Effects of animal/feeding-place ratio on the behaviour and performance of fattening pigs fed via sensor-controlled liquid feeding

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Abstract

Sensor feeding is a liquid feeding system for fattening pigs that is run with a restricted animal/feeding-place ratio (AFR). Feeding occurs at specific periods, so that the trough is left empty in-between. Therefore, it must be regarded as an ad libitum feeding system. The aim of the present study was to quantify the effect of three different AFRs (4:1, 7:1 and 13:1) with nine, six and three feeding places per group, respectively, on the behaviour and performance of fattening pigs (25–100 kg) housed in groups of 40 individuals. Each AFR was tested with seven groups (21 groups in total). With each group, four pigs were selected from each weight class (lightweight, middleweight and heavyweight) as focal animals. The behaviour in the feeding area was observed by means of 24 h-video-recording for the 12 focal pigs at an age of 14 and 17 weeks. Daily weight gain was calculated for all animals. As the AFR increased, feeding bout duration at the trough declined significantly ($p < 0.001$), whilst the duration of waiting increased ($p < 0.001$). The AFR had no significant effect on the frequency of aggressive displacements at the feeding trough. On the other hand, the fatteners were more frequently pushed away from the trough without aggressive interactions as the AFR increased ($p < 0.001$). Besides the AFR, the age and weight class of the focal pigs had a significant effect on behaviour. Lightweight animals waited longer for access to the trough and were more often displaced from the trough as a consequence of aggressive interactions. Weight gain was lower as AFR increased ($p < 0.001$), an effect that was more pronounced in lightweight focal
animals \((p < 0.001)\). In conclusion, the AFR has a decisive influence on the behaviour and performance of fattening pigs fed by sensor feeding. Lightweight pigs, most likely the subordinate group members, are more affected by an increased AFR, and hence most at risk of impaired welfare. An AFR of 13:1 has marked negative effects on the pigs’ performance and behaviour and is inadvisable to be used for this feeding system.

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1. Introduction

Over the past few years, various new feeding systems for fattening pigs have been developed. One of these systems is sensor-controlled feeding, whereby the animals are fed with liquid feed. A sensor registers the liquid feed level of the trough, which will automatically be refilled if empty. Unlike ad libitum feeding systems with dry feed, sensor feeding occurs at periods, so that the trough is left empty in-between these periods. Nevertheless, sensor feeding must be considered an ad libitum feeding system, as the total amount of feed provided per day is usually at the upper limit of the pigs’ consumption capacity. Finally, sensor feeding is run with a restricted animal/feeding-place ratio (AFR).

Liquid feeding systems are different from dry feeding systems in many respects. Larger volumes of feed are consumed and a feeling of satiation may therefore be reached sooner in the individual pig. On the other hand, satiation probably lasts for a shorter time and feed must be provided several times during the day. As the water content in the feed is high, it takes the pigs longer to consume the same amount of digestible energy in the form of liquid feed compared to dry feed. Given these differences, the effects of a restricted AFR on the behaviour and performance of fatteners may be different for dry and liquid feeding systems.

With dry feeding systems for fatteners, it has been observed that a restricted AFR may lead to competition for feed, and consequently to increased aggression at the feeding trough, reduced duration of feeding and lower weight gain with more variation in weight between individuals (Hansen et al., 1982; Botermans and Georgsson, 2001; Kircher, 2001; Turner et al., 2002). As a result of increased competition at feedings, some pigs, especially the smaller ones, may have difficulty gaining access to the trough, and thus feed less (Botermans and Georgsson, 2001). These individuals may tend to be of lower social rank. In other studies on pigs, it has been found that there is a correlation between weight and social rank within a group (Rushen, 1988; Hicks et al., 1998; Andersen et al., 2000; O’Connell et al., 2004).

