Influence of photoperiod on the behavior and performance of newly weaned pigs with a focus on time spent at the feeder, feed disappearance, and growth

Kerstin Reiners, MSc; Engel F. Hessel, PD Dr; S. Sieling, MSc; Herman F. A. Van den Weghe, Prof Dr Ir

Summary

Objective: To evaluate whether a prolonged photoperiod days 1 to 4 after weaning influences behavior and performance.

Materials and methods: Weaned pigs were allotted to daily photoperiods of 20 hours and 8 hours of light, respectively, for days 1 to 4 after weaning. Data were obtained from 234 pigs from 12 pens, resulting in n = 6 replicates per treatment. Behavior was observed during the initial 48 hours after weaning and on day 5 (when photoperiod was changed from 20 hours to 8 hours) in the prolonged light exposure group. Feed disappearance was recorded throughout the whole nursery period. Pigs were individually weighed on the day of weaning and at weekly intervals during the 7-week nursery period.

Results: Feed disappearance tended to be higher (*P* = .09) in the prolonged light exposure group in the initial 24 hours after weaning. Considering the whole nursery period, feed disappearance did not differ between the treatment groups (*P* = .73). Pigs in the prolonged light exposure group did not gain more weight in the first week after weaning (*P* = .34). Also considering the entire 7-week nursery period, body weight gain did not differ between the groups (*P* = .84).

Implications: Feed disappearance on the day after weaning tends to be greater in pigs housed in a prolonged photoperiod. Nevertheless, prolonging the photoperiod during the first 4 days after weaning does not influence feed disappearance or body weight gain over the entire nursery phase.

Keywords: swine, time spent at the feeder, performance, photoperiod, weaning

Received: September 27, 2009
Accepted: March 23, 2010

Resumen - La influencia del fotoperiodo en la conducta y desempeño de cerdos recién destetados con un enfoque en el tiempo invertido en el comedero, desaparición del alimento, y crecimiento

Objetivo: Evaluar si un fotoperiodo prolongado los días 1 a 4 después del destete influencía la conducta y el desempeño.

Materiales y métodos: Se asignaron cerdos destetados a fotoperiodos diarios de 20 horas y 8 horas de luz, respectivamente, los días 1 a 4 después del destete. Se obtuvo información de 234 cerdos de 12 corrales, que resultó en n = 6 réplicas por tratamiento. Se observó la conducta durante las primeras 48 horas después del destete y en el día 5 (cuando el fotoperiodo se cambió de 20 horas a 8 horas) en el grupo de exposición prolongada a la luz. Se registró la desaparición del alimento durante todo el periodo en el destete. Se pesaron los cerdos individualmente en el día del destete y en intervalos semanales durante el periodo de lactancia de 7 semanas.

Resultados: La desaparición de alimento tendió a ser más alta (*P* = .09) en el grupo de exposición prolongada a la luz durante las 24 horas iniciales después del destete. Considerando el periodo completo en el destete, la desaparición de alimento no difirió entre los grupos de tratamiento (*P* = .73). Los cerdos en el grupo de exposición prolongada a la luz no ganaron más peso en la primera semana después del destete (*P* = .34). También, considerando el periodo completo de lactancia de 7 semanas, la ganancia de peso corporal no difirió entre los grupos (*P* = .84).

Implicaciones: La desaparición de alimento en el día después del destete tiende a ser mayor en cerdos alojados en un fotoperiodo prolongado. Sin embargo, prolongar el fotoperiodo durante los primeros 4 días después del destete no influencía la desaparición de alimento ó la ganancia de peso corporal durante la fase completa de lactancia.

Résumé - Influence de la photopériode sur le comportement et les performances des porcs nouvellement sevrés avec une emphase sur le temps passé à la mangeoire, la disparition de la nourriture, et la croissance

Objectif: Évaluer si une photopériode prolongée aux jours 1 à 4 après le sevrage influence le comportement et la performance.

Matériels et méthodes: Des porcs sevrés ont été répartis dans des groupes avec des photopériodes quotidiennes, respectivement de 20 heures et de 8 heures de lumière, pour les jours 1 à 4 après le sevrage. Les données de 234 porcs provenant de 12 parcs ont été obtenues, ce qui représente six réplications par traitement. Dans le groupe avec la période d'exposition

Department of Animal Sciences, Division: Process Engineering, Georg-August University of Goettingen, D-49377 Vechta, Germany

Corresponding author: Kerstin Reiners, Department of Animal Sciences, Division: Process Engineering, Georg-August University of Goettingen, Universitätsstr. 7, D-49377 Vechta, Germany; Tel: 0049 4441 15439; Fax: 0049 4441 15448; E-mail: kerstin.reiners@agr.uni-goettingen.de.

This article is available online at http://www.aasv.org/shap.html.

Reiners K, Hessel EF, Sieling S, et al. Influence of photoperiod on the behavior and performance of newly weaned pigs with a focus on time spent at the feeder, feed disappearance, and growth. *J Swine Health Prod.* 2010;18(5):230–238.

prolongée à la lumière, le comportement a été observé pendant les 48 premières heures suivant le sevrage et au jour 5 (lorsque la photopériode a été changée de 20 heures à 8 heures). La disparition de nourriture a été enregistrée durant toute la période en pouponnière. Les porcs étaient pesés individuellement le jour du sevrage et de manière hebdomadaire pour la période de 7 semaines en pouponnière.

Résultats: La disparition de nourriture avait tendance à être plus élevée (*P* = .09) dans le groupe avec exposition lumineuse prolongée dans les premières 24 heures suivant le sevrage. En prenant en considération tout le temps passé en pouponnière, il n'y avait pas de différence entre les deux groupes en ce qui regarde la disparition de nourriture (*P* = .73). Les porcs dans le groupe avec exposition prolongée à la lumière n'ont pas pris plus de poids dans la première semaine suivant le sevrage (*P* = .34). En prenant en considération la période de 7 semaines passée en pouponnière, il n'y avait pas de différence entre les deux groupes en ce qui concerne le gain de poids corporel (*P* = .84).

