Number of visits and length of each visit to a nipple cup drinker by 7-week-old pigs after a water deprivation period or ad libitum access to water

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Summary

Objective: To determine how quickly all pigs visited the nipple cup drinker, the number and duration of visits, and water disappearance when water was restored after a 15-hour withholding period.

Materials and methods: A total of 184 seven-week-old pigs, identified with unique numbers, were commercially housed (23 pigs per pen), with one stainless steel nipple cup drinker per pen. Two treatments were compared in a crossover design: withheld (WH; four pens), pigs did not have access to water for 15 hours, and control (C; four pens), pigs had ad libitum access to water. One camera was positioned over each drinker to record visits lasting ≥ 5 seconds between 7:00 AM and 1:00 PM on 2 consecutive days. One meter was installed on each water line to record water disappearance.

Results: All pigs from both treatments visited the nipple cup drinker during the 6-hour observation period. Control pigs made fewer total visits and spent less time at the nipple cup drinker than WH pigs ($P < .05$). The WH pigs spent longer at the water nipple and visited more often than the C pigs only for the first hour after water was restored ($P < .05$). Water disappearance was greater for the WH pigs ($P < .05$).

Implications: Under the conditions of this study, all pigs were able to visit the nipple cup drinker between 7:00 AM and 1:00 PM; thus, withholding water for 15 hours to encourage consumption of medicated water is not recommended.

Keywords: swine, water withholding, behavior, nursery

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Resumen - Número de visitas y duración de cada visita al bebedero de tazón de cerdos de 7 semanas de edad después de un periodo de privación de agua o un acceso ad libitum de agua

Objetivo: Determinar que tan rápido visitaron todos los cerdos el bebedero de tazón, el número y duración de las visitas, y la desaparición de agua cuando se resutituyó el agua después de un periodo de privación de 15 horas.

Materiales y métodos: Un total de 184 cerdos de 7 semanas de edad, identificados con números únicos, se alojaron comercialmente (23 cerdos por corral), con un bebedero de tazón de acero inoxidable por corral. Se compararon dos tratamientos en un diseño cruzado: privación (WH; cuatro corrales), los cerdos no tuvieron acceso al agua por 15 horas, y control (C; cuatro corrales), los cerdos tuvieron acceso ad libitum al agua. Se posicionó una cámara sobre cada bebedero para registrar las visitas que duraron ≥ 5 segundos entre las 7:00 AM y 1:00 PM durante 2 días consecutivos. Se instaló un medidor en cada línea de agua para registrar la desaparición de agua.

Resultados: Todos los cerdos de ambos tratamientos visitaron el bebedero de copa durante el periodo de observación de 6 horas. Los cerdos control realizaron menos visitas totales y pasaron menos tiempo en el bebedero de copa que los cerdos WH ($P < .05$). Los cerdos WH pasaron más tiempo en el bebedero y lo visitaron más seguido que los cerdos C sólo durante la primera hora después de que se restauró el agua ($P < .05$). La desaparición de agua fue mayor para los cerdos WH ($P < .05$).

Implicaciones: Bajo las condiciones de este estudio, todos los cerdos fueron capaces de visitar el bebedero de tazón entre las 7:00 AM y 1:00 PM; por tanto, retener el agua durante 15 horas para alentar el consumo de agua medicada no es recomendable.

Résumé - Nombre de visites et durée de chaque visite à un abreuvoir à tétine par des porcelets de 7 semaines après une période de privation d'eau ou un accès ad libitum à l'eau

Objectif: Déterminer la rapidité à laquelle les porcs visitent l'abreuvoir à tétine, le nombre et la durée des visites, et la disparition de l'eau lorsque l'eau a été restaurée après une période de retrait de 15 heures.

Matériels et méthodes: Un total de 184 porcs âgés de 7 semaines, identifiés individuellement, ont été hébergés dans une bâtisse conventionnelle (23 porcs par enclos), avec un abreuvoir à tétine en acier inoxydable par enclos. Deux traitements ont été comparés dans un plan alterné: privation (WH; quatre enclos), les porcs n'avaient pas accès à l'eau pour une durée de 15 heures, et témoin (C; quatre enclos), les porcs avaient accès ad libitum à de l'eau. Une caméra a été positionnée au-dessus de chaque abreuvoir pour enregistrer les visites qui duraient ≥ 5 secondes entre 7:00 AM et 1:00 PM pendant 2 jours consécutifs. Un cadran a été installé sur chaque ligne d'eau pour enregistrer la disparition de l'eau.

