unit. Results were analyzed by period. Average weights of all pigs at the beginning and ending of each period (day on test) were subtotaled. All statistical analysis was conducted using GLM procedures as outlined by SAS (SAS; Cary, North Carolina).

Water:feed (W:F) ratios were analyzed as a time series using the ProcMix procedures of SAS. In Experiment One, the model included trial (season), drinker type, weight block, facility, and all two-way and three-way interactions. In Experiments Two and Three, the model included drinker type, weight block, facility, and the two-way interaction.

Death loss and data on pigs removed for poor performance (i.e., pigs with two consecutive weigh periods with < 0.2 kg per day average daily gain [ADG]) were analyzed by χ^2 analysis.

Results

Experiment One

Feeder type did not interact significantly (P > .1) with trial (season) or initial weight on pig performance (Table 1).

Pigs using the two-hole wet/dry feeder grew faster (P <.05) and had a higher daily feed intake (P <.001) than pigs using the traditional dry feeder and nipple drinker. Because feed disappearance for pigs using the wet/dry feeder increased more than daily gain, their feed conversion was worse (P <.005).

Feeder type had no effect (P >.1) on carcass lean, rate of lean gain, or pig health as measured by the percentage of pigs that died or that were removed for poor performance.

Total water use was reduced by 26% for the wet/dry feeders compared to the dry feeders with nipple drinkers (P <.05). Trial (season) had no effect on water use.

In the winter trial, total manure volume was excessive for one of the wet/dry feeder treatments in one of the two facilities because feed was found to be lodged against the nipple drinker in the feed trough for a 2-day weekend, which discharged a large volume of water into the manure collection pit. While corrections were immediately made for water disappearance, no such

Table 1: Effect of feeder type on performance, Experiment One

	Feeder type			
Item	Wet/dry	Dry	SEM	*P* values
Number of pens	12	12		
Pig weight, kg				
Initial	18.6	18.5	<.01	
Final	108.0	107.4	.4	Not Significant (NS) (*P* >.1)
CV *	9.5	10.4	.5	NS
ADG, kg	.780	.760	.006	.036
ADFI, kg	2.379	2.250	.019	<.001
Gain:feed	.328	.338	.002	.002
Carcass lean †	46.7%	47.0%	.2%	NS
Lean gain, kg/d †,‡	.273	.272	.002	NS
Pigs dead or removed	1.7%	1.4%		NS
Water, L x pig^{-1} x day^{-1} §	4.49	6.06	.36	.037
Water:feed, kg:kg §	1.78	2.79	.08	.003
Manure production, L x pig^{-1} x day^{-1} ¶ Summer	4.96	7.02	.20	.087

* CV=Coefficient of variation of within pen weight when first pig removed for slaughter
† Containing 5% fat
‡ Equation of NPPC (1991)
§ Represents four observations per feeder type
¶ Represents two observations per feeder type

Table 2: Manure production

	Experiment One (summer)		Experiment Two	
	Dry	Wet/dry	Swing	Nipple
Per pig per day				
Volume	7.02 L (1.85 gal)	4.96 L (1.31 gal)	3.96 L (1.05 gal)	4.59 L (1.21 gal)
Mass*	7.0 kg (15.4 lb)	4.9 kg (10.8 lb)	3.9 kg (8.6 lb)	4.5 kg (9.9 lb)
Per 1000 kg bodyweight				
Mass	109 kg (240 lb)	76 kg (167 lb)	61 kg (134 lb)	70 kg (154 lb)

* 990 kg per m^3 (61.8 lb per cu. foot); ASAE[8]

corrections were made to the manure volume. Thus, manure production was statistically analyzed only for the summer trial (Table 2). Use of the wet/dry feeder resulted in a 29.3% reduction (P <.1) in daily manure volume compared to the dry feeders and nipple drinkers.

Experiment Two

Within 2 days of initiating this experiment, all pigs were coughing severely and a consulting veterinarian diagnosed pneumonia caused by *Mycoplasma hyopneumoniae*. An intensive water medication program was initiated. Although death loss was minimal (Table 3), the within-pen variation in performance increased, as did the number of pigs removed from the experiment due to poor performance.

Overall, drinker type had no effect (P >.10) on daily gain, feed intake, feed conversion efficiency, carcass lean, or lean growth (Table 3). Drinker type had no effect on the uniformity of gain as measured by coefficient of variation of within-pen weights when the first pigs were removed for slaughter on day 103 of the experiment.