Implications: La disparition de nourriture le jour après le sevrage a tendance à être plus importante chez les porcs avec une photopériode prolongée. Néanmoins, en considérant la période entière passée en pouponnière, une prolongation de la photopériode durant les 4 premiers jours après le sevrage n'influence pas la disparition de nourriture ou le gain de poids journalier.

Weaning of pigs is one of the most critical phases in modern pig production. The most important factors causing both acute and chronic stressors experienced by individual weaned pigs are separation from the sow, transport, changes in accommodation, feed supply, and olfactory environment, as well as increased aggression as new dominance hierarchies are established after commingling of previously unfamiliar piglets.[1-3] All factors causing stress in the weaning phase may have consequences on the pigs´ physical,[4] immunological,[5] and psychological[6] status. As a result, feed intake in weaned pigs is frequently suboptimal during the first week after weaning.[1]

Due to suboptimal feed intake, the high growth potential of the weaned pigs may not be realized.[1,6] In addition to a number of other factors, feed and water intake of pigs is closely related to circadian rhythm, as generally intake occurs during the activity phases. The activity of domestic pigs is reported in the literature as being an endogenous, biphasic, alternans-type circadian activity rhythm.[2,7] It has been shown, however, that a number of other factors influence pigs' activity rhythms and thus their food-seeking and food-ingestive behavior: for example, photoperiod, ambient temperature, and age at weaning.[8,9] Other authors have described the high adaptability of young pigs as being due to their lack of an internal rhythmus for activity and food intake, which means that they can become accustomed quickly to changed conditions.[10]

In the present study, the length of the photoperiod in a pig nursery was increased for the first 4 days after weaning from 8 hours per day to 20 hours per day. It was assumed that prolonging photoperiod during the first 4 days after weaning would increase or accelerate the weaned pig´s feed intake due to a better orientation in the critical transition period from sow´s milk to solid food in a novel environment. The objectives of this study were to compare the effects of different photoperiods on the behavioral repertoire of the recently weaned pig and to determine how photoperiod affects performance during the nursery stage.

Materials and methods

The experimental protocol followed the facility´s production practices and met or exceeded requirements of the regulation to protect farm animals of the Federal Ministry of Food, Agriculture and Consumer Protection of Germany.[11]

Housing and feeding

The study was conducted at the Department of Animal Sciences, Division: Process Engineering, of the Georg-August University of Goettingen in Vechta, Germany.

Pigs were housed in two pens (4.60 m × 1.80 m) in a conventional nursery facility. The environmental temperature was automatically regulated by a ventilation system (Exavent; Fancom, The Netherlands). Each pen was divided into a solid concrete resting area (2.80 m × 1.80 m) and a fully slatted activity area (1.80 m × 1.80 m), with a manure pit 0.85 m deep to store the manure for a 7-week period. The resting area had an incline of 6% and was equipped with a sectional electric floor-heating system. The pens were separated by solid partitions 1 m high.

Each pen was equipped with a circular feed-level-controlled mash feeder (PreMixer; EFS-System GbR, Essen i. Oldenburg, Germany) which was placed on the solid concrete floor at the edge of the slatted floor with free access for the pigs. A sensor extending into the trough controlled its filling level. As long as the sensor did not come into contact with the mash, 23 g of pelleted feed per minute was transported over a conveyor spiral to the trough and blended with water at a ratio of 1:1.5 shortly before being dispensed.[12] On day 21 of the nursery stage, the feed-level-controlled mash feeders were replaced with conventional tube mash feeders (Lean Machine; Big Dutchman, Vechta, Germany). With this system, in contrast to the feed-level-controlled model, the pigs had to actively move two dosing brackets arranged horizontally above the plastic trough for the feed to be released. Subsequently, the animals could blend the feed to mash with water from two spray nipples on the top part of the feeder, as water dripped onto the dry feed when the piglets drank. For both the feed-level-controlled mash feeders and the tube mash feeders, the troughs had a circumference of 78.5 cm and provided five feeding spaces. The feeders were replenished daily at 8:00 AM. Two additional water nipples were provided at the back of the slatted section of each pen.

The temperature in the nursery was 27.0°C during the first week after weaning. From week 2 until the end of the 7-week nursery period, the temperature was reduced by 0.83 C° weekly, down to 22.0°C. A data logger (Therm 5500-3; Ahlborn, Germany) suspended 1.5 m above the floor in the activity area of each pen collected temperature data. Temperature was measured at 10-minute intervals and daily averages were calculated.

Experimental design

The experiment was performed in six 7-week periods between December 2005 and June 2007. During three of these periods, weaned pigs were allotted to a photoperiod of 20 hours light:4 hours darkness from Day 1 until Day 4 post weaning (prolonged light exposure group). In the other three periods, the photoperiod was 8 hours light:16 hours darkness from Day 1 until Day 4 in the nursery (control group). From Day 5 of the nursery period, the photoperiod for both groups was 8 hours light:16 hours darkness.

To ensure complete control of the photoperiod, windows were covered with chipboard to completely eliminate natural light.

Seven fluorescent lamps on the ceiling of the nursery were used for lighting. At the beginning of each trial, light intensity at the pigs' eye level was verified in three positions in each pen with a Ral Max Lux-Sensor (Technetics, Freiburg, Germany), which was connected to a Micromec Data-Logger (Technetics). When the lights were switched on, the light intensity was 100 lx. Photoperiods were controlled by a clock timer (Siemens, Munich, Germany).

