Understanding Feeders and Drinkers for Grow-Finish Pigs

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Ad libitum feed and water access is the goal of most North American production facilities. Attention to the many details involved in feeder and drinker selection is the first step in attaining this goal.

Number of Feeding Spaces

Traditionally, advisors to the swine industry have recommended one feeding space per four pigs for the growing pig and one feeding space for four or five pigs for the finishing pig (MWPS, 1991). However, this recommendation makes no mention as to the dimensions of the space, the location of the space within the animal's environment, or other factors that influence the growing pig's interaction with the feed delivery device. Australian guidelines are somewhat more specific by recommending one space for four growing pigs with the space recommended to be 250 mm in length (Farrin, 1990). The European recommendation is one space per four pigs with the space averaging 59 mm/pig for 50-kg pigs and 74 mm/pig for 100-kg pigs (English et al, 1988).

Research on feeder space allocations is surprisingly limited. Wahlstrom and Seerley (1960) concluded that one feeder space per six pigs within the weight range for 30 to 91 kg was probably adequate. Using 12 pigs per pen, Wahlstrom and Libal (1977) concluded there was no difference in performance when three, four, or six pigs were allotted for each available feeder space when wooden feeders were used as the feed delivery device for pigs from 28 to 70 kg.

McGlone et al (1993) provided one, two, or three feeder spaces for 20 pigs per pen from 61 to 104 kg live weight. Using a meal diet, they concluded that the feeder space requirement is one space per ten pigs. Bates et al (1993) in a study at a commercial swine finishing unit, also concluded that growing-finishing pigs can be stocked at a rate of ten pigs per feeder hole.

Morrow and Walker (1994) recommended that two, single-space feeders be used in pens of 20 finishing pigs when meal diets are available ad libitum. They also recommended that the feeders be sited some distance apart (> 2 m), not side by side when pigs are provided 0.60 m^2 per pig pen space from 37 to 91 kg live weight. Growing pigs in this study showed a clear feeder preference, with a higher proportion of feed consumed from the feeder nearest the service passage.

Quality of Feeding Spaces

Although many feeders have some type of feeder space division, they may not accurately reflect the true space requirements. Baxter (1991) suggested that the minimum width of a feeding space should be the shoulder width of the pig, plus 10% to accommodate pig variability and movement. The shoulder width of a pig, in centimeters, is approximately $6.1 * BW^{0.33}$, with body weight expressed in kilograms (Petherick, 1983). Thus, the width of feeder spaces for 5-, 25-, 50-, and 120-kg pigs would be 11.1, 19.8, 24.8, and 32.8 cm, respectively.

Baxter (1991) also examined the preference of pigs to eat at different heights. Although pigs prefer to eat from a surface at or slightly above floor level, they can eat from levels as high as their shoulders. Some feeders may have an elevated feeding surface or feed access lever, which could limit feeding if these exceed shoulder height. Elevated feeding surfaces usually require pigs to stand at an angle to the feeder and rotate their heads when eating (Gonyou and Lou, 1998).

The depth of the feeder, from the lip at the front of the feeder to the feed access point at the back, determines the extent to which pigs will step into the feed bowl or trough while eating. When feeder depth was only 20 cm, approximately 50% of 20 kg pigs would step into the feeder while eating. For 95-kg pigs, none would step in at feeder depths of 20 cm, < 20% at a depth of 30 cm, and all of the pigs would when the depth was 40 cm (Gonyou and Lou, 1998). However, large pigs (95 kg) have difficulty eating from an area closer than 20 cm from the front of the feeder.

A compromise in feeder depth is needed when feeders are used over a wide range of pig body weights. Gonyou and Lou (1998) suggest that feeder depths for growing-finishing pigs should be 20 to 30 cm.

All of the design concepts discussed above assume that the pig is standing at right angles to the feeder. However, when pigs are allowed to eat feed placed on the floor along a wall, they stand at an angle of approximately 30^{o} from the vertical surface (Gonyou and Lou, 1998). Such a position may facilitate apprehension of the feed. It may be advisable to consider designs that provide such an angle to the feed access point.

Feeder Design and Feed Wastage

The movements associated with feed falling onto the floor (feed wastage) were studied by Gonyou and Lou (1998). The most common movements associated with feed wastage were backing away from the feeder, eating while the head was raised, fighting, and stepping into the feeder. Two of these behaviors, fighting and stepping, were more common for smaller pigs that also waste a higher percentage of feed. Fighting was more common among smaller pigs as some of the feeders studied had wider feeder spaces than recommended and two pigs would eat from the same space. As indicated above, when feeders have depths exceeding 20 cm, as required for large pigs, small pigs must step into the feeder while they eat. The compromise required when a wide range of pig sizes are fed from the same feeder results in greater wastage by the smaller pigs.