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Résultats: Tous les porcs provenant des deux groupes de traitement ont visité l'abreuvoir à tétine durant la période d'observation de 6 heures. Les porcs témoins ont effectué moins de visites au total et ont passé moins de temps à l'abreuvoir que les porcs WH ($P < .05$). Les porcs WH ont passé plus de temps à la tétine et ont visité plus souvent que les porcs témoins seulement pour la première heure après que l'eau ait été rétablie ($P < .05$). La disparition de l'eau était plus prononcée pour les porcs WH ($P < .05$).

Implications: Dans les conditions expérimentales de la présente étude, tous les porcs ont été en mesure de visiter l'abreuvoir à tétine entre 7:00 AM et 1:00 PM; ainsi, la privation d'eau pour 15 heures afin d'encourager la consommation d'eau médicamentée n'est pas recommandée.

The "forgotten nutrient" is a phrase coined by Brooks,[1] referring to the limited attention water has received in comparison to research conducted on proteins, fats, and carbohydrates in the pig's diet.[2] Water is the most essential nutrient for life, and an inadequate supply can result in devastating consequences such as overheating, dehydration, and, in the extreme case, death.[3,4] In the Canadian laying-hen industry, water may be withheld before water-based vaccines are delivered, with the assumption that all hens will visit the drinking resources more quickly, spend longer there, and visit more often to enhance the probability of consuming water that contains a vaccine (Oral communication; anonymous poultry veterinarian, 2006). With an increasing focus on water-based oral vaccines in the swine industry, such a management tool may be useful. Therefore, the objectives of this study were to determine how quickly all 7-week-old pigs visit the nipple cup drinker, the number and duration of visits to the drinker, and water disappearance from each drinker after water is restored to a pen after a 15-hour withholding period.

Material and methods

Animals and location

The project was approved by the Iowa State University Institutional Animal Care and Use Committee. A total of 184 crossbred nursery-age pigs (PIC, USA, Franklin, Kentucky) were used at 49 ± 4 days of age and average body weight 22.98 ± 5.4 kg. Pigs were obtained from a single high-health-status herd (negative by serological testing for pseudorabies, porcine reproductive and respiratory syndrome virus, and *Mycoplasma hyopneumoniae*). The study was conducted on 2 consecutive days in May 2006 at a commercial nursery facility in central Iowa.

Diet, housing, and husbandry

Twenty-three pigs were placed in each of eight nursery pens (1.5 m × 3.7 m), providing 0.2 m^2 per pig, with either all gilts or all barrows in each pen. Steel penning dividers were 3.6 m length × 90 cm height. Tenderfoot flooring (Tandem Products, Inc, Minneapolis, Minnesota) was utilized in all pens, and pigs had ad libitum access to a corn-soy diet (3264 kcal per kg, 20% crude protein) formulated to meet requirements.[2] Pelleted feed was provided in a five-hole stainless steel feeder (10.2 cm depth × 74.3 cm height × 76.8 cm length) with a capacity of 58.5 kg. Lights were turned on at 7:00 AM and off at 4:00 PM, which provided a 9 to 15 ratio of light to dark hours. Farm personnel observed all pigs twice daily, at 7:00 AM and 3:30 PM. Each pen contained one stainless steel nipple cup drinker (12.7 cm depth × 30.5 cm height × 20.3 cm width; Farmweld Inc, Teutopolis, Illinois).

Indoor environmental measurements

Indoor environmental measurements were recorded with data loggers (Hobo Pro series; Forestry Supplies Inc, Janesville, Wisconsin). One Hobo was suspended over each nursery pen at a height of 1 m from the floor. Ambient temperature and relative humidity were recorded at 10-minute intervals. Environmental measurements averaged for the trial were 27.48°C and 47.27% relative humidity.

Treatments and experimental design

Four barrow and four gilt pens were used during the trial. Pigs were first identified by sex, then weighed and assigned to pens so that pen weight was even across pens. Pigs were weighed individually on an electronic scale accurate to 0.1 kg. The experimental unit was the pen. Two treatments, with four pens per treatment, were compared. Treatment one, Withheld (WH), was defined as no access to water for 15 hours. At 4:00 PM the day before data were collected, water was prevented from flowing to the nipple cup drinker of each WH pen using a two-way, 1.91-cm polyvinyl chloride butterfly valve (United States Plastic Corporation, Lima, Ohio) attached to the water line supplying the pen. Water was restored at 7:00 AM the following morning. Treatment two, Control (C), was defined as ad libitum access to water. A crossover design of treatments was utilized whereby each pen was a treatment and a control on alternate days during the trial.