Animals

Pigs were obtained from a single-source farm that had a history of producing pigs serologically positive for porcine reproductive and respiratory syndrome and enzootic pneumonia and serologically negative for *Actinobacillus pleuropneumoniae*. A total of 240 crossbred pigs [(Large White × German Landrace) × Pietrain] were used. Pigs were weaned at 21 ± 0 days of age (Day 0) and were transported to the nursery (a distance of 12 km) on a commercial, two-deck, air-suspended pig trailer (Menke-Janzen, Sögel, Germany) immediately after weaning at 2:00 PM. Weaned pigs from seven litters were mixed into the nursery. Pigs that were easiest to catch were caught first and tagged with eartags, each labeled with a unique number allocated to a weaned pig prior to the beginning of the experiment. Eartag numbers were then randomized to the pens. Body weight (BW) was not taken into account when the pigs were assigned to pens. However, in order to balance the effect of sex, the gender ratio was adjusted, with 10 male and 10 female pigs placed in each pen. Therefore, male and female eartag numbers were randomized to the pens separately. At the beginning of the experiment, initial BW was 5.92 ± 0.82 kg in the prolonged light exposure group and 5.91 ± 0.85 kg in the control group.

Two pigs in the prolonged light exposure group and four in the control group died during the nursery period.

Feeding

For the first 10 days after weaning, the pigs received a pre-starter feed with 16.30 MJ metabolizable energy (ME) per kg dry matter (DM) and 21% crude protein (CP). From Day 11 until the end of the nursery period, a feed with 13.52 MJ ME per kg DM and 18% CP was offered. Feed and water were available ad libitum throughout the experiment.

Data management

Behavior. Pig behavior was continuously recorded on videotape during the nursery period. Four cameras (WV-BP330; Panasonic, Japan) were placed 2 m above floor level in the nursery room. The cameras were connected to a multiplexer (WJ-FS216; Panasonic), which monitored the pictures and simultaneously recorded them on a time-lapse recorder with a recording mode of 24 hours (AG-6730; Panasonic). Two postures (upright, lying-sitting) and two behaviors (time spent at the feeder and agonistic) were recorded (Table 1).

To minimize errors caused by using different observers, behavioral observations in the first 48 hours after weaning were conducted by a single observer. Behavioral observations of the prolonged light exposure group on Days 4 and 5 were made by another single observer. To minimize errors, intra-observer reliability was tested for 60 minutes on each observation day and was 94.5%. In order to characterize the behavior of the whole group, 5-minute scan samples of the videotapes were used, during which the number of pigs performing a specific behavior was noted. Observations for the whole group were made during the initial 48 hours after weaning, beginning at 4:00 PM on the day of weaning, immediately after the pigs were assigned to their nursery pens. In order to determine whether the change in lighting schedule on Day 5 influenced behavior, observations of the whole prolonged light exposure group were additionally conducted 24 hours before and 24 hours after the photoperiod was changed. As observations of the whole group were also conducted when the barn was not lit, it was equipped with four infrared lamps with a wavelength range of 850 nm, which is not visible to the animals.[13]

For observation of the behavior of focal animals, the heaviest pig and the lightest pig in each pen were identified at the beginning of the experiment, and each was identified with a unique mark sprayed on and renewed daily at feeding time. The behavior of the selected focal animals was continuously analyzed using the focal sampling method of the program package "The Observer" (Version 3.0; Noldus, The Netherlands). With this method, the beginning and end of each type of behavior performed was recorded. The observations of focal animals in the prolonged light exposure and control groups were performed on Days 1 and 2, beginning at 8:00 AM and

Table 1: Definition of the specific behaviors of weaned pigs observed* to evaluate how a prolonged photoperiod from Day 1 to Day 4 after weaning influences behavior and performance

Behavior	Definition of behavior
Upright	Pig in an upright position, standing or moving
Lying-sitting	Body of the pig in contact with the floor, in lateral recumbency (all legs extended), inclined (lying not completely on the side, but with legs partly extended), sternal (upright on the chest), or sitting (caudal portion of the trunk in contact with and supported by the floor)
Time spent at the feeder	Pig standing at the feeder with its head extended into the trough
Agonistic	Physical encounters between at least two pigs, including head-to-head fights, biting another pig, and pushing another pig with the head

* Pigs weaned at approximately 21 days of age. For observation of the whole group, the scan sampling method was used, with a 5-minute sampling interval. For observation of selected focal animals, the focal sampling method was used (The Observer, version 3.0; Noldus, The Netherlands).

ending at 4:00 PM. Additionally, observations of focal animals in the prolonged light exposure group were performed on Days 4 and 5, beginning at 8:00 AM and ending at 4:00 PM, in order to determine whether the change in lighting schedule influenced their behavior. Observations of the focal animals were performed when the barn was lit, as their identifying marks were otherwise difficult to recognize.

Feed disappearance. Average feed disappearance for each pen was determined daily at 7:45 AM during the entire nursery period when the daily screening of the animals was conducted. Feed disappearance and daily screening were determined by a single person in each trial. To determine feed disappearance, the feed at the beginning of the day and the feed left in the feeder at the end of that day were weighed. Additionally, the control unit of the feed-level-controlled mash feeder recorded the time it was operating (ie, delivering 23 g of dry feed per minute) each day.

BW gain. Pigs were weighed individually on the day of weaning and at weekly intervals during the nursery period. Pigs were weighed on an electronic scale (accuracy 0.05 kg) which was adjusted to the standard by the German bureau of standards every 2 years.

Statistical analysis

The experiment followed a randomized block design with repeated measures**.** Data were obtained from 234 weaned pigs in 12 pens, resulting in six replicates per treatment, with 118 weaned pigs in the prolonged light exposure group (barn lit 20 hours per day in the 4 days after weaning) and 116 weaned pigs in the control group (barn lit 8 hours per day in the 4 days after weaning). Pigs that died during the experiment were excluded from the analysis.