The effect of a wide range of AFRs on the behaviour and performance of fatteners has not yet been studied with regard to sensor feeding systems. In the present study, the AFR was varied from 4:1 to 7:1 and 13:1, and the effects on the behaviour and performance of the pigs of different weight classes at 14 and 17 weeks of age were investigated. These three AFR were selected to represent a wide range of possible AFRs and to test their effects on indicators of animal welfare. The aim of the study was to define an AFR that is acceptable with regard to animal welfare when sensor-controlled liquid feeding is used.
2. Materials and methods

2.1. Animals, housing and feeding

The experiment was performed between February 2002 and January 2004 in the facilities of the Swiss Federal Research Station for Economics and Engineering (Agroscope FAT Taenikon, Switzerland). The pigs were housed in four identical pens with a lying area (22.2 m²) with deep-litter sawdust and a feeding area (22.2 m²) with a partially slatted floor. The pens were illuminated by natural daylight and the indoor climate was similar to that outdoor. The pigs had free access to water, and straw was provided daily in a rack. The individuals were placed in groups of 40 at a weight of 25 kg and remained in the pen until slaughtering. Groups were balanced with regard to age, weight and sex. The variation in initial weight within each group was kept as low as possible (±3.3 kg, S.D.).

Before introduction to the fattening facility, the pigs had ad libitum access to dry feed. In the fattening facility, they were fed by means of sensor-controlled liquid feeding in five feeding periods per day (at 7.30, 10.30, 15.00, 18.00 and 21.00 h). Each feeding period lasted a maximum of 80 min and a minimum of 15 min. During each period, the feed level in the trough was automatically checked six times (computer programmed) by a sensor positioned 3 cm above the bottom of the trough. If the feed level was lower than the position of the sensor, fresh feed was mixed for this trough, at most six times per feeding period. The amount of feed delivered was independent of the level of feed left in the trough under the 3 cm limit. Between feeding periods, no feed was delivered when the trough was empty. With regard to feed quality, pigs were fed in three growing phases, the digestible energy content in the dry matter of the feed being increased from 15.4 MJ/kg (days 1–76 in the fattening facility) to 15.5 MJ/kg (days 77–91) and 15.6 MJ/kg (day 92 until slaughter). The feed-to-water ratio was 1:3 throughout the experiment.

2.2. Experimental design

The investigation was performed with 840 fattening pigs (Swiss Large Whites) kept in 21 groups of 40 animals. The AFR was varied from 4:1 (9 feeding places, 3 m trough length, 40 l feed per delivery) to 7:1 (6 feeding places, 2 m, 30 l feed per delivery) and 13:1 (3 feeding places, 1 m, 20 l feed per delivery). This corresponds to a feeding space of 33 cm per pig. Each AFR was replicated seven times, and allocation of the AFR to the four experimental pens was randomised. The replications were performed in batches so that every AFR was represented in every pen throughout the year to minimize a seasonal influence (Table 1). New groups of pigs (replicates) were introduced to the pens at intervals of about four weeks in-between, starting with AFR 4:1 in pen 3.

At the age of 14 weeks, 12 pigs per group were selected as focal animals (total: 252 pigs). Of these individuals, four (two castrates and two females) fell into the lightweight (37.8 ± 1.6 kg), middleweight (45.6 ± 0.8 kg) and heavyweight (53.4 ± 2.0 kg) categories each. The pigs were individually marked by spray-painting their backs and flanks.
2.3. Weight gain

The pigs were individually weighed upon introduction into the experimental pens and every fortnight thereafter until slaughter at an average weight of 102 ± 5 kg (S.D.). From these data, average daily weight gain was calculated for the focal animals of the three weight classes as well as for all members of each group. Daily feed intake was recorded on the behavioural observation days in weeks 14 and 17.

2.4. Behavioural observations

Behavioural data was collected via 24 h time-lapse video recordings. Each group was observed on a single day when the pigs were 14 and 17 weeks of age. To allow for video observations during the night, a dim light was left on round the clock over the entire experimental period. Behavioural data for the focal animals were recorded continuously from the videotapes. Frequency and/or duration of the following behavioural parameters was recorded: (1) feeding bouts (focal pig has head in trough) and number of visits at the trough (raising the head for longer than 3 s before resuming eating meant a new bout/visit); (2) waiting (focal pig is standing behind trough, its body in contact with feeding pigs, and its head facing the trough); (3) displacements from trough involving aggression (focal pig is displaced from trough by another individual using aggressive behaviour such as biting, head-butting or fighting); (4) displacements from trough not involving aggression (focal pig is pushed away from trough either to the side or to the back of the row of feeding pigs without aggressive behaviour).