Total water use was reduced by 11.1% for the swinging drinker compared to the conventional drinker (P <.05). Manure volume is reported through day 103 of the experiment (Table 2). From study days 103–117 a leak in the water line where it entered one of the facilities through the manure storage pit for one treatment went undetected. Water disappearance for the period remained valid since the leak was prior to the water meters for each drinker type. For the first 103 days of the experiment, manure volume was reduced 13.7% (P <.05) for the swinging drinker versus the conventional drinker.

Experiment Three

Although drinker type had no effect on uniformity of weight within a pen or ADG, pigs on the bowl drinkers ate less feed (P <.01), resulting in a trend to improvement in feed conversion efficiency (P <.1; Table 4). Pigs on the bowl drinkers used 25% less water (P =.057) than pigs on the swing drinker. Manure production is not reported due to apparent errors in pit depth measurements. The effect of drinker type on carcass data is not reported due to the packer's failure to provide information on one delivery of pigs.

Water:Feed Ratio

Water:feed ratios (W:F) were calculated as kg of water per kg of feed disappearance for all experiments (Figure 2) using a water density of 1 kg per L. In Experiment One,

Table 3: Effect of drinker type on performance, Experiment Two

Item	Drinker type: Swing	Nipple	SEM	*P* values
Number of pens	6	6		
Pig weight, kg				
Initial	18.2	18.3	<.1	
Final	110.0	109.9	.5	Not significant (NS) (P>.1)
CV *	9.7	10.0	.4	NS
ADG, kg	.754	.748	.008	NS
ADFI, kg	2.302	2.307	.028	NS
Gain:feed	.324	.327	.003	NS
Carcass lean,†	52.3%	52.2%	.5%	NS
Lean gain, kg/d †,‡	.313	.313	.004	NS
Pigs dead or removed	3.3%	2.1%		NS
Water, L x pig^{-1} x day^{-1} §	4.90	5.50	.04	.058
Water:feed, kg:kg §	2.34	2.64	<.01	.003
Manure production, L x pig^{-1} x day^{-1} §¶	3.96	4.59	.41	.018

* CV=Coefficient of variation of within pen weight when first pig removed for slaughter
† containing 5% fat
‡ equation of NPPC (1991)
§ represents two observations per feeder type
¶ through d 103 of experiment

pigs on the wet/dry feeders had a lower W:F than pigs on the dry feeder system for every time period reported. The first two time periods (19–34 kg) had higher (P <.01) W:F than the last three on both drinker types. For the overall experiment, pigs on wet/dry feeders used 1 kg of water less per kg of feed than did pigs on the conventional system (P <.005; Table 1).

In Experiment Two, W:F was always significantly different (P <.001) between drinkers for every time period reported (Figure 2). Overall, pigs on the swing drinker used 0.3 kg less water per kg of feed than pigs on the nipple drinker (P <.005; Table 3).

In Experiment Three, there was an interaction (P <.01) between drinker type and observation period. Water:feed ratios remained relatively constant for the bowl drinker, but fluctuated for the swing drinker (Figure 2).

The overall W:F ratio was lowest for the wet/dry feeder (1.78; Experiment One) and similar to the bowl drinker (1.89; Experiment Three). The swing drinker had similar overall ratios in Experiment Two (2.34) and Experiment Three (2.41).