Statistical analysis was performed using analysis of variance in SAS 9.1 (SAS Institute, Inc, Cary, North Carolina). Pen was the experimental unit (n = 12). Analysis of data with a Gaussian distribution or that could be logarithmically transformed into a Gaussian distribution was performed using the GLM and MIXED procedures. The results are presented as least squares means with standard error (SE) (*t* test). The least squares means were separated using the PDIFF procedure of SAS. Variables which did not have a Gaussian distribution and could not be transformed into a Gaussian distribution were analyzed using a Wilcoxon 2-sample test (NPAR1WAY procedure). Data resulting from the Wilcoxon 2-sample test are presented as means (standard error of the mean; SEM). A value of $P < .05$ was considered statistically significant, and $P < .10$ describes a trend.

Behavior. To analyze behavioral data, hourly means were calculated for each group. In addition, the data were split into time blocks for each observation day (period of 4 consecutive hours). The time blocks were chosen on the basis of the photoperiod in the nursery (Day 1 until Day 4). The photoperiod for the prolonged light exposure group was divided into five time blocks per observation day in which the nursery was lit (8:00 AM until 12:00 noon, noon until 4:00 PM, 4:00 PM until 8:00 PM, 8:00 PM until 12:00 midnight, and midnight until 4:00 AM) and one time block per observation day in which the light was switched off (4:00 AM until 8:00 AM). The photoperiod for the control group was divided into two time blocks in which the nursery was lit (8:00 AM until 12:00 noon, noon until 4:00 PM) and four time blocks in which the light was switched off (4:00 PM until 8:00 PM, 8:00 PM until 12:00 midnight, midnight until 4:00 AM, and 4:00 AM until 8:00 AM).

The data for the number of pigs in an upright position, lying-sitting pigs, and pigs spending time at the feeder could be logarithmically transformed into a normal distribution and were analyzed by analysis of variance using the MIXED procedure of SAS. The model included the fixed effects of group, observation day, time block, and group × observation day × time block.

The data for the number of pigs performing agonistic behavior could not be transformed into a normal distribution, so the statistical analysis of these data was carried out using the NPAR1WAY procedure.

For evaluation of the behavioral data for the 24 selected focal animals (12 per group), a data set of 5460 observations was available. Daily pen averages were determined for all focal animals and observation days. The data for the weaned pigs in an upright position, lying-sitting pigs, and pigs spending time at the feeder were logarithmically transformed into a normal distribution. The subsequent statistical analyses were performed using the MIXED procedure of SAS, including fixed effects of group, observation day, and group × observation day. No interaction between group and observation day was established. As with group data, the data for pigs showing agonistic behavior were not normally distributed, could not be transformed into a normal distribution, and were analyzed using the NPAR1WAY procedure.

Feed disappearance. The feed disappearance data were normally distributed, and statistical analysis was performed using the MIXED procedure, including fixed effects of group, day of nursery, and group × day of nursery.

BW gain. Residuals predicting the BW gain on each weighing date as a function of gender and BW at weaning were calculated using the GLM procedure of SAS. The residuals calculated in this manner were pooled by pen and replicate and analyzed using the MIXED procedure. The model for analysis included group as a fixed effect.

Results

Behavior

Pigs in the prolonged light exposure group tended to spend less time at the feeder than pigs in the control group ($P = .07$). The proportion of pigs in an upright position was higher in the prolonged light exposure group than in the control group ($P = .01$). The level of agonistic behavior was low in both treatment groups and did not differ between them (Table 2). In the first 24 hours after weaning, no differences were observed for the time spent at the feeder with respect to photoperiod when 4-hour blocks after weaning were compared ($P = .88$). The proportion of pigs spending time at the feeder 24 hours to 28 hours after weaning (4:00 PM to 8:00 PM) was higher in the control group than in the prolonged light exposure group ($P < .001$). The pen was lit during this time period in the prolonged light exposure group, but the control group was in darkness. Independent of photoperiod, the lowest number of visits to the trough were observed from 12 hours to 16 hours after weaning and from 36 hours to 40 hours after weaning (4:00 AM to 8:00 AM in each case). The pens were not illuminated during these two time periods.

In contrast to the proportion of pigs spending time at the feeder, the proportion of pigs in an upright position was higher in the prolonged light exposure group during the first 4 hours after weaning (4:00 PM to 8:00 PM) ($P = .04$). However, the two groups did not differ in this respect 4 to

Table 2: Percentage of observations where weaned pigs were upright, lying-sitting, spending time at the feeder, or showing agonistic behavior* during the initial 48 hours after weaning in a study comparing the influence of two different photoperiods during the first 4 days after weaning on behavior and performance of weaned pigs

Parameter	PLE†	Control‡	SE	*P*§
Upright (%)	12.87	10.85	0.58	.01
Lying-sitting (%)	83.78	83.85	0.74	.94
Time spent at feeder (%)	2.84	3.26	0.16	.07
Agonistic (%)¶	0.44 (0.03)	0.43 (0.03)	NA	.95

* Behaviors defined in Table 1. Scan sampling during the initial 48 hours after weaning as a function of group beginning at 4:00 PM the day of weaning.

† Prolonged light exposure group (PLE; n = 6 pens); barn lit 20 hours/day from Day 1 to Day 4 after weaning, and 8 hours/day from Day 5 to Day 49.

‡ Control group (n = 6 pens); barn lit 8 hours/day from Day 1 to Day 49.

§ Analysis of variance (MIXED procedure of SAS; SAS Institute, Inc, Cary, North Carolina) was utilized for pigs that were upright, lying-sitting, and spending time at the feeder. The NPAR1WAY procedure of SAS was used for agonistic behavior. Six pens of approximately 19 pigs per pen were included in the analysis. Pen was the unit of analysis.

¶ Mean (standard error of the mean).

NA = not applicable.

