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Livestock Science 104 (2006) 91–102
LIVESTOCK SCIENCE
www.elsevier.com/locate/livsci

Effect of nose ringing and stocking rate of pregnant and lactating outdoor sows on exploratory behaviour, grass cover and nutrient loss potential

J. Eriksen [a,*], M. Studnitz [b], K. Strudsholm [a], A.G. Kongsted [a], J.E. Hermansen [a]

[a] *Department of Agroecology, Research Centre Foulum, Danish Institute of Agricultural Sciences, PO Box 50, 8830 Tjele, Denmark*
[b] *Department of Animal Health, Welfare and Nutrition, Danish Institute of Agricultural Sciences, PO Box 50, 8830 Tjele, Denmark*

Received 6 December 2005; received in revised form 3 March 2006; accepted 13 March 2006

Abstract

Nose ringing of outdoor sows is practiced to reduce grass sward damage for environmental reasons but conflicts with natural behaviour considerations. We investigated effects of ringing pregnant and lactating outdoor sows on foraging and explorative behaviour, grass cover and nutrient deposition. The experiment included both ringed and unringed sows. For unringed sows the paddocks were either used continuously throughout the experiment or divided into two and sows were moved half way through the experimental period leaving the first used paddock for regrowth. Ringing did not prevent the sow's rooting, but rooting was less pronounced, when sows were ringed. On average, ringing increased grass cover from 14% to 38% and from 64% to 81% in paddocks with pregnant and lactating sows, respectively. In paddocks with unringed sows kept at a double density and followed by a resting period, the grass cover in autumn was restored to a high degree in paddocks with pregnant sows. In lactating sow paddocks the level of inorganic N was high but with no significant relation to extent of grass cover. In pregnant sow paddocks the soil inorganic N content was significantly reduced by increased grass cover and at 60% grass cover soil inorganic N content was at a low level. From the experiment it was evident that although ringing did have a positive environmental effect, it was not the main factor influencing potential losses. Management choices in terms of feeding, animal density and nutrient distribution are considered to be at least as important.

Keywords: Outdoor pigs; Nose ringing; Rooting behaviour; Pasture damage; Environmental impact

1. Introduction

An increasing number of pigs are being kept outdoors in Europe in response to consumers' demand for 'naturally' raised pigs (Watson and Edwards, 1997). Outdoor pig production has benefits in terms

* Corresponding author. Tel.: +45 89 99 18 70; fax: +45 89 99 17 19.
E-mail address: jorgen.eriksen@agrsci.dk (J. Eriksen).

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doi:10.1016/j.livsci.2006.03.008

of animal welfare, e.g. possibility to perform natural behaviour, and low costs of buildings and equipment (Deering and Shepherd, 1985) but there may be environmental costs resulting from high feed consumption (Larsen and Kongsted, 2000), losses of nitrate to aquifers (Eriksen, 2001), ammonia volatilization (Sommer et al., 2001) and atmospheric nitrous oxide emission (Petersen et al., 2001). These losses contribute to global warming, acid rain and the eutrophication of natural environments.

Outdoor pig units are most often based on freely draining sandy soil presenting a great risk of nitrate loss especially since pigs are outdoor all year around and the rooting and trampling during the stocking period typically leaves the soil surface compacted and without vegetative cover. Williams et al. (2000) showed that nitrate leaching can be greatly reduced by using a management system that stocks pigs on established grassland compared to arable stubbles. After 6-month stocking, the vegetative cover on the grass system had been destroyed so in the following winter nitrate losses were similar from both systems. Although it may be possible to maintain grass cover by reduction of the stocking density (Larsen and Kongsted, 2000, 2001) this conflicts with the farmers need to maximise fodder production and thus minimise land use for pigs.

A methodical use of pasture as a feed source in outdoor sow units is relatively sparsely documented in the scientific literature. All though there are large differences between the daily intake of fibre-rich food for individual sows (Kongsted et al., 2000), especially, the pregnant sows have a general high capacity to obtain and utilize energy from grass (Sehested et al., 2004).

