RESEARCH ARTICLE

Feed intake behaviour of piglets in single and group suckling pens

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Received: Sept 29, 2020
Revised: November 03, 2020
Revised: December 31, 2020
Accepted: January 05, 2020

HIGHLIGHTS

- **Creep feed intake was highest in group suckling pens when compared to two single suckling pens, but piglets did not gain more weight.**
- **Overall, the prevalence of pigs visiting the trough of the sow was just as high as of pigs visiting the creep feeding place.**
- **Around 25 % of the studied piglets were never observed at the feeding area.**

KEYWORDS **creep-feed, free-farrowing, feed intake, social facilitation**

Abstract

Early contact to plant-based feed (creep feed) should stimulate the adaption of the gastrointestinal system and promote gut development, with the desired effect of less physiological stress at weaning, lower incidence of diarrhoea and higher growth rates due to better feed efficiency.

From May 2013 to July 2015 we studied the feed intake behaviour of piglets during a 6-week suckling period (93 farrowings, 917 weaned piglets). The piglets were born in one of two different free farrowing systems for one sow, after two weeks half of the farrowing batches were transferred to a group suckling system from their initial housing system (2x2 factorial design: initial housing organic or conventional and subsequent grouping or not). We observed the time the piglets began to consume relevant amounts of creep feed, the quantities they consumed, their growth rates and the frequency and length of their visits at two locations for feeding (piglet area, trough of sow). Additionally, we tested whether intervisibility between the two feeding areas influenced feed intake of the piglets.

Piglets that remained in the single suckling systems consumed 18.6±4 g piglet^{-1} (organic) and 26.1±4 g piglet^{-1} (conventional) on days 7-9 after the beginning of the creep feeding period. In the same time period, piglets transferred to the group suckling system from organic pens consumed 7.1±4 g piglet^{-1} and piglets from conventional pens 16.2±4 g piglet^{-1}. Piglets that remained in the organic single suckling pen were heaviest at weaning (11.9±0.2 kg) but consumed only 43.6±19 g piglet^{-1} on days 22-24 after beginning of the creep feeding period. Piglets in the group suckling system consumed 125.0 g piglet^{-1} (conventional) and 236.4 g piglet^{-1} (organic), but weighed only 10.6 kg (conventional) and 11.0 kg (organic).

Subsequent grouping and the interaction of initial housing, grouping and day had a statistically significant effect on feed intake (grouping: p=0.03; interaction: p<0.001) and body weight of piglets (grouping: p=0.01; interaction: p<0.001). Influence of birthpen was significant only for body weight (p<0.001).

Within the four hours observed (11:00-13:00; 16:00-18:00), the piglets visited the feeding places on average 4 times a day, with one peak at the beginning of the feeding phase and another one close to weaning. Piglets in the group suckling system spent most of the time at the creep feeding place (organic: 9.9±1 min, conventional: 9.6±1 min) and less than one minute at the sow's trough. Piglets in the organic system spent the least amount of time at the feeding place (2.5±1 min, statistically significant) and most of it at the sow's trough (4.6±1 min). Piglets in conventional pens were observed for 7.2±1 min at the creep feeding place and 8.2±1 min at the sow's trough.

Piglets consumed more at feeding places when provided intervisibility with the sow's trough, but the difference was not statistically significant. Overall, the prevalence of pigs visiting the creep feeding area was as high as of pigs visiting the trough of the sow.

The results suggest that to promote feed intake at the creep feeding place, group suckling is preferable to single litter suckling systems.

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1 Introduction

Natural weaning of pigs gradually progresses over several weeks. Brooks and Tsourgiannis (2003) distinguish four developmental phases: hiding, following, learning and independence. Until day 16, piglets mainly stay inside their nest (hiding phase) and begin to leave in week two, resting close by the foraging sow and sampling the food she eats (following phase). Piglets at productive teats still exclusively suckle the sow, while littermates suckling a less productive teat will often start to consume solid feed earlier. In week four they begin to apply this acquired knowledge and actively explore which foods are palatable (learning phase). As suckling frequency diminishes around week eight, the piglets enter the phase of independence and weaning.

In commercial farming however, it became common practice to abruptly separate the piglets from the sow several weeks earlier than under natural conditions. This can cause stress, often leading to malnutrition, weakened immune status and post weaning diarrhea (Moeser et al., 2017; Pluske et al., 2018). Farmers and veterinarians regularly must administer antibiotics to prevent animal suffering and monetary losses. As Kruse et al. (2019) report, 65 % and 54 % of antibiotic treatment doses for weaners and finishers in Danish organic pig herds (80 and 68 % in conventional herds) are accountable to gastrointestinal indication. This is a serious health and welfare issue and negatively impacts growth and feed efficiency in the growing stage.