Table 1 summarizes the critical dimensions for feeder design when the feeders will be used where pigs are given ad libitum feed access.

Wet/Dry Feeders

An alternative to dry feed presentation is to allow pigs to access both water and dry feed from the feeder, with the option to combine them before consumption. This is referred to as a wet/dry feeder. Various methods are used to provide access to feed in these feeders. Some feeders allow access to dry feed on an elevated platform or shelf. The pigs may eat from this shelf or push the feed into the bottom pan of the feeder where it can be combined with water. Another method of accessing dry feed is to press a lever or bar that drops feed into the feeder pan. Water is normally available from a nipple that may be oriented downward or horizontally. A key feature to wet/dry feeders is that there is a separation of the water from the access point of the dry feed. Otherwise the water will "wick" into the feed storage and plug the feeder.

Walker (1990) reported an increase in daily gain and feed intake when water was available at the feeder versus located 3 m distant from the feeder. Patterson (1991) reported no benefit to pig performance for wet/dry feeders.

The decision on wet/dry feeders versus dry feeders and nipple drinkers located at a distance from the feeder is often based on issues not related to pig performance. Gadd (1988) summarized a series of on-farm experiences and concluded that slurry production was reduced as much as 50% with wet/dry feeders versus dry feeders. Maton and Daelemans (1992) concluded all wet-dry feeders reduce water spillage, resulting in a 20 to 30% reduction in slurry volume. Brumm et al. (2000), using a two-hole wet-dry feeder for 24 pigs per pen also reported a 30% reduction in slurry volume.

Both Rantanen et al (1995) at Kansas State University and Brumm et al (2000) at the University of Nebraska report a significant reduction in daily water use for pigs on wet/dry feeders vs dry feeders and nipple drinkers separate from the feeder. The Kansas workers reported total water disappearance of 6.25 L/pig/d for the dry feeders vs 4.16 L/pig/d for the wet/dry feeder from 48 to 83 kg live weight. The Nebraska workers reported total water disappearance of 6.06 L/pig/d for the dry feeders versus 4.50 L/pig/d for the wet/dry feeders from 19 to 108 kg live weight.

Several studies have indicated that one model of wet/dry feeder resulted in increased intake compared to a particular dry feeder (Anderson et al., 1990; Walker, 1990). In a summary of several on-farm tests, Payne (1991) concluded that the wet/dry feature resulted in increased growth but no increase in apparent feed intake. However, he suggested that the level of feed wastage may have been less in wet/dry feeders and that actual intake may have been higher. Gonyou and Lou (2000) compared feed intake and growth from six models of wet/dry feeders with that of six models of dry feeders. The wet/dry feature resulted in a 5% increase in both feed intake and growth rate.

Water

Water is the nutrient that is required in the largest quantity by swine. Compared to the nutrients supplied by feed, it is the most frequently misunderstood and mismanaged nutrient. While various sources recommend that water be available free choice, most fail to offer specific recommendations as to number of drinking spaces, drinker type, delivery rates of drinkers, or to specify quality parameters.

In contemporary production facilities, decisions must be made concerning all of the above. In addition, the costs of water acquisition and the storage and disposition of wasted water has led to an increased desire to better understand the water availability needs of pigs.

At birth, water accounts for 82% of the pig's empty body weight. By the time the pig weighs 240 pounds, water comprises only 51% of the empty body weight (Shields et al., 1983). In addition to body tissue and metabolic functions, water is used for: a) the adjustment of body temperature; b) the maintenance of mineral homeostasis; c) the excretion of the end products of metabolism (particularly urea); d) the achievement of satiety (gut fill); and e) satisfaction of behavioral needs (Brooks et al., 1989).

Major sources of water for physiological needs, including growth, reproduction, and lactation are water from feedstuffs, water from metabolic processes, and drinking water. As a practical matter, drinking water is the major water source (Thacker, 2001).