In Denmark it is common practice to nose ring outdoor sows. In the UK and the Netherlands this is prohibited in organic farming. The purpose of the ring is to reduce rooting, which damages the grass sward. A well-maintained grass sward is important for environmental reasons as it absorbs and preserves nutrients excreted during grazing. Although the ringing of sows may not cause frustration (Studnitz et al., 2003), it conflicts with the organic ideals that natural behaviour and positive experiences should be taken into consideration. In natural environments sows spend about 30% of their waking hours rooting (Stolba and Wood-Gush, 1989) and it has been demonstrated that rooting is the preferred explorative behaviour of pigs (Studnitz et al., 2003). Therefore the ringing is a compromise of the organic principles and it is relevant to ask whether the environmental gain of the ringing justifies this compromise and if grass cover can be maintained in other ways.

The objectives of this study were to examine concomitantly the effects of nose ringing and animal density on: (1) foraging and exploration behaviour, (2) grass cover, (3) nutrient deposition, and interactions between these observations. To the knowledge of the authors similar studies have not been published before. It was our aim to provide information needed to develop integrated management practices to reduce the environmental impact of outdoor sow production systems without compromising the natural behaviour of the animals.

2. Materials and methods

2.1. Experimental design, feeds, feeding and recordings of animal production

The investigation was carried out on a commercial organic outdoor pig-producing farm in southwest Denmark on a coarse sand soil. In this herd the pregnant sows were kept indoors at winter and outdoor in the grazing season, while the farrowing/lactating sows were kept outdoors the year around. Each lactating sow had a 9-week residence in individual paddocks; while the pregnant sows were kept in paddocks with 5 sows in a 10-week period after a service period in indoor facilities.

In the experiment were three treatments for both lactating and pregnant sows (Table 1). The treatments were replicated two and three times for pregnant and lactating sows, respectively. Thus, in the field were established six paddocks of 40 × 45.5 m for pregnant sows and nine paddocks of 30 × 11 m for lactating sows. The experiment was carried out from May to September 2002 and with two sequential rounds of introductions in farrowing and pregnancy paddocks in the period. All sows were multiparous Landrace × Large White sows.

Sows in treatment 1 were ringed immediately before introduction. The nose ring, a bullring of steel with a diameter of 3.4 cm, was fitted through the nasal septum with a special pair of pliers when the sow was held in a

Table 1
Experimental treatments in sow paddocks

Treatment		Pregnant sows				Lactating sows			
		Sows per ha	Sows per paddock	Area (m^2)	Duration of stay (days)	Sows per ha	Sows per paddock	Area (m^2)	Duration of stay (days)
(1) Ringed		27.5	5	1820	146	30.5	1	328	133
(2) Unringed		27.5	5	1820	146	30.5	1	328	133
(3) Unringed, double density[a]	1st	55	5	910	67	61	1	164	64
	2nd	55	5	910	79	61	1	164	69

[a] The paddock divided in two and sows moved halfway through the experimental period.

nose sling. None of the sows had nose ring previously. In treatments 1 and 2 the same paddock was used throughout the experimental period for two successive groups of sows at each treatment. In treatment 3 sows used half the paddock until July 3rd. After July sows used the second half of the paddock in the remaining period. Before introduction to the second half of the paddock a grass cutting took place 2 weeks before. The stocking rate (Table 1) was calculated to cause a nitrogen deposition of 280 kg N ha^{-1} based on the national definition of a livestock unit and the national guidelines allowing pastures to be used for grazing pigs only every other year (European Commission, 2000; Ministry of Environment, 2002). The stocking rate was 18.2 m^2 per sow per residence week in all paddocks. The split residence period in treatment resulted in a double animal density in each half of the experimental periods.

Pregnant sows were fed once daily with 1.75 kg rolled barley and 30 g pure mineral supplement per sow (Table 2). This was assumed to cover 70% of their daily energy requirement. The remaining nutrient requirement was assumed to be covered by grazing or intake of grass silage. Grass silage was allotted weekly. A ready-mixed feed with 16% protein and 80% organic origin of the dry matter was fed to the lactating sows: 2.5 and 9 kg daily before and after farrowing, respectively (Table 2).