There is a range of feed additives and components utilised in an effort to alleviate the negative symptoms of early weaning (e.g. pro- and prebiotics, organic acids, short- and medium chain fatty acids; for reviews see: Dong and Pluske (2007) and Rhouma et al. (2017). While these compounds may be able to provide help as auxiliary measures, solid feed intake of many piglets is usually low during the suckling phase and the first days after weaning, thereby constraining their efficacy.

Suckling piglets cover only 1.2 % to 17.4 % of their total energy demand with solid feed (Pluske et al., 1995). On day 7 after weaning at day 26 (average body weight of 8.4 kg) energy uptake was found below maintenance in 45 % of the piglets dissected by Vente-Spreeuwenberg et al. (2003). This had a negative effect on villus height and brush border enzyme activity in the small intestine and thereby increased faecal score (0-3; where 3=thin, liquid faeces) and the risk for diarrhoea. Usually, creep feed is offered with the intention of facilitating the transit from milk to solid food (Meyer, 2013). Piglets that consume creep feed before weaning might have increased feed intake post weaning (Muns and Magowan, 2018), but the consumed amount of creep feed varies heavily between and within litters (Azain et al., 1996; Corrigan, 2002; Pajor et al.,1991).

Sow and litter of wild boars synchronously increase their activity after farrowing, and as they begin to forage together the piglets encounter a broad variety of food sources (Gundlach, 1968). With an innate aversion for bitter (Nelson and Sanregret, 1997; Roura et al., 2008) and a preference for sweet taste, young pigs differentiate between wholesome digestible and potentially harmful foodstuff. Still it would be advantageous for them to observe closely where and what the experienced piglets or the sow are foraging. Among other influences (e.g. palatability, sensory diversity, milk yield of sow), learning and social facilitation therefore could act as mechanisms to overcome food neophobia and increase solid feed intake of piglets.

Oostindjer et al. (2011) utilized social learning in pigs by demonstrating that piglets showed interest for the feed of the sow even when they could not reach it. When they gained access to it, they began to eat sooner and consumed greater amounts than piglets that had never observed the sow eating. Morgan et al. (2001) found that the feed intake of piglets inexperienced with solid feed increased when they were housed together with an experienced piglet.

Clayton (1978) defined social facilitation of behaviour as "an increase in the frequency or intensity of responses or the initiation of particular responses already in an animal's repertoire, when shown in the presence of others engaged in the same behavior at the same time". Pigs are highly social and feeding behaviour is synchronised. By demonstrating that already satiated pigs will resume feeding due to the introduction of another feeding pig, Hsia and Wood-Gush (1984) could confirm that social facilitation affects the feeding behaviour of pigs.

In this study, we assessed how feed intake behaviour of piglets differed in three free farrowing systems that vary in placement of the creep feed and the number of litters present in one pen by usage of the feeding area and consumption of creep feed. We expected to observe clear differences in feed intake behaviour of piglets between the three systems. To investigate the effect of social learning on feed intake of piglets, we also tested the effect of intervisibility between the feeding place of the sow and the creep feeding place within one of the three systems.

2 Materials and Methods

We collected data (group level: feed intake; animal: live weight, feeding place usage) of 93 litters (917 weaned piglets) and 44 sows (1-4 litters per sow) between May 2013 and July 2015. The experiment took place at the research farm of the Institute of Organic Farming and Farm Animal Biodiversity (Agricultural Research and Education Centre Raumberg-Gumpenstein) in Thalheim/Wels. The farm keeps an average of 45 sows in a 3-week production rhythm with a group size of six sows per farrowing batch. Piglet losses are recorded, and cause of death is routinely evaluated by autopsy.

2.1 Experimental design

To analyse feeding place usage in the three different housing systems we used video recording (one day per week). Four of the pens were of type „Welser" (W), four pens were type „WelCon" (WC) and one of them was a group suckling pen (GS, capable of housing up to five sows).

To ensure consistent group sizes, we decided on a batch size of four sows. There was one farrowing batch per treatment and four consecutive batches were one replication. In total there were six replications, three with 16 litters (replication 2, 3, 4) and three replications with only 15 litters (replication 1, 5, 6).

One week before parturition, the sows were moved to one of two different single farrowing systems: one of those was designed to comply with organic standards (Welser pen), the other one built as a conventional loose housing pen (WelCon pen). Two weeks after parturition 46 of the 93 litters (10 batches of four and two batches of three litters) were moved from this initial housing system (birthpen) to the group suckling system. The remaining 47 litters (11 batches of four and one batch of three litters) stayed in their respective single farrowing pens. Because the group size on the research farm is 6, the possibilities for randomization of sows were limited. Therefore, not every sow was housed in every system and if possible, we tried to not assign one sow too often to the same treatment.