Behavioral equipment and collection

Solid plywood sheets (1.2 m height × 2.4 m width) were secured with heavy-duty plastic ties to the pen dividers in the area of the drinker to prevent pigs on either side of a pen divider being able to see each other.[5,6] One day prior to visual recording of behavior, each pig was identified with a unique number placed on the back between the scapulas using an animal-safe crayon (Raidex Animal Marking Crayons; Thousand Hill Supply, Walworth, New York). One 12-V black-and-white CCTV camera (Model WV-CP484; Panasonic Matsushita Co Ltd, Japan) was positioned over each nipple cup drinker and recordings were made from 7:00 AM to 1:00 PM on 2 consecutive days onto a digital video recorder (RECO-204; Darim Vision Corp, Pleasanton, California) at 1 frame per second. The collection of behavior concerning the nipple cup drinker was collected by one experienced observer who viewed the DVDs using a 24-hour mode (1 frame per second) and recorded observational data using Observer software (The Observer Version 5.0.25; Noldus Information Technology, Wageningen, The Netherlands). A visit to the drinker started each time the pig's head was in the nipple cup drinker for a period of ≥ 5 seconds.[7] The visit terminated when the pig's head moved out of the drinker.

Behavioral measures

Time of the first ≥ 5-second visit to the nipple cup drinker. The first visit of ≥ 5 seconds each pig made to the nipple cup drinker was determined on an hourly basis on the 2 consecutive days of the trial.

Number and duration of visits to the nipple cup drinker. Visits and duration of time spent at the nipple cup drinker (≥ 5 seconds) were recorded for each pig between 7:00 AM and 1:00 PM on the 2 consecutive days of the trial (132,480 seconds of data recorded). Visits and duration were calculated as totals for the 6-hour observation period of each day and for each hour of each day.

Water flow rates and disappearance

Water flow rates met industry flow standards (average for the eight pens, 137 seconds per liter).[8] A water meter (DLJ-hose Bibb; Daniel L. Jerman Co, Hackensack, New Jersey) was installed on the water line to each nursery pen so that water disappearance for both treatment groups could be ascertained. Water disappearance from all pens was recorded on both study days for each hour between 7:00 AM and 11:59 AM (5 hours total in error instead of 6 hours). Water disappearance occurred when a pig depressed the nipple (located inside the nipple cup drinker) during a visit lasting ≥ 5 seconds, and water was drawn down through the pipe passing through the water meter which then read the amount of water drawn. Only visits of ≥ 5 seconds in duration were recorded, as Turner et al[7] have determined that it is not possible to tell if water is drawn during shorter visits.

Statistical analysis

The number and the duration of visits to the nipple cup drinker made by each pig were acquired through Observer and entered into Microsoft Excel Software. Any visit < 5 seconds in duration was not included in the final analysis. The data were sorted by day, pen, pig, and hour. The total number of visits to the nipple cup drinker and the total time spent at the nipple cup drinker for each pig for each of the 6 observed hours were calculated.

The total number of visits and visit duration (on an hourly basis) were analyzed by ANOVA for parametric data, using the PROC MIXED procedure of SAS (SAS Institute, Inc, Cary, North Carolina) with pen the experimental unit. Day (one and two), treatment (C and WH), pen (n = 8), gender (barrow and gilt), and pig number (n = 23) were used in the class statement. The statistical model main plot included the parameters of interest (day, treatment, and gender), and the subplot included all two- and three-way interactions. Body weight (kg) the day before the trial began was used as a linear covariate. Pen nested within treatment and day was included as a random effect in the model. A value of $P < .05$ was considered significant, and nonsignificant main effects (gender and day) and nonsignificant interactions were removed from the final model.

Descriptive results for the total number of visits during the 2 days were calculated. Data were sorted by day, treatment, and pig. The frequencies of visits to the waterer during the 12-hour observational period were determined for the WH and C treatment groups using the categories 1 to 5, 6 to 10, 11 to 15, 16 to 20, and ≥ 21 visits. The frequencies of visit duration during the 12-hour observational period were determined for the WH and C treatment groups in the categories 5 to 30, 31 to 60, 61 to 90, 91 to 120, and ≥ 121 seconds. Categories were determined post hoc after graphing the data.