The huts and troughs were moved in a routine every month, while the wallow areas were stationary during the period. Paddocks for pregnant sows were used from May 1st to September 25th and paddocks

Table 2
Complementary feed allowance and performance of pregnant and lactating sows with or without nose ring (ns: no significant difference between treatments, $P>0.05$)

	Ringed	Unringed	Unringed, double density	*P*-value
(A) Paddocks with pregnant sows (#sows)	2 (34)	2 (29)	2 (37)	
Feed, supplement, kg/sow/day[a]				
Crushed barley	1.75	1.75	1.75	–
Clover–grass silage	2.1	2.1	2.1	–
Mineral mixture[b]	0.03	0.03	0.03	–
Daily live weight gain, g (S.E.M.)	−17 (18)	−36 (21)	−34 (18)	ns
(B) Paddocks with farrowing sows (#sows)	3 (6)	3 (6)	3 (6)	
Feed, supplement kg/sow/daya				
Concentrate mix[c] before farrowing	2.2	2.2	2.2	–
Concentrate mix[c] after farrowing	9.0	9.0	9.0	–
Average consumption in period	6.7	6.6	6.9	–
Change of live weight, kg/sow (S.E.M.)[d]	−13.8 (4.5)	−6.0 (5.0)	−17.3 (5.0)	ns
Weaned piglets per litter, kg (S.E.M.)	157 (6.9)	152 (6.9)	154 (6.9)	ns
Weaned piglets per litter, # piglets	9.0	8.0	8.8	–

[a] Fixed amounts by design.
[b] Monocalcium phosphate (54%), $CaCO_3$ (31%), NaCl (15%)=(120 g P/kg).
[c] Per kg feed: 160 g crude protein; 66 g crude fat; 8.3 g lysine; 2.6 g methionine; 6 g P.
[d] From introduction (before farrowing) to at weaning.

for lactating sows from May 1st to September 11th in 2002. The live weight was measured individually when the sows were introduced to and removed from the paddocks, while the piglets were weighted collectively at weaning.

2.2. Behavioural observations

Behavioural elements were observed 1 day each week during the experimental period. Every other week paddocks with lactating sows were observed four times during 9–10 am, 11–12 am and 5–6 pm and paddocks with pregnant sows were observed four times during 10–11 am and 4–5 pm. The next week vice versa starting with pregnant sows. In total, all paddocks were observed for 45 h during the 21 weeks the experiment was running. The paddocks were divided into sub zones. For pregnant sows the zones were *hut* (the hut and one sow length from the hut), *straw* (the initial hut allocation), *fence* (within one sow length from the fence), *wallow* (the areas for wallowing), *trough* (within one sow length from the trough), *water* (within one sow length from the water trough) and *field* (all other places in the paddock). For lactating sows the zones were: *hut*, *wallow*, *trough*, *water* and *field*. The observer walked along the fields and stopped by each field for 2 min when observing pregnant sows and 1 min when observing lactating sows in each zone. The following behavioural elements were recorded as scan samples in each zone: In *hut*, *lying*, *standing*, *walking*, *rooting* and *grazing*. The first four were recorded mutually exclusive. Furthermore *throwing soil* and *pawing* were recorded as all occurrences. Definitions of behaviour are given in Table 3.

Table 3
Definitions of behavioural elements observed by scan sampling except for the elements marked with asterisk (*) which were registered by all occurrence sampling

Behaviour	Definition
In hut	Sow in hut, behaviour not specified
Lying	Lying with eyes closed or open
Standing	Standing on all four legs
Walking	Moving at least one leg
Rooting	Snout in contact with substrate, snout movements along or into the soil surface and snout movements deep into soil both with tight and relaxed body posture
Grazing	Snout or mouth in contact with grass
Throwing soil*	Throwing soil with the snout
Pawing*	Drawing foreleg over the surface of the ground

2.3. Determination of grass cover

Grass cover was estimated by determining spectral reflectance in the sow paddocks. This technique has been widely used and accepted for determination of crop growth in many agricultural crops (Petersen, 1992), but is a new method for estimation of grass cover. We consider it a huge improvement compared to a visual inspection as the data seems very reliable, more precise and the subjective and individual nature of visual determination is overcome.