2.2 Pen layout

The farrowing pen of type Welser is 12.5 m² big (4.3 m² lying, 6.0 m² free-run, 1.1 m² for eating, 1.1 m² as creep area). The lying area is in an outdoor environment and constructed as wooden huts with removable lids and a subdivided piglet area. A plank was mounted between creep feeding place and lying area/nest to keep the creep feed clean from straw. The creep feeding place of this pen is physically separated from the trough of the sow and located at the opposite side of the pen (Figure 1).

Layout and arrangement of the functional areas of farrowing pens type WelCon (6.5 m²) is like the Welser pens, but these were constructed indoors and did not provide an outdoor-run, therefore they did not comply with organic standards. The creep feeding place (0.33 m²) is not accessible for the sow but located right next to her trough. To provide interivisibility, the pens had an opening between the trough and the feeding place. The opening was equipped with stainless steel bars (30 x 40 cm) that could be easily closed with a PVC panel. Through these bars, the piglets were able to see, hear and smell the sow when eating. This window was open in either one, two or none of the four WelCon pens in each of the five replications (Table 1). Temperature was measured

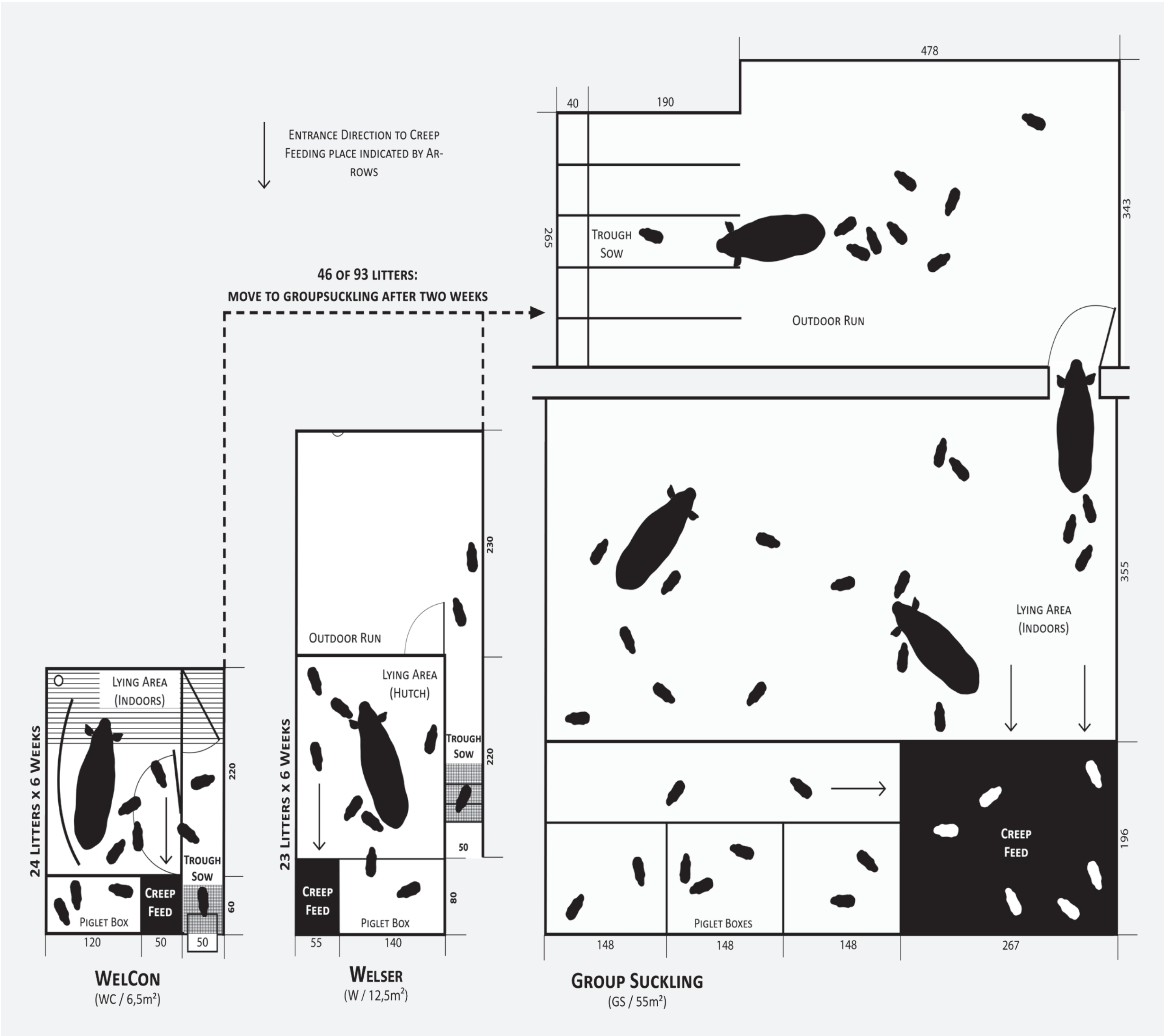


FIGURE 1
Pen layout in the different housing systems

TABLE 1
In each of the four WelCon pens a window provided intervisibility between trough of sow and creep feeding. The window was either closed or open.