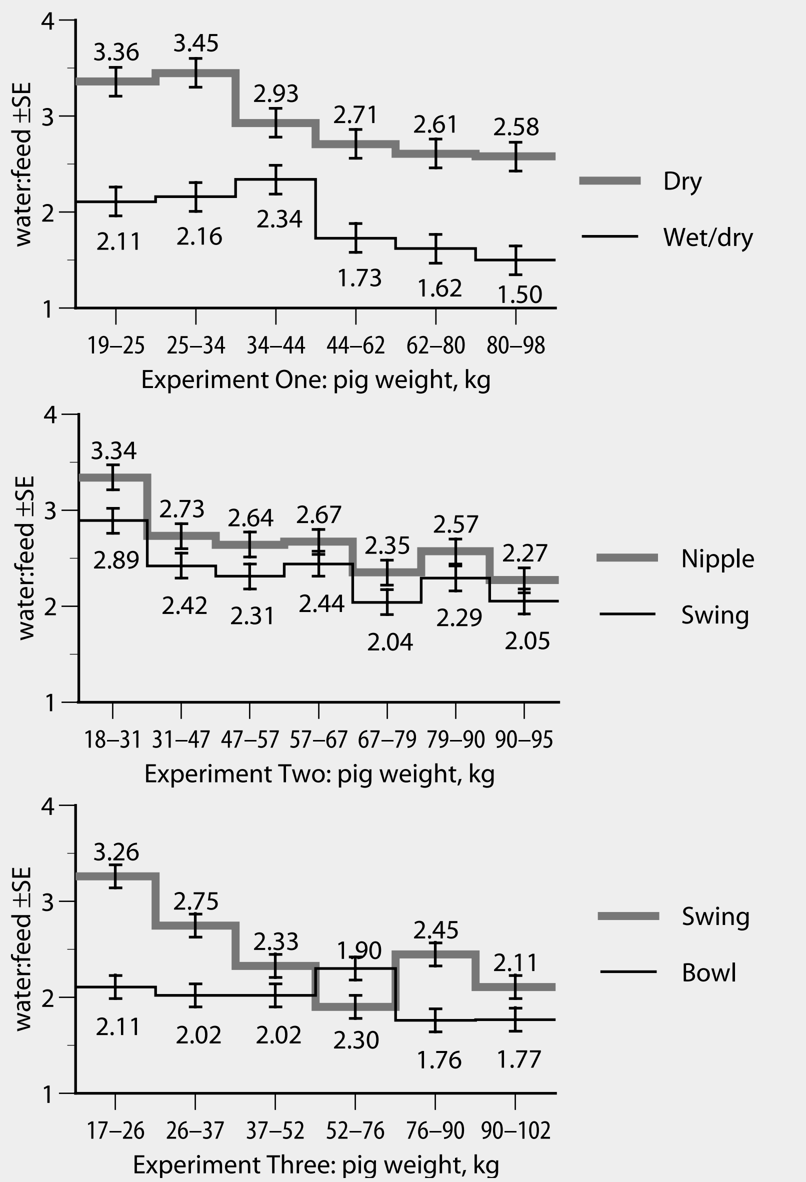
Table 4: Effect of drinker type on performance, Experiment Three

Item	Drinker type: Swing	Drinker type: Bowl	SEM	*P* values
Number of pens	6	6		
Pig weight, kg				
Initial	17.5	17.4	.1	
Final	115.1	113.9	.5	Not significant (NS) (P>.1)
CV *	8.8	8.8	.4	NS
ADG, kg	.831	.820	.005	NS
ADFI, kg	2.118	2.043	.014	.006
Gain:feed	.392	.401	.003	.090
Pigs dead or removed	0.8%	2.5%		NS
Water, L x pig^{-1} x day^{-1} †	5.01	3.78	.08	.057
Water:feed, kg:kg †	2.41	1.89	<.01	.005

* coefficients of variation of within pen weight when first removed for slaughter

† represents two observations per feeder type

Figure 2: Impact of drinker device on water usage for Experiments One, Two, and Three



Discussion

Feed wastage, assessed by visual observation, was not considered a problem in any feeder type in any of the experimental pens. During the winter trial (Experiment One), coarse-ground feed was delivered once from the commercial feed mill, making adjustment of the wet/dry feeders difficult; once the feed milling problem was corrected, no further feeder management difficulties were observed.

Patterson[10] reported that use of a wet/dry feeder improved ADG but had no effect on average daily feed intake (ADFI), gain:feed, or carcass characteristics. In a subsequent experiment, he reported that feeder type had no effect on pig performance.[11] Walker[12] also observed that a wet/dry feeder had no effect on feed conversion, but did report that use of this type of feeder improved ADFI and ADG and increased P2 backfat. Young and Lawrence[13] concluded that pigs can adapt to the physical and social constraints imposed by a feeding system by altering aspects of their feeding behavior. This supports the lack of major performance differences we observed between feeder types in Experiment One, suggesting that the appropriate range of feeder designs and stocking densities in swine facilities may be wider than the recommended four to five pigs per feeder space.[7]

In observations consistent with ours in Experiment One, Maton and Daelemans[14] concluded that all wet feeders included in their experiments reduced water spillage so that water consumption was only 70%–80% of that observed from conventional feeders and nipple drinkers. In addition, slurry (manure) volume was reduced by 20%–30% in their study.