8 hours after weaning (8:00 PM to 12:00 midnight) (*P* = .36). However, 8 to 12 hours after weaning (12:00 midnight to 4:00 AM), the proportion of pigs in an upright position tended to be higher in the prolonged light exposure group (*P* = .09), and 28 hours to 32 hours after weaning (8:00 PM to 12 midnight), the proportion of pigs in an upright position was higher in the prolonged light exposure group (*P* = .02). During all of these time periods, the pens were lit for the prolonged light exposure group and dark for the control group.

The proportion of lying-sitting pigs did not differ between the two groups during the first 24 hours after weaning (*P* = .94). However, at 24 hours to 32 hours post weaning (4:00 PM to 12:00 midnight), treatment groups differed by length of photoperiod. While the proportion of lying-sitting pigs in the prolonged light exposure group was greater (*P* = .03) in the 4-hour period 24 hours to 28 hours after weaning (4:00 PM to 8:00 PM), the pigs in the control group tended to lie-sit more 28 hours to 32 hours after weaning (12:00 midnight to 4:00 AM) (*P* = .07). The light was on during these time periods for the prolonged light exposure group but not for the control group.

When the photoperiod was changed on Day 5 from 20 hours light to 8 hours light, the behavior of the pigs in the prolonged light exposure group did not change (*P* = .30) (Table 3).

Observation of the focal animals showed that pigs in an upright position, lying-sitting, feeding (time spent at the feeder), or performing agonistic behavior did not differ by treatment group (*P* = .33) (Table 4). In addition, time spent at the feeder also did not differ between the two groups with respect to average length of trough time and number of visits to the trough (data not shown).

Feed disappearance

On the first day after weaning, photoperiod tended to influence feed disappearance, which averaged 0.15 kg per animal in the prolonged light exposure group and 0.09 kg in the control group (*P* = .09). After the change in photoperiod from 20 hours to 8 hours, feed disappearance in the prolonged light exposure group was no longer higher than that in the control group, and on Day 6 post weaning, feed disappearance in the control group was higher than that in the prolonged light exposure group (*P* = .047). However, when the first week of the nursery period (*P* = .69) and the whole 7-week nursery period (*P* = .73) were taken into consideration, the two treatment groups did not differ with respect to average feed disappearance (Table 5).

Body-weight gain

Weight changes in the two groups (Table 6) did not differ either in the first week of the nursery period (when photoperiods for the two groups differed) nor in any other nursery weeks (when photoperiods were the same). Also, when the whole 7-week nursery period was taken into consideration, BW gain of the weaned pigs did not differ between the two groups.

Discussion

The influence of light on the biphasic activity rhythm of pigs has been demonstrated both under artificial conditions with windowless barns using light programs[14-16]and under natural conditions.[17] The body appears to be controlled by a system which adapts the rhythm of organs and cells to temporal cues from the environment. Such signals can, for example, be photoperiod stimuli. The luminous stimuli are assimilated by the eye and then transmitted via the optic nerve to the pineal gland.[18] The pineal gland has a central function in regulation of the body's intrinsic rhythms and is an intermediary unit in the synchronization of diurnal rhythms of behavior. The signals are transmitted from the pineal gland to the middle part of the forebrain and the reticular system of the spinal cord, from where the behavior of the organism is influenced.[19]

In contrast to earlier investigations, the long photoperiod in the present study was not used over the whole of the nursery period, but just in the first 4 days after weaning. Due to many stressors, eg, separation from the sow, transport, changing nutrition, and novel environment, as well as increased aggression as new dominance hierarchies are established, the first days after weaning are one of the most critical phases in pig production.[1-3] In the first week after weaning, feed intake is often suboptimal, resulting in poor growth, which has wide-ranging consequences for the subsequent course of the nursery and finishing period.[1] Prolonging the photoperiod during the most critical phase after weaning should increase or accelerate feed intake, and thus growth performance, due to a better orientation of the weaned pigs in a novel environment. When feed intake and thus growth performance are increased directly after weaning, growth depressions are likely to be minimized and performance

Table 3: Percentage of pigs in the prolonged light exposure group* exhibiting behaviors on Day 4 and Day 5 post weaning† in a study comparing the influence of two different photoperiods during the first 4 days after weaning on behavior and performance

Parameter	Day 4	Day 5	SE	*P*‡
Upright (%)	7.84	8.22	0.83	.75
Lying-sitting (%)	86.59	86.82	1.13	.89
Time spent at feeder (%)	4.35	4.62	0.43	.65
Agonistic (%)§	0.28 (0.04)	0.21 (0.04)	NA	.30

* Photoperiod 20 hours/day from Day 1 to Day 4 after weaning, and 8 hours/day from Day 5 to Day 49. Behaviors described in Table 1.

† Observations of 5-minute scan samples of videotapes.

‡ Analysis of variance (MIXED procedure of SAS; SAS Institute, Inc, Cary, North Carolina) was utilized for pigs that were upright, lying-sitting, and spending time at the feeder. The NPAR1WAY procedure of SAS was used for agonistic behavior. Six pens of approximately 19 pigs per pen were included in the analysis. Pen was the unit of analysis.

§ Physical interaction with other pigs. Mean (standard error or the mean).

NA = not applicable.

maximized, both directly after weaning and in the subsequent course of the nursery and finishing period. In the present study, no positive effect of a prolonged photoperiod on growth performance during the first 4 days after weaning could be observed. Physiological changes due to a prolongation of photoperiod were not assessed in the present study, as assessing the physiological response to a change in photoperiod in place for only 4 days was not likely to be possible.