Replication	Pen 1	Pen 2	Pen 3	Pen 4
1	Open	Open	Closed	Closed
2	Closed	Open	Open	Closed
3	Closed	Open	Open	Open
4	Closed	Closed	Closed	Closed
5	Open	Closed	Closed	Open
6	Closed	Closed	Open	Open

only in WelCon pens and therefore only included in the analysis of effect of intervisibility.

The group suckling pen for up to five sows offerd 25.5 m^2 for lying and activity, an outdoor run of 16.1 m^2 and an area only for piglets (13.8 m^2). The piglet area had three separate creep nests and one shared area for feeding (2.8 m^2).

2.3 Feeding

The sows in group pens were fed in troughs in the outdoor run. These troughs were transponder activated and only opened when the respective sow stood in front of it. The piglets therefore had only limited access to the trough of the sow. When the sows were moved to the group suckling pens, they took some time to learn how to use the transponder. Within half a day, every one of them was able to feed at her allotted trough. The animals were fed twice a day at 6:00 in the morning and between 12:00 and 13:00. All pens were provided with straw and no other kind of roughage was offered to the animals.

Sows were fed ad-libitium with dry feed. To calculate the amount of feed consumed by each sow, the daily amount of feed was recorded, and the amount of leftover feed measured once a week in the individual troughs.

Piglets were fed creep feed when they were 17±1.8 days old. Creep feed was offered on the floor of the creep feeding area in all three farrowing systems. The feed was weighed daily to calculate feed intake for single or mixed litters (group suckling). With the start of creep feeding, each litter was fed 200 g of feed independent of litter size. If less than 60 g were left over the next day, the litter was fed 100 g more. Because feed intake was low after the beginning of the creep feeding phase we grouped the data in eight periods of three days per period. Composition of the sow and creep feed is shown in Table 2.

2.4 Behavioural observations

A camera (Geovision GV-BX-1300-KV) was mounted above each creep feeding place and every sow-trough. From the start of creepfeeding until weaning, the feeding places were recorded every Monday and Tuesday from 05:30 to 18:30. The videos were observed continuously from 11:00 to 13:00 and between 16:00 to 18:00. To assign location (creep feeding place, sow trough) and timestamps for each animal, we used Interact (V.14, Mangold). To identify individual piglets, they were marked with numbers on their back. Unusable videos from Mondays were replaced by using one of the following (tues-)day. Prior to the analysis, each of the three observers had to code a video of one hour length according to the

TABLE 2
Composition and calculated nutrient and energy contents of the diets for the sow and the creep feed

Ingredients/Composition	Lactation feed (meal)	Creep feed (pelleted)
Maize, %	20.0	-
Barley, %	20.0	24.0
Wheat, %	-	25.7
Soy cake, %	11.7	14.1
Triticale, %	10.0	-
Sunflower cake, %	10.0	-
Wheat bran, %	10.0	-
Faba bean, **%**	8.0	-
Dried alfalfa meal , **%**	5.0	-
Rye, %	1.5	-
Oat cake, %	-	12.0
Pea, %	-	9.5
Skimmed milk powder, %	-	7.5
Pumpkin seed cake, %	-	4.7
Mineral mix, %	3.8	2.5
Dry Matter, g kg^{-1}	889	882
ME, MJ/kg * kg^{-1} DM	12.5	13.5
Crude protein, g kg^{-1} DM	155	194
Crude fat, g kg^{-1} DM	50	34
Crude fibre, g kg^{-1} DM	64	37
N-free extractives, g kg^{-1} DM	564	566
Crude ash, g kg^{-1} DM	55	51

TABLE 3
Ethogram for behaviour assessment

Piglet enters creep area	Head of the piglet inside the feeding area, shoulder at height of the pen-border
Piglet leaves creep area	Head of piglet in activity area, shoulder at height of the pen-border. If a piglet leaves in reverse, the whole body has to be outside of the creep area.
Sow at trough	Sow is inside the stall, head looks down and is inside the trough. Short disruptions of less than 2 seconds were not counted. If the head was in horizontal position for at least 3 seconds, the observation was terminated.
Piglet at sow trough	Same criteria as with the creep area; piglets were recorded if they crossed a line 50 cm away from the edge of the trough

ethogram (Table 3) until reaching agreement above 80 % in the KAPPA-Test (Altman 1991, Viera and Garrett 2005).