Nursery and Grow-Finish Drinkers

Water consumption for growing-finishing pigs has a distinct periodicity with a peak at the beginning and at the end of the feeding period when nose-operated drinkers are used. Water consumption between feeding periods peaked two hours after the morning feeding and one hour after the afternoon feeding (Olsson and Andersson, 1985). Weaned pigs housed under conditions of constant light, showed a diurnal pattern for water intake with higher consumption recorded from 0830 to 1700 hr as compared to the 1700 to 0830 hr time period (Brooks et al, 1984). Grow-finish pigs using nipple drinkers showed a large peak from 1500 to 2100 hr, and a smaller peak between 500 and 1100 hr (Korthals, 1998).

Water consumption by nursery and grow-finish pigs has a distinct pattern within a 24-hour period. While there is very good evidence that a majority of water consumption is associated with eating activities in research settings, there is limited data on patterns of water usage in commercial facilities. Figures 1, 2 and 3 document the pattern of water use in wean-finish facilities at 3 locations in Nebraska and Minnesota. These facilities vary in the number of pigs per pen, the type of feeder and drinker, the type of ventilation, relative pig health, etc. The patterns were recorded over a 7-day period 4.5 to 5 months after weaning.

The similarities between the winter and summer patterns at the 3 sites suggests 2 patterns of water usage exist, depending on the temperature in the facility (i.e. time of the year). In thermal-neutral conditions (generally air temperatures in the pig zone <27^0 C), grow-finish pigs begin drinking water around 5 to 6 am, with a peak in drinking water disappearance in early afternoon and a gradual decline the remainder of the day. This pattern is in agreement with published literature (Olsson and Andersson, 1986; Korthals, 1998).

However, when pigs are growing in warm to hot conditions (air temperatures in the pen exceeding 27^0 C for one or more hours per day), they appear to alter their pattern of drinking water usage. Pigs begin drinking earlier in the day, with a morning peak from 8 to 9 am. There is a decline in drinking water use mid-day with a second peak in drinking water use from 5 to 8 pm followed by the decline into the night hours.

It is interesting to note that pigs shift to this pattern of drinking water use on the first day of air temperatures in the pig zone >27^0 C or so and maintain the pattern for 3 to 5 days, even if these subsequent days have temperatures considered to be thermal-neutral. This adaptation is often maintained for several days in anticipation that the heat stress event will be longer than a single day. This suggests that a shift in eating and drinking behavior is one of the first adaptations of the growing pig to heat stress. In the future, it may be possible to use this shift in drinking water usage as a predictor of a performance reduction due to heat stress in grow-finish pigs.

In addition to detection of heat stress and potential disease outbreaks, automatic logging of drinking water usage every 15 minutes has allowed for the detection of water leakage from drinkers in nursery and grow-finish facilities. That is, if drinking water usage is being logged every 15 minutes, there should be one or more 15-minute periods each day (generally midnight to 2 am) when there is no water usage logged. If water usage is logged for every recording period it is likely that one or more drinking devices are leaking, resulting in wasted water going into manure storage devices.

The number of pigs in a group (pen) apparently influences water usage. In one study water usage was higher when pigs were housed in groups of 60 versus 20. Total drinking time per pig decreased when group size increased, even though the number of pigs per drinker was the same for both group sizes (Turner et al., 1999).

Water:feed ratios for liquid feeding systems typically range from 2.5:1 (English et al, 1988) to 3.5:1 (Brooks, 1986). Recently, water:feed ratios ranging from 1.78:1 to 2.79:1 for pigs weighing from 18 to 114 kg and fed dry feed ad libitum have been reported (Brumm et al, 2000). The lowest reported water:feed ratios were with wet/dry feeders and bowl drinkers whereas gate-mounted nipple drinkers had the highest ratios. With similar performance, this suggests that the major cause of differences in water:feed ratios between the various drinking devices is due to differences in water wastage, not differences in the amount consumed.

Water:feed ratios decrease as pigs grow (Brumm et al, 2000). For example, in two experiments, water:feed ratios with gate-mounted nipple drinkers were 3.35:1 for 18 to 23 kg pigs, declining to 2.27:1 and 2.58:1 for 95 kg pigs. When pigs were given water only in the feeding trough using a commercially available wet/dry feeder, water:feed ratios declined from 2.11:1 to 1.50:1 and when pigs were offered water using a bowl drinker the ratios declined from 2.11:1 to 1.77:1. Recent on-farm data [M.C. Brumm, unpublished data] supports the conclusion that water:feed ratios decline as pigs grow, with a ratio as low as 1.5:1 common in facilities that use wet/dry feeders or stainless steel bowl drinkers in late finishing.