2.5. Statistical analysis

Data were analysed using mixed-effects models in S-Plus (method “lme” in S-PLUS® 6.1 for Windows, http://www.insightful.com/; Pinheiro and Bates, 2000). The fixed effects were AFR, weight class of the focal pigs and age of the pigs at the time of data collection, as well as interactions between these factors. In addition, a random intercept effect was included for the individuals nested in groups nested in batches. Assumptions regarding the mixed-effects models were checked graphically. Residuals and random effects were plotted to assess normality and homoscedasticity. In case of deviations from the assumptions, data was transformed logarithmically (duration of feeding bouts, number of visits at the trough, waiting, feed intake).

Table 1
Assignment of the three animal/feeding-place ratios to the four experimental pens

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<th>Pen 2</th>
<th>Pen 3</th>
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3. Results

Feed intake (average per group and day ± S.E.) was between 351 ± 11 and 476 ± 17 l. Whereas the age of the pigs had an influence on feed intake ($p < 0.001, F_{1,13} = 50.7$), the AFR did not. The trough was quickly emptied after the end of a feeding period for the 13:1 AFR, and feed was never available at night. In the case of the 4:1 and 7:1 AFRs, feed often remained in the trough for a longer period after a feeding period, and could also be available at night.

On average, the focal pigs’ feeding bouts lasted about 1 min. As the AFR increased, pigs fed for a shorter time per visit to the trough ($F_{2,18} = 11.6, p < 0.001$; Fig. 1). Moreover, feeding bouts were shorter for the 14-week-old pigs than for 17-week-old ones ($F_{1,228} = 5.9, p < 0.05$). The pigs’ weight class had no effect on the duration of feeding bouts. The number of visits at the feeding trough (average per pig and day ± S.E.) varied between 36.5 ± 7.3 (heavyweight individuals, AFR 4:1) and 54.5 ± 7.2 (lightweight individuals, AFR 7:1) for 14-week-old pigs and between 29.8 ± 2.4 (heavyweight individuals, AFR 7:1) and 42.9 ± 8.1 (lightweight individuals, AFR 13:1) for 17-week-old pigs. The number of visits at the feeding trough did not differ between AFRs but the lightweight pigs visited the trough most frequently ($F_{2,223} = 10.5, p < 0.001$). In addition, the number of visits was lower in the 17-week-old pigs ($F_{1,228} = 102.8, p < 0.001$). The total duration of visits (average per pig and day ± S.E.) at the age of 14 weeks was 37.2 ± 3.2 min for the AFR 13:1 and 46.2 ± 3.0 min for the AFR 4:1. For 17-week-old pigs, this duration was between 26.9 ± 1.9 min per pig (13:1) and 41.7 ± 2.8 min per pig (4:1).

The focal animals had a longer duration of waiting in front of the trough as AFR increased ($F_{2,18} = 44.7, p < 0.001$; Fig. 2), and the duration of waiting decreased with increasing weight class ($F_{2,223} = 15.0, p < 0.001$). The duration of waiting was also longer at the age of 17 weeks than at 14 weeks, but only with AFR 13:1 (age–AFR interaction; $F_{2,228} = 7.6, p < 0.05$).

![Fig. 1. Duration of feeding bouts of focal pigs aged 14 weeks (left) and 17 weeks (right) fed at different animal/feeding-place ratios (average values and standard errors); bars show values of light-, middle- and heavyweight animals.](image-url)
The AFR had no influence on the frequency of displacements involving aggressive interaction (Fig. 3), but lightweight focal individuals were more often displaced from the trough with aggression than heavyweight ones ($F_{2,223} = 49.8$, $p < 0.001$). Such displacements were more frequent at the age of 14 weeks than at 17 weeks ($F_{1,228} = 24.0$, $p < 0.001$). As the AFR increased, the focal pigs were more often pushed away from the trough without aggression ($F_{2,18} = 25.3$, $p < 0.001$; Fig. 4). Moreover, the pigs of the lightest weight class were pushed away more frequently at the AFR 13:1 (weight class–AFR interaction; $F_{4,223} = 3.5$, $p < 0.01$). Animals were observed being pushed away from the trough without aggression more frequently at 14 than at 17 weeks ($F_{1,228} = 29.4$, $p < 0.001$).

Taking into account the data for all the experimental pigs, the absolute average daily weight gains ($\pm$S.E.) for the different AFRs were between $811 \pm 9$ g/day (13:1) and $918 \pm 6$ g/day (4:1) and this effect was significant ($F_{2,18} = 5.0$, $p < 0.05$). The focal animals gained less weight as AFR increased ($F_{2,18} = 15.0$, $p < 0.001$; Fig. 5). Moreover, weight
gain was lower for lighter pigs ($F_{2,223} = 83.6, p < 0.001$). At an AFR of 4:1 and 13:1, the heavyweight pigs gained on average 167 and 187 g/day more than lightweight pigs, respectively.