The handheld equipment consisted of two sensor units, one unit measured the red (650 ± 10 nm) and the near infrared (800 ± 10 nm) reflection from the canopy and another similar unit measured the incoming radiation. The sensor units of type SKR1800 with a 15° view were connected to an A/D converter of type SDL2500 (Skye Instruments Ltd, UK) and data were recorded on a computer. All observations were taken at a height of 1.8 m, thus representing 0.5 m^2 ground area. The spectral reflectance measurements were converted to a mean value of the ratio vegetation index (RVI). At two dates, July 5 and September 25, spectral reflectance was determined in 36 and 24 points, respectively, in paddocks with pregnant sows and similarly in 8 points in paddock with lactating sows. In treatment 3 the points were split between 3a and 3b. The points were evenly distributed in a grid to obtain internal distance between points of 5.5 to 10 m, the exact distance depending on sow group and sampling time. At each date RVI was determined for bare soil and for 100% grass cover as a reference and the grass cover at each point was determined from interpolation between these.

2.4. Soil sampling and analysis

For soil sampling at the end of the experiment (September 25) each of the pregnant sow paddocks were divided into four quadrants of 20 × 22.75 m and each of the lactating sow paddocks into two halves of 11 × 15 m. In each of the divisions eight soil cores were sampled to 40 cm depth and bulked. Soil samples were stored frozen until processing. The contents of ammonia and nitrate were determined spectrophotometrically on the bulked samples after extraction with 1 M KCl (1:2 w/v).

2.5. Nitrogen balance

Nitrogen balances were calculated as input in feed and pigs minus the output in pigs. All feed and pigs entering and leaving the individual paddocks were weighed. Nitrogen in pigs was estimated to 25 g/kg live weight according to Poulsen et al. (2001). The nutrient content of feeds was estimated based on the feed manufacturer's production report on the feed mixtures and on literature values. These were (g/kg feed): feed mixture 25.5; barley 15.5; clover–grass silage 8.7; and straw for bedding 5.4.

2.6. Climatic conditions

A soil water balance was calculated using the Evacrop model (Olesen and Heidmann, 1990), for which inputs were daily meteorological measurements (precipitation, temperature and evaporation), crop type and soil physical parameters. Fig. 1 shows temperature, precipitation and estimated drainage from the root zone during the experimental year. High summer precipitation caused drainage from the root zone of 67 mm in July, which is not unusual for this soil type. However, it does lead to downward transport of nitrate from the upper soil layers. The experiment finished before onset of autumn drainage.

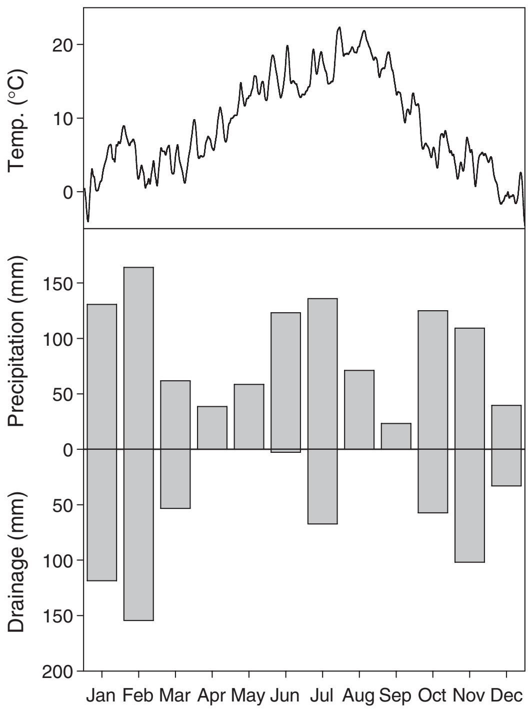

Fig. 1. Precipitation, temperature (—) and estimated drainage at 1 m depth in the experimental year.

2.7. Statistical analysis

For nutrient balances, grass cover and soil inorganic N content, analysis of variance was carried out using the General Linear Model (GLM) procedure of SAS (SAS Institute Inc, 1999) to estimate differences between treatments. For behavioural elements a Kruskal–Wallis test was carried out using the Npar1-way procedure of SAS (SAS Institute Inc, 1999) to estimate differences between treatments.