Assuming similar water:feed ratios for both barrows and gilts, it follows that barrows drink more water than gilts (Van der Peet-Schwering and Plagge) since barrows eat more feed per day than gilts in mid to late finishing (Reese et al, 2000). Pigs fed meal diets drink more water than pigs fed pelleted diets (Laitat et al, 1999), reflecting similar water:feed ratios and differences in feed conversion efficiency.

General recommendations exist for the number of pigs per drinking device (MWPS, 1983), but research to support these recommendations is limited. Researchers using 3- to 4-week-old weaned pigs reported a slight reduction in average daily gain and an increase in weight variation within pens of 16 pigs given access to one versus two nipple drinkers for 5 weeks post weaning (Brumm and Shelton, 1986). Generally, for groups larger than 10 pigs in a nursery and 15 to 20 pigs in a grow-finish facility, a minimum of two delivery devices is recommended (MWPS, 1983; Brumm and Reese, 1992).

Grow-finish pigs spent from 3 to 16 minutes per day at nipple drinkers when flow ranged from 1100 ml/min down to 100 ml/min (Nienaber and Hahn, 1984). This suggests pigs will exert some extra effort in order to obtain water. But it is not clear at what point having to wait for drinker access or exert extra effort impairs performance.

Water and Manure issues

In addition to consideration of providing for the pigs needs, decisions on water delivery devices increasingly include manure storage and land application issues (Massabie et al, 1992). Researchers have demonstrated no difference in pig performance between grow-finish pigs when water was provided in a wet/dry feeder versus when water access was via a gate-mounted nipple drinker (Brumm et al, 2000). Yet, total manure production was reduced 30% for the wet/dry feeder in a summer trial. In a winter trial, a 14% decrease in manure volume occurred with a swinging drinker versus a gate-mounted nipple drinker, and a 25% decrease in water usage when comparing a stainless-steel bowl drinker to a swinging drinker.

Production systems that store manure in deep pits under fully slatted floors are selecting drinker devices that limit the amount of water wastage (and resultant manure volume) in order to increase the amount of available manure storage capacity. Water usage is in the range of 4 liters per grow-finish pig per day with wet/dry feeders and bowl drinkers and 6 liters per pig per day with gate-mounted nipple drinkers. Manure production patterns follow water usage (Brumm et al, 2000; Christianson et al, 2002).

While manure volume varies with water wastage, the amount of total nutrients (N, P, and K) in the manure does not vary. Even though there is less total volume of manure to deal with when drinkers that minimize water wastage are used, the total amount of land needed for responsible land application of the collected nutrients does not vary, just the amount applied per acre. In addition, when water wastage is minimized, the stored manure can have dry matter concentrations as high as 8 to 10%. This compares to manure in deep pits with nipple drinkers having dry matter concentrations in the range of 3 to 4%. This difference in dry matter content means different equipment may be needed to agitate, load, and apply the liquid manure depending on the drinking device.

In production systems where manure is stored in a lagoon and applied with irrigation devices, water savings associated with drinkers are of less concern. In fact, water wastage from drinker devices may make manure flow easier through pipes to the lagoon. Moreover, the waste water contributes to a more dilute lagoon effluent, reducing the risk of odors from the manure storage device.

Water Medication Issues

Another criteria considered in the selection of drinking devices is water medication expenses. A 50% reduction in medication expense was reported when sulfadimethoxine was administered in drinking water via bowl drinkers versus swinging nipple drinkers for a four-day period (Brumm and Heemstra, 1999). Similar data has been reported for differing types of drinkers (Almond, 2002). With no differences in pig performance between drinker types, it is logical to assume that intake per pig was similar, and the difference is overall drug usage was due to wastage. Producers should not alter drug dosage dependent on type of water delivery device. An increasing number of producers who use contract nursery and grow-finish facilities are requiring facility owners to install water saving drinker devices in order to reduce drug and vaccine expenses for water-administered products.

As swine facilities house more pigs, problems related to water medication devices have increased. This is primarily due to issues associated with water medicator attachments to water supply lines. Most commercially available water medicators in the United States are equipped with a garden- hose bib for attachment to water supply lines. For many facilities, this means the19 mm inside diameter or larger supply line must be reduced in size (and flow) at the point of medicator attachment. In some situations, producers have purchased washing machine supply hoses (12 mm inside diameter) to attach medicators, which further restricts water flow.

Flow Rate Recommendations

How fast does water need to flow from drinking devices? The drinking speed of grow-finish pigs was 1,422 ml of actual water intake/min at a nipple drinker flow rate of 2,080 ml/min (Li et al, 2005). This was a 23.2% spillage rate versus an 8.6% spillage rate when the flow was 650 ml/min.