4. Discussion

The AFR did not significantly influence the number of displacements at the trough involving an aggressive interaction. This was in contrast to the results of other experiments investigating dry-feeding systems for fattening pigs, in which a restriction in the number of feeding places per animal led to increased aggression at the feeding trough (Hansen et al., 1982; Botermans and Georgsson, 2001; Kircher, 2001). As the AFR increased, it would seem to be a poor strategy for pigs to attempt to displace other individuals; when interacting with its
neighbour, the aggressive pig moves its head away from the trough, thereby running a higher risk of displacement. Furthermore, animals have to consider both benefits and costs of aggressive behaviour (see for example Krebs and Davies, 1993, p. 112f). Depending on the value and the possibility to defend a resource, the benefit of displacing a competitor may be lower than the costs (e.g. risk of injury) associated with an aggressive interaction. In such cases, it is likely that the rate of aggressive displacements is reduced and that scramble competition takes over. This interpretation of our results is supported by the fact that, as the AFR increased, pigs were more frequently displaced from the trough without aggression.

Increasing the number of individuals per feeding place also lead to longer waiting periods near the trough as well as shorter feeding bouts. These effects most likely account for the fact that pigs in groups with an increased AFR had significantly lower daily weight gains, indicating greater competition for feed as also seen by Hicks et al. (1998) and Turner et al. (2002). Similarly, Walker (1991) found that with increased competition at the trough for dry feed, the number of pigs queuing increased and the duration of time spent feeding per visit decreased.

The number of visits at the through did not differ between AFR, but it is likely that the individuals increased their feeding rate as the AFR increased to avoid a markedly reduced feed intake when feeding bouts became shorter (Nielsen, 1999). The daily weight gain decreased with increased AFR, but feed intake did not differ. This could imply that there was either a greater feed wastage at the more restricted AFR because of the competition at the trough or a poorer utilisation of feed due to competition induced stress.

For several of the parameters recorded in the present study, it was shown that increasing the AFR had a negative effect on the lightweight focal animals in particular within each group. Compared to heavyweight group members, lightweight individuals had a longer duration of waiting at the trough, were more often displaced from the trough by an aggressive interaction, had to visit the trough more frequently and had poorer daily weight gains. This is probably because the lightweight pigs were of lower social rank. Botermans et al. (2000) also observed that, for dry-fed fattening pigs, the frequency of displacements at the trough increased along with an increased AFR, and that this effect was most pronounced for lightweight animals. As in the present study, Hicks et al. (1998) also found that dominant young pigs gained more weight per day than intermediate and subordinate pigs.

Although the time spent at the trough per visit declined as the AFR increased, the weight of the focal animals had no influence on the duration of feeding bouts. The rate of displacements from the trough without an aggressive interaction was also unaffected by the weight of the focal animals. It appeared that the weight of the individuals no longer played a role if there was significant crowding at the trough. In line with this, the heavyweight focal animals were as often displaced from the trough without an aggressive interaction as lightweight pigs when the AFR was increased.

The age of the fattening pigs at the time of observation also had an influence on their behaviour. The focal animals’ feeding bouts were significantly longer at the age of 17 weeks, but the number of visits was reduced. The daily feed intake though, was higher at this age since older fattening pigs feed more. Feeding patterns of pigs are known to change with the age of the animals from frequent and short visits at the trough to few and longer visits with a higher ingestion rate (Fábrega et al., 2003). It was surprising to note that the frequency of displacements with and without aggressive interactions was lower at 17
weeks of age than at 14 weeks. It is possible that enough feed was available, eliminating the need for severe competition for access to the trough at the start of a feeding period.

In conclusion, the AFR has a decisive influence on the behaviour and performance of fattening pigs fed via sensor-controlled liquid feeding, leading to higher competition for feed and lower weight gain. An increased AFR has a negative effect on lightweight pigs in particular, most likely the subordinate group members. Differences between the 4:1 and 7:1 AFRs were minor in comparison to 13:1. As a consequence of the findings, an AFR of 13:1 cannot be recommended from an animal welfare point of view.

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References