The time spent at the feeder was not analyzed over the whole 7-week investigation period, but only for the first 48 hours after weaning and on Days 4 and 5, when the lighting schedule in the prolonged light exposure group was changed from 20 hours to 8 hours per day. Even though the proportion of pigs spending time at the feeder did not differ between the two groups in the first 4 hours after weaning, the proportion of pigs in an upright position was higher in the prolonged light exposure group during the first 4 hours after weaning. This indicates that these animals were more active directly after weaning and so went through the orientation phase in their new surroundings more quickly than the control group, which were subjected to darkness during this time. Christison[20] showed that in weaned pigs managed with continual light at either 1 lux or 100 lux for the whole nursery period, time spent at the feeder did not differ between treatment groups. Bearss et al[21] and Bruininx at al[15] also found that photoperiod did not affect behavior during the nursery period. From these investigations,[15,21] it could not be determined whether behavior is influenced by an increase in photoperiod directly after weaning.

Hsia and Wood-Gush[22] compared feed intake during the nursery period in pigs held under continual 24-hour light or held under an 8.5-hour photoperiod. The pigs subjected to the 8.5-hour photoperiod spent more time at the feeder than those subjected to continual light. However, pigs managed in the 24-hour photoperiod spent more time at the feeder per day when the whole of the nursery period was taken into consideration. These results could not be confirmed in the present study when the first 48 hours and Days 4 and 5 were taken into consideration. Both the average length of time spent at the trough and the

Table 4: Time budgets for behaviors performed by focal animals as a function of group and observation day in a study comparing the influence of two different photoperiods in the first 4 days after weaning on behavior and performance of weaned pigs*

	Day 1				Day 2			
Parameter	PLE†	Control‡	SE	*P*§	PLE†	Control‡	SE	*P*§
Upright (min)	188.65	145.73	40.45	.26	145.60	174.65	40.45	.58
Lying-sitting (min)	283.03	325.33	51.28	.81	321.37	287.47	51.28	.65
Time at feeder (min)	6.25	7.69	3.52	.77	11.36	16.37	3.52	.33
Agonistic (min)¶	1.09 (0.46)	1.17 (0.35)	NA	.57	0.71 (0.11)	1.05 (0.35)	NA	.98

* Behaviors described in Table 1. Observations made from videotapes using the focal sampling method on Days 1 and 2 after weaning, from 8 AM to 4 PM on each day.

† PLE: prolonged light exposure group, n = 12 focal animals; lights on 20 hours/day from Day 1 to Day 4 after weaning, and 8 hours/day from Day 5 to Day 49.

‡ Control group, n = 12 focal animals; lights on 8 hours/day from Day 1 to Day 49 after weaning.

§ Analysis of variance (MIXED procedure of SAS; SAS Institute, Inc, Cary, North Carolina) was utilized for weaned pigs that were upright, lying-sitting, and spending time at the feeder. The NPAR1WAY procedure of SAS was used for agonistic behavior. The individual pig was the unit of analysis.

¶ Physical interaction with other pigs; mean (standard error of the mean).

NA = not applicable.

Table 5: Feed disappearance on each of the first 7 days of the nursery period and the entire 7-week nursery period as a function of group in a study comparing the influence of two different photoperiods in the first 4 days after weaning on behavior and performance of weaned pigs

	Feed disappearance (kg/pig)			
Day after weaning	**PLE ***	**Control†**	**SE**	***P*‡**
1	0.150	0.087	0.034	.09
2	0.300	0.284	0.034	.79
3	0.325	0.325	0.034	.99
4	0.350	0.306	0.034	.37
5	0.350	0.381	0.034	.52
6	0.325	0.425	0.034	.047
7	0.400	0.463	0.034	.20
Total (7 days)	2.267	2.305	0.064	.69
Total (49 days)	38.479	39.561	0.034	.73

* PLE: prolonged light exposure group, n = 6 pens of approximately 19 pigs/pen; lights on 20 hours/day from Day 1 to Day 4 after weaning, and 8 hours/day from Day 5 to Day 49.

† Control group, n = 6 pens of approximately 19 pigs/pen; lights on 8 hours/day from Day 1 to Day 49 after weaning.

‡ Analysis of variance (MIXED procedure of SAS; SAS Institute, Inc, Cary, North Carolina). Pen was the unit of analysis.

total time spent at the trough were not higher in the focal animals subjected to 20 hours light per day on the first day of observation, and more visits to the trough were not observed. It should be taken into account, however, when comparing these results to those of Hsia and Wood-Gush,[22] that in the current investigation, behavior was investigated only during the first 48 hours and on Days 4 and 5 after weaning, and that the photoperiod was longer for a total of only 4 days immediately after weaning.

Barnett et al[23] were able to show that there is less aggression among weaned pigs in the first hours after weaning when the barn is not illuminated. Furthermore, it has been shown that pigs preferentially choose dark areas for resting behavior, while they undertake their active and agonistic behavior in the brighter areas of the pens.[24] In contrast to the investigation of Barnett et al,[23] prolongation of the photoperiod in the present study had no effect on the agonistic behavior of the weaned pigs. The reason for this apparent lack of difference in agonistic behavior may lie in the observation method used. Assessment of behavior of the whole group was undertaken with the time sampling method in the present study. Scan samples of 5 minutes were used to characterize agonistic behavior of the group. It is conceivable that agonistic behavior was also occurring between scan samples, therefore the sampling interval should be shortened in future investigations.

Although the prolonged light exposure group spent less time at the feeder in the first 48 hours after weaning, feed disappearance in this group tended to be higher on the first day after weaning. However, greater feed disappearance could not be confirmed throughout the first week of the nursery period and the entire 7-week nursery period. Furthermore, greater feed disappearance did not result in better growth performance, either in the first week of the nursery or over the entire 7-week nursery period. It might be assumed that, due to their better orientation in the environment, the prolonged light exposure group accessed the feed in the trough more easily and consumed feed faster. In consequence of their play instinct, it is conceivable that the pigs spilled more feed rather than ingesting it. Bruininx et al[15] observed greater feed disappearance in weaned pigs subjected to 23 hours light per day in the first 2 weeks after weaning than in those subjected to only 8 hours light per day.