2.5 Statistical analysis

Data were analysed using SAS Enterprise Guide 9.4. All data were normally distributed and computed as mixed linear models. Multiple comparison of means were conducted using the Tukey-Kramer test ($p \leq 0.05$). Body weight was measured on individual piglets at multiple time points. To consider the random effect of the individual piglet, body weight and daily weight gain were analysed using the procedure MIXED. Feed intake was measured at group level at multiple time points, therefore 'day' was analysed as the repeated measure with 'number of litter' specified as subject. Four suitable covariance structures were tested (Toeplitz, autoregressive (1), unstructured, 20 variance components), of which First order autoregressive structure [type = ar(1)] was chosen because of the BIC being closest to zero.

Videos of piglets and sows were coded using Interact, events of less than five seconds were removed from the dataset. Not aggregated frequencies of observations were analysed exploratory and represented as diagrams. Because these data were not normally distributed, tests of significance were computed in SAS using aggregated data of individual animals (visits animal^{-1} day^{-1}). Events of animals that were not identifiable were removed from the data set. The following final models were used for the analyses:

Bodyweight of individual piglets:

$$Y_{klmnopqr} = \mu + IH_k + SG_l + R_m + IH_k \times SG_l \times d_n + R_o + LS_p + S_q + P_r + \varepsilon_{klmnopqr}$$

with

$Y_{klmnopqr}$: Body weight (kg piglet^{-1})
μ : Intercept
IH_k : Fixed effect of initial housing system (k=2)
SG_l : Fixed effect of subsequent grouping (l=2)
R_m : Fixed effect of replicate (m=6)
$IH_k \times SG_l \times d_n$: Interaction H_k, SG_l and fixed effect of day$_n$ (n=1, 8, 15, 22, 25)
R_o : Fixed effect of replicate (o=6)
LS_p : Fixed effect of litter size (p=5, 6 … 14)
S_q : Random effect of sow (q=number of ear tag) within replicate
P_r : Random effect of piglet (r=number of ear tag)
$\varepsilon_{klmnopqr}$: Random error

Feed intake of piglets (group level):

$$Y_{klmnop} = \mu + IH_k + SG_l + R_m + IH_k \times SG_l \times p_n + LS_o + L_p + \varepsilon_{klmnop}$$

with

Y_{klmnop} : Feed intake (g day^{-1})
μ : Intercept
IH_k : Fixed effect of initial housing system (k=2)
SG_l : Fixed effect of subsequent grouping (l=2)
R_m : Fixed effect of replicate (m=6)
$IH_k \times SG_l \times p_n$: Interaction IH_k, SG_l and fixed effect of 3-day-period$_n$ (n=8)
LSo : Fixed effect of litter size (p=5, 6 … 14)
Lp : Random effect of litter (q=93)
ε_{klmnop} : Random error

Effect of intervisibility on feed intake:

$$Y_{klmnopqr} = \mu + R_k + SK_l + WK_m + VT_n + S_o + Lactday_p + WG_q + Temp_r + \varepsilon_{klmnopqr}$$

with

$Y_{klmnopqr}$: Variable studied – feed intake (g piglet^{-1} day^{-1}) :
μ : Intercept
R_k : Fixed effect of replicate (k=6)
SK_l : Fixed effect of intervisibility (l=1,2)
WK_m : Fixed effect of parity group (m=4)
VTB_n : Fixed effect of time (n=8 periods of 3 days each)
So : Random effect of sow (o=19)
$Lacday_p$: Day of lactation of sow (p=age of piglets)
WG_q : Littersize q
$Temp_r$: Temperature r (inside, mean of 4 hours, 11:00-13:00 and 16:00-18:00)
$\varepsilon_{klmnopqr}$: Random error

Behavioural observations (visits/time spent at feeding place/sow trough per piglet per replicate; average duration of visits per piglet):

$$Y_{klmn} = \mu + IH_k + SG_l + IH_k \times SG_l + R_m + P_n + \varepsilon_{klmn}$$

with:

Y_{klmn} : Variable studied
μ : Intercept
IH_k : Fixed effect of initial housing system k (k=2)
SG_l : Fixed effect of subsequent grouping l (l=2)
$IH_k \times SG_l$: Interaction $H_k \times SG_l$
R_m : Fixed effect of replicate (m=6)
P_n : Random effect of piglet (n=number of ear tag)
ε_{klmn} : Random error

3 Results

1.173 piglets (93 litters) were born during May 2013 and July 2015, of those 917 piglets were weaned. 23 piglets died during the creep feeding phase. 89 % of the lost piglets died within the first 14 days after birth. 43 % of all losses were due to crushing and 13.5 % of piglets starved (Table 4).