A minimum delivery rate of over 250 ml/min was advised for grow-finish pigs and the rate of 1,000 ml/min appears to be more than adequate (Brumm and Mayrose, 1991). Research results support the conclusion that one nipple drinker per 16 to 22 pigs is inadequate (Brumm and Mayrose, 1991). These results are in contrast to the conclusions that providing one versus two nipple drinkers per 20 grow-finish pigs does not affect drinking behavior, social behavior or production (Turner et al, 1999). Flows of 70 ml/minute for lactating sows decreased overall performance when compared to flows of 750 ml/min (Leibbrandt et al, 2001). Flows as low as 70 ml/min did not affect weaned pig performance (Thulin et al, 1990).

Table 2 lists the recommended flow rates by class of pig for drinking devices in swine facilities. There is no data available to suggest that flow rates differ between nipple drinkers, bowl drinkers, tube feeders, etc.

Another often overlooked restriction in water delivery systems is the installation of a pressure regulator. Manufacturers of wet/dry feeders often recommend pressure reductions to 70 kPa for the water supply lines and other drinker devices are often installed with line pressures of 140 kPa. The intent of these lower pressures is to reduce the effort required by the pig to activate the delivery devices, making wastage less likely.

However, changes in pressure change flow. The formula to compute the impact of a change in pressure on flow is (W. Kranz, University of Nebraska personal communication):

$$\sqrt{(P_1 / P_2)}$$

Thus, if the supply pressure to the facility is 280 kPa and the pressure reducer is set to 140 kPa, the resulting flow rate is 71% of what it was at 280 kPa. At 70 kPa versus a supply pressure of 280 kPa, the flow rate is 50%. Conversely, if you double the pressure (go from 140 kPa to 280 kPa), the flow increases only 41%, assuming there aren't other limits to flow in the delivery system. A general recommendation is that water pressure in drinking supply lines be limited to 140 kPa. This makes activation of delivery devices (paddles, nipples, etc) easier and tends to reduce water wastage from drinking devices.

Number of drinkers

In Table 3 are listed the number of pigs recommended per drinker and suggested drinker height when gate-mounted nipple drinkers are utilized (MWPS, 1983). Note that these height recommendations are appropriate for nipple drinkers mounted at a 90º angle. When mounting brackets with 45º angles are utilized, greater heights are necessary in order for the pig to manipulate the drinker and minimize water wastage. When swinging drinkers are used, it is recommended that they be adjusted to a height of 5 to 7.5 cm above the back of the pig every 2 to 3 weeks as the pigs grow.

With wet/dry feeders, the general recommendation is up to 12 pigs per feeder space. There is no data available to suggest an appropriate stocking density for tube feeders or bowl drinkers. Many manufacturers recommend no more than 20 to 25 pigs per bowl drinker.

Water Supply Issues

In addition to drinking water needs, water must be available for cleaning and other uses. As swine facilities have grown in size, issues associated with sizing of water supply lines have become more critical.

For example, consider designing the water delivery system for a 1000 head finishing facility that has 20 pens on each side of a center aisle. Each pen will have two nipple drinking devices. If all of the nipples on one side of the aisle are being used at the same time, this would be 40 drinkers that must be supplied with water. Assuming 1000 ml/min flow from each drinker (Table 2), total water flow from the supply line would need to be 40,000 ml/min (1000 ml/min x 40 drinkers). If the water flow were any less than this, there is the chance that one or more drinkers would have reduced or even no flow when a pig attempted to drink.

Water supply lines should be sized to have friction losses less than 7 kPa per 32 m of pipe and flow velocities less than 1.2 m per second (MWPS, 1997). This means that in order to supply 40,000 ml per minute the pipe needs to have an inside diameter of 2.5 cm.

Water as a predictor of performance

With the introduction of water recording devices, producers are becoming aware of the relationship of drinking water usage and animal health (Pedersen and Madsen, 2001). Figure 4 depicts the impact of swine flu on daily water disappearance in a fully slatted 860 head finishing facility in Nebraska 6 weeks after pig placement. The advantage of recording daily water use versus trying to record daily feed disappearance is that water meters are readily available and if water delivery devices are well-maintained, water will generally always be available to pigs.