3. Results

3.1. Production and nitrogen balance

Pregnant sows tended to lose weight during the period although the weight change did not differ significantly from zero and not differing significantly among treatments. This illustrates that the complementary feeding was in the lower range of what is necessary (Table 2). Also lactating sows lost weight during the period, not differing significantly among treatments. However, it should be noticed that the weight change included the live weight loss due to farrowing. Taken a normal weight loss during farrowing into account (approximately 20 kg) it appears that the feeding fully supported the sow in maintaining or even gaining live weight during the suckling period.

Since the same stocking rate in terms of m^2 per sow was applied in the experiment, the N surplus was approximately 3 times as high in paddock with lactating sows compared with pregnant sows due to a much higher feed input in farrowing paddocks which could not be counteracted by the N removed with piglets (Table 4). No significant differences in N surplus were observed between treatments within pregnant sows or lactating sows.

Table 4
Nitrogen balance in paddocks with pregnant and lactating sows (kg N ha^{-1} ± S.E.) (ns: no significant difference between treatments, $P > 0.05$)

	Ringed	Unringed	Unringed, double density	P-value
Pregnant sows				
Input				
Feed	177 (14)	177 (14)	177 (10)	ns
Straw	2.7	2.7	5.4	–
Output				
Meat	−6 (8)	−11 (8)	−13 (6)	ns
Surplus	186 (15)	191 (15)	195 (10)	ns
Farrowing sows				
Input				
Feed	754 (24)	748 (24)	780 (17)	ns
Straw	27	27	27	–
Output				
Meat	209 (9)	213 (9)	199 (7)	ns
Surplus	572 (24)	562 (24)	608 (17)	ns

3.2. Behaviour

Figs. 2 and 4 show the distribution of behaviour between treatments and Fig. 3 shows the distribution of behaviour related to the location in the paddock. The rooting behaviour of both the pregnant and the lactating sows was significantly influenced by the treatments.

For the pregnant sows, the unringed sows at double density rooted significantly more than other sows (Fig. 2). The rooting was mainly performed in the field, at the trough and at the fence (Fig. 3). Across location, unringed sows did not root significantly more than ringed sows (Fig 2), however, when divided into location, unringed sows (including those at double density) spend significant more time rooting in the field than ringed sows (Fig. 3). The ringed sows were the only ones pawing (Fig. 4) and they mainly did this in the wallowing area (results not shown). Pregnant sows at double density spend more time than the other sows throwing soil in the field and near the trough (results not shown). Treatments had no effect on time spend in hut, lying, standing, walking or grazing, however, there was a tendency ($P < 0.07$) that unringed sows at double density was standing more (Fig. 2). Related to location in the paddock, no significant differences were observed between treatments regarding lying, standing, walking or grazing showing that the sows from all treatments spread these behaviours in a similar way in the paddocks (Fig. 3).

For lactating sows, the unringed rooted (Fig. 2) and threw soil (Fig. 4) significantly more than the ringed sows. Both rooting and throwing soil was mainly carried out in the field (Fig. 3). Like for pregnant sows, the ringed sows were the only ones pawing (Fig. 4) and this was primarily performed in the wallowing area (results not shown). The ringed sows walked significantly more than the other sows but no significant effect of treatment on time spend in hut, lying, standing or grazing was observed (Fig. 2). Related to location in the paddock, no significant differences were found between treatments regarding lying, standing or grazing (Fig. 3).

3.2.1. Grass cover

Despite variations due to uneven distribution of grass cover in the paddocks some clear differences