Feed intake was also numerically greater in the first week after weaning in the study of Bruininx et al,[15] although this difference could not be confirmed statistically. McGlone et al[25] found no positive influence of a prolonged photoperiod on the feed uptake of weaned pigs during a 28-day nursery period. However, in this investigation, the influence of photoperiod on feed uptake during the first days after weaning was not determined, as feed disappearance was assessed only at 14 and 28 days post weaning.

In contrast to earlier investigations, the length of photoperiod in the present study was not maintained during the whole of the nursery period, but only in the first 4 days, and then was increased from 8 hours to 20 hours in the group exposed to a long photoperiod. Lay et al[26] reported that pigs change their behavior with an increase in photoperiod and that they maintain these changes even when the photoperiod is later reduced. Buchenauer et al,[27] Bure,[28] and Veissier et al,[29] in contrast, maintain that the circadian rhythm of pigs is very sensitive to adverse situations, and thus they react to any change in photoperiod. The results of behavior observations on Days 4 and 5 after weaning (0 to 24 hours before and 0 to 24 hours after the change in photoperiod, respectively) might, however, show that the change in photoperiod had no direct influence on the behavior of pigs in the prolonged light exposure group.

Prolongation of the photoperiod in the first 4 days after weaning is one of several approaches to reduce weaning stress and so to increase feed disappearance and growth performance of pigs post weaning. The aim of this investigation was not to analyze physiological changes due to a prolonged photoperiod, but to assess its specific effects on feed intake and thus on growth performance immediately after weaning. In earlier studies, the influence of feeding heated mash on growth and feeding behavior of newly weaned pigs was investigated under conditions identical to those in the present study. When warm mash was fed in the first week after weaning, both growth performance and feed disappearance were greater over the entire 7-week nursery phase.[12] In contrast to the effect of heated mash on performance and time spent at the feeder, the effect of the long photoperiod at the beginning of the nursery period on feed disappearance, growth performance, and

Table 6: Means and weaning-weight and gender-adjusted residuals of body-weight gain of pigs during the 7-week nursery period as a function of group in a study comparing the influence of two different photoperiods during the first 4 days after weaning on behavior and performance

			Weaning-weight (kg) and gender-adjusted residuals			
Period	**Gain (kg)**	**SEM**	**PLE ***	**Control †**	**SE**	***P*‡**
Week 1	1.48	0.08	-0.12	0.11	0.15	.34
Week 2	2.56	0.12	0.22	-0.22	0.23	.24
Week 3	2.93	0.07	-0.02	0.03	0.11	.79
Week 4	3.74	0.17	0.09	-0.07	0.35	.77
Week 5	4.25	0.13	-0.07	0.09	0.29	.72
Week 6	4.94	0.27	-0.17	0.20	0.54	.64
Week 7	4.98	0.19	-0.12	0.14	0.31	.58
Total (7 weeks)	24.84	0.56	-0.13	0.23	1.19	.84

* PLE: prolonged light exposure group, n = 6 pens of approximately 19 pigs/pen; lights on 20 hours/day from Day 1 to Day 4 after weaning, and 8 hours/day from Day 5 to Day 49.

† Control group, n = 6 pens of approximately 19 pigs/pen; lights on 8 hours/day from Day 1 to Day 49 after weaning.

‡ Analysis of variance (MIXED procedure of SAS; SAS Institute, Inc, Cary, North Carolina). Pen was the unit of analysis.

behavior was minimal in the present study. Taking into account the comparatively low costs of a prolonged photoperiod in the first 4 days after weaning (depending on the size of the barn and regional costs of electricity), prolonging photoperiod during the first 4 days after weaning might therefore at most be used as an additional method to improve orientation of the weaned pigs at the feed trough and therefore to stimulate their feed intake.

Implications

- Feed disappearance on the first day after weaning tends to be greater in pigs housed in a prolonged photoperiod (20 hours of light daily).
- Under the conditions of this study, prolonging photoperiod in the first 4 days after weaning does not influence feed disappearance or BW gain over the entire 7-week nursery phase.
- Under the conditions of this study, during the first 4 hours after weaning, the proportion of weaned pigs in an upright position is higher in pigs housed in a prolonged photoperiod than in those housed in the dark during this period.
- A long photoperiod does not influence the number of nursery pigs spending time at the feed trough during the first 48 hours after weaning.

Acknowledgement

The authors gratefully acknowledge the support of the H. Wilhelm Schaumann Foundation (Hamburg, Germany) for providing financial support for this research.

References

1. King RH, Pluske JR. Nutritional management of the pig in preparation of weaning. In: Pluske JR, Le Dividich J, Verstegen MWA, eds. *Weaning the Pig: Concepts and Consequences*. Wageningen, The Netherlands: Wageningen Academic Publishers; 2003:37–47.

2. Jensen P. Behaviour of pigs. In: Jensen P, ed. *The Ethology of Domestic Animals – An Introductory Text*. Oxon, United Kingdom: CAB International; 2003:159–172.

3. Held S, Mendl M. Behaviour of the young weaned pig. In: Varley MA, Wiseman J, eds. *The Weaner Pig: Nutrition and Management*. Oxon, United Kingdom: CAB International; 2001:273–297.

4. Dunshea FR. Metabolic and endocrine changes around weaning. In: Pluske JR, Le Dividich J, Verstegen MWA, eds. *Weaning the Pig: Concepts and Consequences*. Wageningen, The Netherlands: Wageningen Academic Publishers; 2003:61–74.

5. Hopwood DE, Hampson DJ. Interactions between the intestinal microflora, diet and diarrhoea, and their influences on piglet health in the immediate post-weaning period. In: Pluske JR, Le Dividich J, Verstegen MWA, eds. *Weaning the Pig: Concepts and Consequences*. Wageningen, The Netherlands: Wageningen Academic Publishers; 2003:199–212.