TABLE 4
Mean reproductive performance in the different housing systems (standard deviation in parentheses)

Initial housing system: Subsequent grouping:	Welcon No	Welcon Yes	Welser No	Welser Yes	Total
Number of litters	24	22	23	24	93
Piglets born alive	12.3 (3.3)	14.1 (3.6)	11.5 (3.2)	12.5 (2.6)	12.6 (3.0)
Stillborn piglets	1.0 (2.3)	1.0 (1.2)	1.0 (1.4)	1.3 (1.3)	1.1 (2)
Piglets weaned	9.3 (1.8)	10.0 (1.3)	9.8 (1.9)	10.4 (1.6)	9.9 (2)
Piglet losses (%)	21.0 (15.1)	28.0 (15.1)	15.8 (14.2)	15.0 (22.8)	19.8 (15)

Weaning weight of piglets (day 37 to day 50) was 11.9 kg in Welser pens, which is statistically significantly higher than those of the other systems, which do not differ statistically (Table 5).

The effect of birthpen was statistically not significant ($p=0.972$), but the effect of subsequent grouping was ($p=0.03$). The interaction of initial housing system, subsequent grouping and day on feed intake was statistically significant ($p<0.001$): after the move to the group suckling pen both grouping treatments consumed less than the piglets in single farrowing systems, and piglets from organic pens ate less than those from conventional pens (Figure 2).

TABLE 5

LS-means of body weight (kg pig^{-1}) for the four treatments at day 1, 8, 15, 22, 25 after grouping (pigs were weaned at day 25 after grouping)

Birthpen	Welser		WelCon	
Suckling	**GS**	**SS**	**GS**	**SS**
Day 1	5.4 (0.1)	5.5 (0.1)	5.1 (0.1)	5.3 (0.1)
Day 8	7.5^{a} (0.1)	7.0^{ab} (0.1)	6.9^{ab} (0.1)	9.8^{b} (0.1)
Day 15	9.3^{a} (0.1)	8.6^{b} (0.1)	8.6^{b} (0.1)	8.3^{b} (0.2)
Day 22	11.1^{a} (0.2)	10.3^{b} (0.2)	10.0^{b} (0.2)	9.9^{b} (0.2)
Day 25	11.9^{a} (0.2)	11.0^{b} (0.2)	10.7^{b} (0.2)	10.6^{b} (0.2)

GS=group suckling, SS=single suckling
standard errors are given in parentheses
row entries with differing superscripts are significantly different ($p<0.05$)

TABLE 6

LS-means of feed intake (g pig^{-1}, as fed) on the eight three-day-periods after first creep feed presentation

Birthpen	Welser		WelCon	
Suckling	**GS**	**SS**	**GS**	**SS**
Day 1-3	7.7 (3.7)	18.4 (3.6)	9.1 (3.9)	20.5 (3.5)
Day 4-6	8.5^{b} (3.6)	19.9^{ab} (3.5)	13.1^{ab} (3.8)	24.0^{a} (3.4)
Day 7-9	7.1^{b} (4.2)	18.6^{ab} (4.2)	16.2^{ab} (4.4)	26.1^{a} (4.1)
Day 10-12	10.5 (4.5)	23.3 (4.4)	18.0 (4.6)	27.2 (4.3)
Day 13-15	20.4 (4.8)	21.7 (4.8)	21.7 (5.1)	34.0 (4.7)
Day 16-18	40.7 (5.9)	21.6 (5.9)	39.4 (6.3)	34.6 (5.8)
Day 19-21	104.6^{a} (11.9)	30.1^{b} (12.1)	57.1^{ab} (12.4)	63.9^{ab} (11.8)
Day 22-24	236.4^{b} (18.1)	43.6^{a} (18.5)	125.0^{a} (18.8)	106.2^{a} (18.1)

GS=group suckling, SS=single suckling
standard errors are given in parentheses
row entries with differing superscripts are significantly different ($p<0.05$)

Close to weaning, feed intake in the group suckling treatment was higher than in the single suckling treatment and piglets from organic pens consumed significantly more in the group suckling pen than those from conventional pens (Figure 1, Table 6).

Piglets in WelCon pens with intervisibility between the trough of the sow and the creep feeding place (n=10 litters) consumed on average 20±37 g day^{-1} until weaning, piglets who could not see the sow (n=14 litters) consumed 7±10 g day^{-1}. However, the difference was not statistically significant ($p=0.290$).

On average, every piglet visited the creep feeding place 4 times for 1.2 minutes per visit within the four hours observed every day (between 11:00 and 13:00 and 16:00 and 18:00).