Water disappearance was analyzed on a pen basis by ANOVA using the PROC MIXED procedure of SAS for parametric data. Water disappearance on a per pig per pen basis was calculated for each hour and for overall accumulation over the 2 days. The same class and model statements and random effect as previously described were used. A value of $P < .05$ was considered significant, and nonsignificant main effects (gender and day), and nonsignificant interactions were removed from the final model.

Results

Behavioral measures

Hour for the first ≥ 5-second visit to the nipple cup drinker. All pigs in both treatment groups visited the nipple cup drinker at least once between 7:00 AM and 1:00 PM on the 2 days of the trial. On Day One, all WH pigs had visited the nipple cup drinker within 2 hours of water restoration; however, on Day Two, all WH pigs had not visited the nipple cup drinker until 6 hours after water restoration. All C pigs had visited the nipple cup drinker by the last (sixth) hour of observation on both days.

Number and duration of visits to the nipple cup drinker. Total number of visits to the nipple cup drinker during the 6 hours of observation differed by treatment ($P < .001$), with C pigs making fewer total visits to the nipple cup drinker than WH pigs (10.06 versus 14.98 ± 0.77 total visits). Number of visits to the nipple cup drinker differed between WH and C pigs during the first hour (7:00 AM to 7:59 AM) after water was restored to the WH pigs (Table 1). There was a trend for a greater number of visits to the nipple cup drinker for the WH treatment than for the C treatment during the second hour after water was restored to the WH pigs (8:00 AM to 8:59 PM), but for all other hours there were no differences in the number of visits to the nipple cup drinker (Table 1).

Total duration of time spent at the nipple cup drinker during the 6-hour observation period differed between treatments ($P = .02$), with C pigs spending less time at the nipple cup drinker than the WH pigs (106.6 ± 17.9 versus 175.8 ± 17.9 seconds). Duration of time spent at the nipple cup drinker differed during the first hour of observation (7:00 AM to 7:59 AM), with WH pigs spending longer at the drinker than C pigs (Table 2). For all other time periods, there were no differences in duration of time spent at the drinker (Table 2).

Table 1: Least squares means and SE of the number of visits of ≥ 5 seconds made by 7-week-old pigs to a nipple cup drinker during a 6-hour observational period either after a 15-hour water withholding period (WH) or after ad libitum access to drinking water (C)*

Hour	No. of visits/pig		SE	P†
	C	WH		
7:00 AM - 7:59 AM	1.96	4.46	0.26	< .001
8:00 AM - 8:59 AM	2.38	3.53	0.39	.06
9:00 AM - 9:59 AM	1.08	1.33	0.14	.20
10:00 AM - 10:59 AM	1.16	1.28	0.16	.57
11:00 AM - 11:59 AM	1.66	2.08	0.22	.20
12:00 PM -12:59 PM	1.85	2.20	0.25	.32

* Trial conducted in May 2006 using four pens of 23 pigs for each treatment (total 184 pigs) in a crossover design, ie, treatment for each pen was alternated on the 2 consecutive days of the trial.

† ANOVA; pen nested within treatment and day was included as a random effect in the model, with body weight (kg) used as a linear covariate.

Over the entire 12-hour observation period, 23% of WH pigs visited the nipple cup drinker ≥ 21 times, compared to 6% of the C pigs. In addition, 64% of the WH pigs spent ≥ 121 seconds at the nipple cup drinker, compared to 26% of the C pigs. These data were not included in the statistical analysis.

Water disappearance

Cumulative water disappearance for the 10-hour observation period was greater for the WH pigs than for the C pigs (Table 3). Water disappearance differed between WH and C pigs during the first hour of observation (Table 3). There was a trend ($P < .10$) for greater water disappearance in the WH treatment than in the C treatment for the observation periods between 8:00 AM and 8:59 AM and between 11:00 AM and 11:59 AM (Table 3). For all other time periods, there were no significant differences ($P > .05$; Table 3).

When the behavior of the individual pig for visits and duration of time spent at the nipple cup drinker was reviewed, it was anecdotally noted that activity (eg, climbing onto co-specifics) and displacement behaviors of the WH pigs appeared to be at higher levels than those for the C pigs.