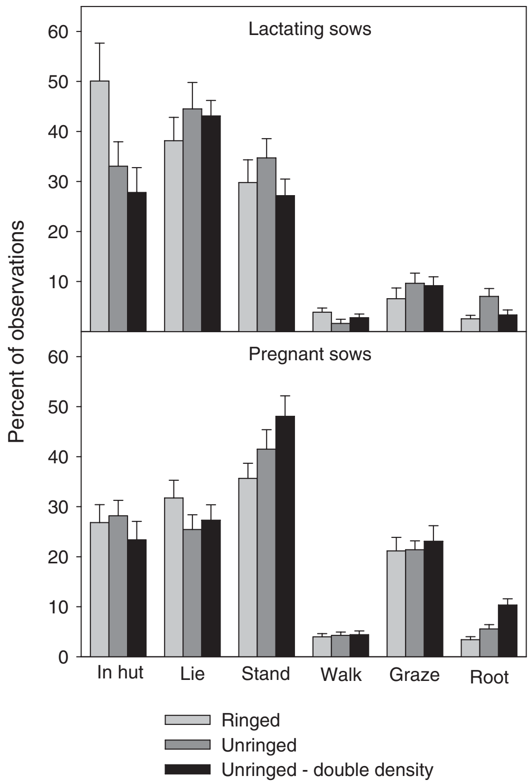

Fig. 2. Distribution of behavioural elements in paddocks with lactating and pregnant sows. Grazing and rooting are always performed in combination with other behaviour. Error bars: S.E.

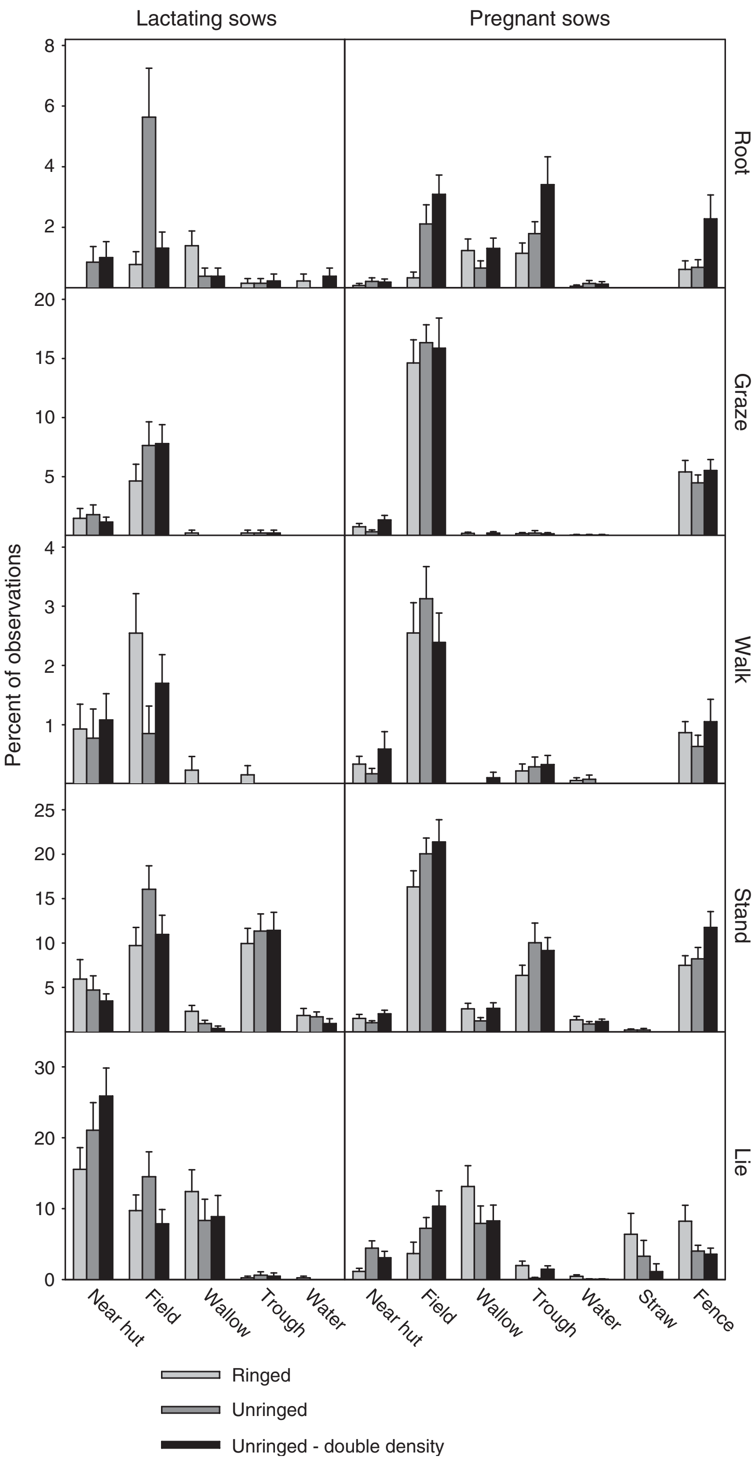

Fig. 3. Distribution of behavioural elements in sub-zones of paddocks with lactating and pregnant sows. Grazing and rooting are always performed in combination with other behaviour. Error bars: S.E.