In all systems, piglets were observed longer and more frequently at the piglet feeding area than at the trough of the sow. Piglets in WelCon pens frequented the feeding place (sow and creep feed) significantly more often and the number

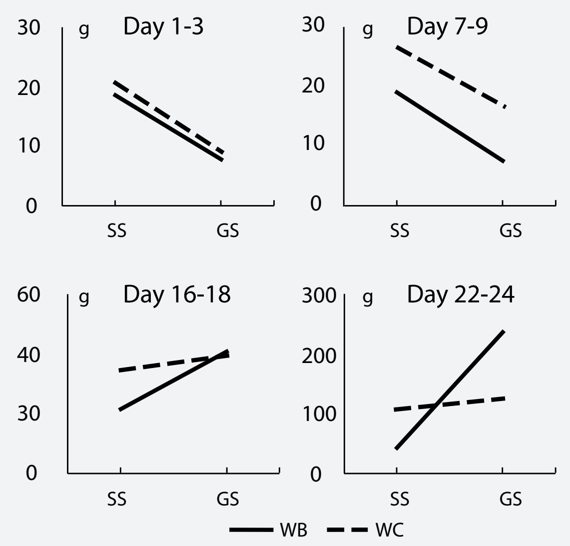


FIGURE 2

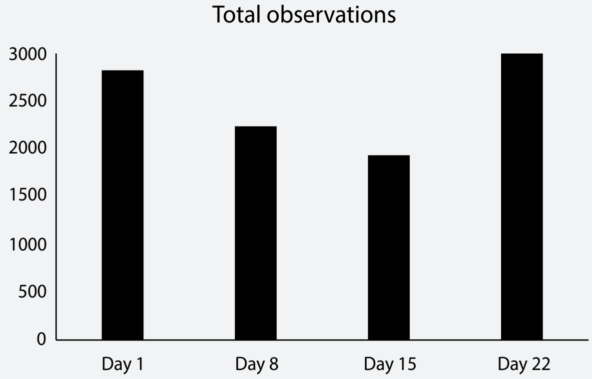
Interaction of initial housing system (WB=Welser/organic; WC=WelCon/conventional) and subsequent grouping (single suckling=SS; group suckling=GS) on feed intake (g pig^{-1}) on four three-day-periods after first creep feed presentation

TABLE 7

LS-means of visits and time (min.) spent at the feeding place of piglets (FP) and sow (FS) during an observation period of 4h per day on days 1 to 25 after first creep feed presentation

Birthpen	Welser		WelCon	
Suckling	**GS**	**SS**	**GS**	**SS**
Visits FP	4.8^{a} (0.4)	3.0^{b} (0.4)	4.5^{a} (0.4)	4.8^{a} (0.3)
Visits FS	3.3^{a} (0.3)	5.1^{b} (0.3)	3.3^{a} (0.3)	5.4^{b} (0.3)
min. FP	9.9^{a} (1.0)	2.5^{b} (1.0)	9.6^{a} (1.0)	7.2^{a} (0.9)
min. FS	0.9^{a} (0.2)	4.6^{b} (0.2)	1.1^{a} (0.2)	8.2^{c} (0.2)

GS=group suckling, SS=single suckling
standard errors are given in parentheses
row entries with differing superscripts are significantly different ($p<0.05$)



Min.	<0.5	0.5-1	1-5	>5	Total
Day 1	61 %	21 %	17 %	1 %	100 %
Day 8	49 %	23 %	26 %	2 %	100 %
Day 15	42 %	20 %	33 %	5 %	100 %
Day 22	33 %	20 %	34 %	12 %	100 %

FIGURE 3
Total observations at trough of sow and creep feeding place on day 1, 8, 15 and 22 after first creep feed presentation and percentages of duration of visits during an observation period of 4h per day

of visits per piglet and day is significantly higher than in the other systems (Table 7).

The frequency of visits at the two feeding places varied between individual piglets, some were observed exclusively at one of the two.

When the pigs were first introduced to creep feed, 60 % of all observations at the feeding places were less than 30 seconds long. The total amount of visits decreased until day 15 after the start of the creep feeding period. At day 22, close to weaning, the share of longer visits increased (Figure 3). In none of the systems more than 75 % of the piglets in a pen were observed at the feeding place.

4 Discussion

Piglets visited the creep feeding place four times during the daily observation periods. Since the data were collected on only four separate days and within 4 hours on each of those days, this necessarily is an underestimation of the actual number of visits per day. Relative to this mean number of visits, the piglets were observed at the feeding place more frequently on the first and the last day of the creep feeding phase.

On the first day though, 60 % of visits were of short duration (<30 seconds). The share of these short visits decreased, whereas the share of longer visits (>5 minutes) increased over time. The production of carbohydrate-degrading enzymes and proteases in gastrointestinal tract of a piglet increases with age (Jensen et al., 1997; Lindemann et al., 1986). Solid feed intake of the piglets correspondingly increased around day 35 of live (day 18 after first creep feed presentation), also visits at the creep feeding site increased in frequency and duration. It seems that the piglets initially explored the space to collect information and only later, when demand for food was growing, used it as a foraging site.