6. Brooks PH, Tsourgiannis CA. Factors affecting the voluntary feed intake of the weaned pig. In: Pluske JR, Le Dividich J, Verstegen MWA, eds. *Weaning the Pig: Concepts and Consequences*. Wageningen, The Netherlands: Wageningen Academic Publishers; 2003:81–115.

7. Van Putten G. Schwein [Pig]. In: Sambraus HH, ed. *Nutztierethologie [Ethology of domestic animals]*. Berlin and Hamburg, Germany: Verlag Paul Parey; 1978:168–213.

8. Feddes JJR, Young BA, De Shazer JA. Influence of temperature and light on feeding behavior of pigs. *Appl Anim Behav Sci*. 1989;23:215–222.

9. Gonyou HW, Beltranena E, Whittington DL, Patience JF. The behavior of pigs weaned at 12 and 21 days of age from weaning to market. *Can J Anim Sci*. 1999;78:517–523.

10. Ingram DL, Walters DE, Legge KF. Variations in motor activity and in food and water intake over 24 hr periods in pigs. *J Agric Sci*. 1980;95:371–380.

11. Federal Ministry of Food, Agriculture and Consumer Protection. Regulation to Protect Farm Animals. 1st rev ed. Bonn, Germany: Federal Ministry of Food, Agriculture and Consumer Protection. 2009. Available at: `http://bundesrecht.juris.de/tierschnutztv/BJNR275800001.htm`. Accessed 26 May 2010.

12. Reiners K, Hessel EF, Van den Weghe HFA. The effect of heated mash on performance and feeding behavior of newly weaned piglets. *J Anim Sci*. 2008;86:3600–3607.

13. Klopfer FD, Butler RL. Color vision in swine. *Amer Zool*. 1964;4:294.

14. Bigelow JA, Houpt TR. Feeding and drinking patterns in young pigs. *Physiol Behav*. 1988;43:99–109.

15. Bruininx EMAM, Heetkamp MJW, van den Bogaart D, van der Peet-Schwering CMC, Beynen AC, Everts H, den Hartog LA, Schrama JW. A prolonged photoperiod improves feed intake and energy metabolism of weanling piglets. *J Anim Sci*. 2002;80:1736–1745.

16. Niekamp SR, Sutherland MA, Dahl GE, Salak-Johnson JL. Immune response of piglets to weaning stress: Impacts of photoperiod. *J Anim Sci*. 2007;85:93–100.

17. Marx D, Buchholz M, Mertz R. Beziehungen zwischen Haltungstechnik and Tagesrhythmus bei frühabgesetzten Ferkeln [Relations between housing technology and diurnal rhythm of newly weaned piglets]. In: KTBL [Association for Technology and Structures in Agriculture], eds. *Aktuelle Arbeiten zur artgemäßen Tierhaltung 323* [Current papers on animal welfare]. Münster, Germany: Landwirtschaftsverlag Münster; 1988:9–35.

18. Lewczuk B, Przybylska-Gornowicz B. The effect of continuous darkness and illumination on the function and the morphology of the pineal gland in the domestic pig. Part 1. The effect on plasma melatonin level. *Neuroendocrinol Lett.* 2000;21:283–291.

19. Fraser AF, Broom DM. Organization of behavior in the individual animal. In: Fraser AF, Broom DM, eds. *Farm Animal Behavior and Welfare*. 3rd ed. Oxon, United Kingdom: CAB International; 2004:69–135.

20. Christison GI. Dim light does not reduce fighting or wounding of newly mixed pigs at weaning. *Can J Anim Prod*. 1996;76:141–143.

*21. Bearss WH, Hacker RR, Batra TR. Some effects of total darkness on young pigs [abstract]. *J Anim Sci.* 1988;39:153.

22. Hsia LC, Wood-Gush DGM. Social facilitation in the feeding behavior of pigs and the effect of rank. *Appl Anim Ethol*. 1984;11:265–270.

23. Barnett JL, Cronin GM, McCallum TH, Newman EA. Effects of food and time of day on aggression when grouping unfamiliar adult pigs. *Appl Anim Behav Sci*. 1994;39:339–347.

24. Taylor N, Prescott N, Perry G, Potter M, Le Sueur C, Wathes C. Preference of growing pigs for illuminance. *Appl Anim Behav Sci*. 2006;96:19–31.

25. McGlone JJ, Stansbury WF, Tribble LF, Morrow JL. Photoperiod and heat stress influence on lactating sow performance and photoperiod effects on nursery pig performance. *J Anim Sci*. 1988;66:1915–1919.

26. Lay DC, Buchanan HS, Haussmann MF. A note on simulating the "Observer Effect" using constant photoperiod on nursery pigs. *Appl Anim Behav Sci*. 1999;63:301–309.

27. Buchenauer D, Fliegner K, Dannemann-Wessel K, Jopski E. Beispiele für haltungsbedingte Änderungen von Tagesrhythmen [Examples for changes in diurnal rhythms depending on housing environment]. In: KTBL [Association for Technology and Structures in Agriculture], eds. *Aktuelle Arbeiten zur artgemäßen Tierhaltung 323* [Current papers on animal welfare]. Münster, Germany: Landwirtschaftsverlag Münster; 1988:36–37.

28. Bure RG. Anpassungsprobleme in der Schweinehaltung [Problems of adjustment in pig production]. In: KTBL [Association for Technology and Structures in Agriculture], eds. *Aktuelle Arbeiten zur artgemäßen Tierhaltung 281* [Current papers on animal welfare]. Münster, Germany: Landwirtschaftsverlag Münster; 1982:168–172.

29. Veissier I, Le Neindre P, Trillat G. The use of circadian behavior to measure adaption of calves to changes in their environment. *Appl Anim Behav Sci*. 1989;22:1–12.

* Non-refereed reference.