Which changes in the pattern of daily water usage are the best predictor of pig health and performance is still unclear. Based on producer and veterinarian observations, when daily water usage drops for three continuous days, or drops more than 30% from day to day, this may indicate that a potential health challenge is occurring in the production facility. These changes in usage pattern should serve as an indication to the caregiver to look more closely at the pigs for signs of illness or discomfort. A spreadsheet to create barn sheets for the purpose of charting daily water patterns is available at: http://porkcentral.unl.edu.

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Table 1. Critical design dimensions for single and multi-spaced grow-finish feeders – ad libitum feed access.

Feeder space width	300-360 mm
Feeder lip height	100-125 mm
Feed trough depth	
Lip to delivery mechanism	200-300mm
Number of pigs per space	
Dry feeder	10
Wet/dry feeder	12

Table 2. Recommended flow rates for swine drinkers.

Class of swine	ml/min
Nursery (5-25 kg)	250-500
Grow-Finish (20-130 kg)	500-1000
Breeding Herd	1000

Table 3. Nipple drinker stocking and height recommendations (MWPS, 1993)

Pig Wt	Pigs/nipple	Nipple Height, cm
5-14 kg	10	15-30
14-34 kg	10	30-45
34-57 kg	12-15	45-60
57 kg+	12-18	60-75
Breeding Herd	15-15	75-90

Figure 1. Effect of season on 24-hour water usage pattern in a 1200 head wean-finish facility 5 months after weaning in central Nebraska. Data courtesy Dicamusa.com.

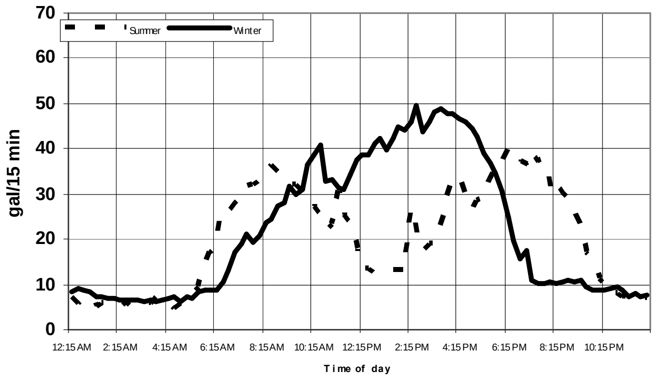

Figure 2. Effect of season on 24-hour water usage pattern in a 600 head fully slatted wean-finish facility in Southeast Minnesota when pigs averaged 89 to 95 kg bodyweight. Data courtesy Herdstar.com.

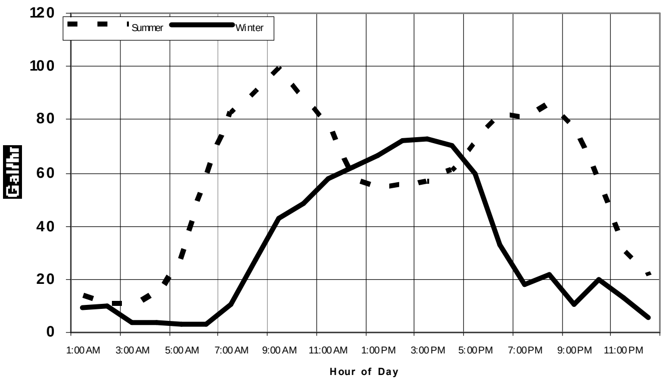

Figure 3. Effect of season on 24-hour water usage pattern in a wean-finish facility in eastern Nebraska 4.5 months after weaning. Data courtesy Dicamusa.com.

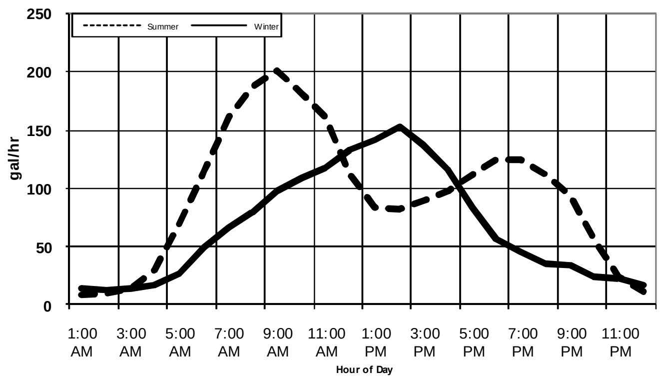

Figure 4. Impact of swine flu on daily water usage in a 860 head fully slatted finishing facility in Nebraska. Data courtesy Dicamusa.com.