Available space might have affected the use of the creep feeding area by simply increasing the probability of a piglet to enter. In WelCon pens (0.66 m^2 per animal), piglets visited the creep feed area significantly more often than in Welser pens (1.24 m^2 per animal) or group suckling pens (1.38 m^2 per animal). Since size of the pen affects the functionality of the different areas for lying, feeding and activity, piglets in WelCon pens additionally could have expanded the activity into the area designated for feeding. This hypothesis is supported by the lower duration of visits of the creep feeding place.

The group suckling system housed around 40 to 50 piglets per pen. The increased duration per visit of the feeding area could have been because of social facilitation of feeding behaviour, while the lower frequency of visits could be partly due to the social drive to interact with other pigs, licking and touching their penmates to get to know them. Social drive and feeding behaviour are represented by groups of neurons that can inhibit each other if activated. In mice, optogenetic stimulation of selected neurons exlusively related to feeding increased specific feeding behaviours, while stimulation of neurons related to exploratory social behaviour (getting to know a juvenile individual) resulted in decreased feeding behaviour (Jennings et al., 2019).

Verdon et al. (2019) report more disrupted nursing behaviour in group suckling systems. This might have additionally increased creep feed intake by decreasing the amount of milk piglets could consume.

While it is common practice to invest considerable thought, time and money into the design of a (separate) creep feeding place, the benefit of these efforts is arguable: piglets were observed at the trough of the sow just as much as at the creep feeding place. The rewarding character of foraging and the negative reinforcement of sensory satiation contribute to the motivation of pigs to explore their surroundings and consume different kinds of food. Middelkoop et al. (2018) showed that creep feed consumption per piglet increased, if an additional food contributed to dietary diversity. The difference in the sensory qualities of creep-feed and sow feed therefore could have been another factor that drove piglets to visit the trough of the sow.

On average piglets consumed more feed in pens with intervisibility between sow-trough and creep feeding place. Although the difference was not statistically significant, this could have been due to a too low sample size (n=24) considering the relatively high variability in feed intake within the two groups.

Even though piglets in Welser pens were heaviest at weaning, they consumed the least amount of creep feed. They therefore might be more likely to suffer post weaning weight depression. Sulabo et al. (2010) report that although being heavier at weaning, non-eaters consumed less feed in the first three days post weaning (20±2 d) when compared to eaters. As it is questionable if these results can be extrapolated to later weaning age, it is worthwhile to consider further hypothesis why heavier pigs might mainly consume milk until weaning and consume less feed in the first days after weaning.

Sommavilla et al. (2015) found that piglets suckling at anterior teats, which tend to be more productive, were found to be heavier than their littermates at weaning (on day 28). After weaning they spent more time lying and less time eating and vocalising. The authors attribute this to their lower experience in recognizing, consuming and ingesting solid food, but also argue that due to their higher reserves, heavier pigs from anterior teats could have adopted an energy saving strategy to cope with weaning stress (Sommavilla et al., 2015).

In general, the percentage of piglets that consume relevant amounts of solid feed before weaning seems limited and very variable. Pajor et al. (1991) report differences in individual feed intake of 13 g to 1911 g from start of creep feeding (day 10-28, Ø 12) until weaning at day 28. Middelkoop et al. (2018) observed around 5 % to 19 % so called "non-eaters", piglets that never visited the feeding place. The number of non-eaters in our study was similar: at most, we observed 75 % of all animals of one pen visiting the feeding place.

The assessment of measures to promote feed intake therefore should not focus on the total amount of consumed feed per pen only, but also on differences in the share of "non eaters". After weaning, "non-eaters" might require particular attention, as they could be prone to developing weaning diarrhoea. To routinely identify "high", "low" and "non-eaters" without utilising labour intensive video analysis or messy food coloring and rectal swabs, it is necessary to develop new tools. Smart- and precision (livestock) farming might offer interesting solutions addressing this problem (Adrion et al., 2018; Brown-Brandl, 2017; Zhang et al., 2019).

5 Conclusions

Piglets began to consume relevant amounts of creep feed on the 29th day of life in the single suckling systems and on the 35th day of life in the group suckling pen. Yet piglets in the group suckling system consumed significantly more creep feed, probably due to social facilitation of feed intake. In the single farrowing systems, the piglets were observed at the trough of the sow as frequently as at the creep feeding place. Piglets that could see the sow trough at the creep feeding place consumed considerably more food. Likely due to the low sample size the difference was statistically not significant, this result therefore needs further validation.

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