Miyawaki, et al.,[15] reported that growing-finishing pigs with access to a wet/dry feeder similar to that used in Experiment One had a faster eating speed than pigs given access to conventional dry feeders with separate drinkers, resulting in reduced eating time per pig. As the number of pigs per space increased from five to 15, both total and average eating time decreased. For the wet/dry feeder investigated, they concluded that a reasonable number of finishing pigs per feeding space is eight to ten.[16] The stocking density in Experiment One was 12 pigs per feeder space.

Our observation in Experiment One that season did not interact with feeder type is in contrast to the results of Miyawaki, et al.,[17] who reported that water disappearance in a summer experiment was greater using a conventional system, (16 L per pig per day) than that using a feeder similar to the wet/dry feeder we used in Experiment One (7.5 L per pig per day). However, they observed no effect of feeder type on water disappearance in a winter experiment (5.9 versus 6.2 L per pig per day).

Estimates of total water use by growing-finishing pigs are limited and varied.[1,4,7] For pigs between 20–90 kg (44–198 lb) BW, the NRC[4] recommends a minimum requirement of approximately 2 kg (1.9 gal) of water for each kg (2.2 lb) of feed (water:feed ratio). In Experiments One and Three, mean W:F did not reach these recommended values and declined for all delivery devices investigated in all experiments as pigs grew (Figure 2). The NRC[4] estimate makes no mention of a possible interaction between BW and W:F. Our results are also inconsistent with the observations of Crumby,[18] who noted that the voluntary W:F for growing pigs that were allowed ad libitum access to feed was about 2.5:1. Mount, et al.,[19] reported W:F of 2.1:1 for 37-kg (81-lb) pigs, 5.0:1 for 50-kg (110-lb) pigs, and 2.2:1 for 73-kg (161-lb) pigs fed ad libitum, contradicting our observations that W:F decreases as pigs grow.

Brumm, et al.,[5] reported manure production values for growing-finishing pigs offered ad libitum feed from 14–91 kg (31–200 lb) BW and nipple drinkers similar to those used in Experiments One and Two to average 5.7 kg (12.5 lb) per pig per day. The ASAE[8] cites an average value of 84 kg ± 24 kg (185 lb ± 53 lb) manure (feces and urine only) production per 1000 kg (2200 lb) liveweight per day. The Nebraska DEQ[20] uses an estimate of 62 kg per 1000 kg (136 lb per 2200 lb) liveweight plus 20% for spillage and washwater or 74 kg per 1000 kg (163 lb per 2200 lb) liveweight.

One possible explanation for the differences in manure production noted between our results and other reports is a difference in feed conversion efficiency. In the studies included in the data by Brumm, et al.,[5] mean gain:feed in 14–91 kg pigs (31–200 lb) were .302[21] and .289.[22] These are lower than the .333 average we observed in Experiment One, the .325 average in Experiment Two, and the .397 average in Experiment Three. In these experiments, the improved feed conversions occurred even though final weights were 10–15 kg (22–33 lb) heavier. These results suggest that feed conversion has improved due to improvements in genetics, nutrition, and equipment design, and that manure production has decreased, and that the estimates used by regulators[20] and designers[8] of manure storage facilities have not been modified to properly account for this evolution.

Currently, the Midwest Plan Service (MWPS)[7] estimates total daily water needs at 11.4 L (3 gal) per growing pig and 15.1 L (4 gal) per finishing pig. When combined with their manure production estimates, this is a water:manure ratio (water volume ÷ manure volume) of 2.9 for the growing pig and 2.2 for the finishing pig. In Experiment Two, the ratio was < 50% of these MWPS[7] estimates. In these experiments, overall water use and manure volume does not include washwater, which can partially account for why the recorded values are lower than those used to design the manure storage facilities. However, washwater almost always enters the manure storage device at a ratio of 1:1. Thus, it seems that current estimates of daily manure volume in the literature are too high, even when additional water needs for facility cleaning are included in the estimate.

Implications

- Water use and manure volume ranges widely depending upon feeder and drinker type.
- Decisions regarding drinker device selection have a major impact on water use and manure production.
- Differences in pig performance that could be attributed to feeder and drinker type were minimal.
- We observed lower amounts of total water use and manure production than reported elsewhere in the literature or suggested by regulatory officials.

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