Discussion

Previous research has evaluated the number and duration of visits to the water resource within a pen and water disappearance in nursery[9,10] and grow-finish pigs,[11] the time of day grow-finish pigs[12] engage in drinking-related activities, and drinking-system design.[13,14] In this study, the 15-hour withholding period was defined after surveying the US swine industry (five companies that raise ≥ 1 million nursery-age pigs annually). Producers were asked when the last nursery-site check was usually completed. The majority of respondents responded 4:00 PM and reported that they would often be back on site for the morning check at 7:00 AM. The 6-hour observation time in this trial was selected because labels of some orally administered vaccines recommend withholding drinking water for a minimum of 4 hours and a maximum of 6 hours. All pigs in this study, regardless of treatment, had time during the 6-hour observation period to visit the drinking resource for a period of ≥ 5 seconds (time period validated that water is drawn through the water pipe into the cup). The within-treatment variation on the number of visits and the duration of time spent at the drinking resource revealed some interesting patterns. Twenty-three percent of the WH group and only 6% of the C group visited the nipple cup drinker ≥ 21 times, and 64% of the WH group and only 26% of the C group spent ≥ 121 seconds at the nipple cup drinker. Therefore, withholding water did seem to shift both the number of visits to the drinker and the duration of time spent at the drinker. Furthermore, the overall duration of time spent at the nipple cup drinker was 69 seconds greater in the WH pigs than in the C pigs, and the WH pigs made five more visits to the drinker than the C pigs during the 12-hour observation period. However, these results should be interpreted with caution. When the visits and duration of time were broken down into individual hours, these differences were seen only in the first hour after water was restored (7:00 AM to 7:59 AM). After this, duration of time at the nipple cup drinker and the number of visits did not differ significantly between treatments. Similarly, overall water disappearance was higher in the WH group, but when this was broken down into hourly time blocks, the difference was seen only in the first hour after water was restored. In addition, the physiological mechanisms that compensate for hydration status were not assessed, and therefore the difference in total water disappearance between WH and C groups should not be interpreted as conclusive evidence of compromised well-being. It cannot be stated that water

Table 2: Least squares means and SE of the duration of visits of ≥ 5 seconds to a nipple cup drinker during a 6-hour observational period of 7-week-old pigs either after a 15-hour water withholding period (WH) or after ad libitum access to drinking water (C)*

Hour	Time at drinker (seconds/pig)		SE	*P*†
	C	WH		
7:00 AM - 7:59 AM	18.08	64.44	4.02	< .001
8:00 AM - 8:59 AM	26.49	40.31	6.19	.14
9:00 AM - 9:59 AM	12.42	15.16	2.51	.46
10:00 AM - 10:59 AM	12.16	14.19	2.55	.24
11:00 AM - 11:59 AM	16.81	20.25	2.44	.34
12:00 PM -12:59 PM	20.68	21.43	4.36	.10

* Trial described in Table 1.

† ANOVA; pen nested within treatment and day was included as a random effect in the model, with body weight (kg) used as a linear covariate.

Table 3: Least squares means and SE of water disappearance during a 5-hour observational period of 7-week-old pigs either after a 15-hour water withholding period (WH) or after ad libitum access to drinking water (C)*

Hour	Water disappearance (L/pig)		SE	*P*†
	C	WH		
7:00 AM - 7:59 AM	0.11	0.58	0.03	< .001
8:00 AM - 8:59 AM	0.22	0.35	0.04	.06
9:00 AM - 9:59 AM	0.09	0.10	0.02	.83
10:00 AM - 10:59 AM	0.07	0.10	0.01	.12
11:00 AM - 11:59 AM	0.14	0.24	0.03	.07
Cumulative	0.62	1.37	0.10	< .01

* Trial described in Table 1.

† ANOVA; pen nested within treatment and day was included as a random effect in the model, with body weight (kg) used as a linear covariate.

disappearance did in fact represent water consumed by the pigs, as wasted water was not collected in this trial. However, a relationship is evident between the usefulness of using a water-recording device and the application of behavioral measures. If pigs were "fighting" for water after restoration, greater water disappearance for WH pigs might have been due to an increase in wastage, which is not only a well-being issue for the pig, but also a water sustainability concern and an economical challenge for the producer. These findings need to be scientifically validated in further studies to add more information to the use of water withholding as a management strategy.

Implications

- When drinking water is withheld for a period of 15 hours, overall number of visits and duration of visits to the nipple cup drinker are greater for restricted pigs than for unrestricted controls only during the first hour after water restoration.
- When drinking water is withheld for a period of 15 hours, overall water disappearance is greater in restricted pigs than in unrestricted controls only during the first hour after water restoration.
- Under the conditions of this study, all pigs were able to visit the nipple cup drinker between 7:00 AM and 1:00 PM; thus, withholding water for a 15-hour period for the purpose of encouraging consumption of medicated water is not recommended.

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