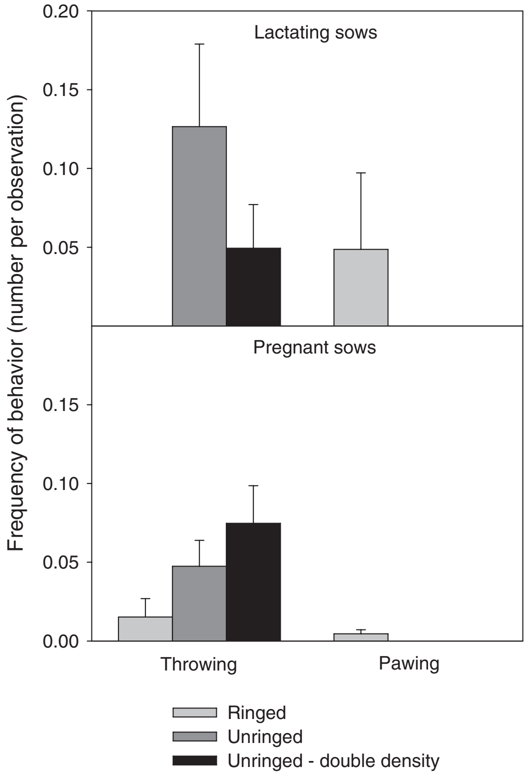

Fig. 4. Occurrence of throwing and pawing in paddocks with lactating and pregnant sows (observed 1 and 2 min, respectively, per observation). Error bars: S.E.

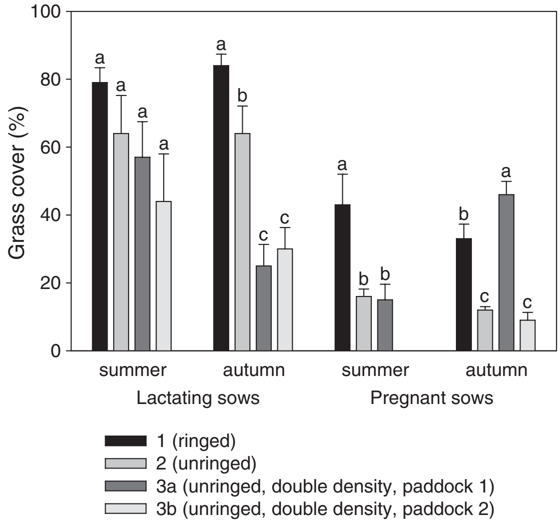

Fig. 5. Grass cover in sow paddocks determined in summer and autumn (end of experiment). Bars with the same letter within each combination of sow type and date are not significantly different ($P<0.05$). Error bars: S.E.

appeared (Fig. 5). Generally, the grass cover was best preserved where sows were ringed. As there was always less grass in paddocks with pregnant sows compared to lactating sows (not statistically tested) the effect of ringing was relatively more pronounced here. On average, ringing increased grass cover from 14% to 38% and from 64% to 81% in paddocks with pregnant and lactating sows, respectively. The strategy behind treatment 3, where paddocks were used only by one sow or group of sows before abandonment, gave different results for different types of sows. With lactating sows it caused a much reduced grass cover especially at the autumn measurement where intensive use reduced grass cover from 64% to 28%. For pregnant sows there were no effect of grazing intensity at the summer measurement. However, in the autumn the re-growth of the grass in treatment 3a, that was used in the first half of the experiment only, made these paddocks the most grass-covered; even more than those with ringed sows.

3.3. Nutrient excretion

The soil inorganic N content was very variable (Fig. 6) probably as a consequence of nutrient ‘hot spots’ created by the excretory behaviour of the pigs. There were no treatment effects of nose ringing (the difference between treatments 1 and 2). In the intensively used pregnant sow paddocks (treatment

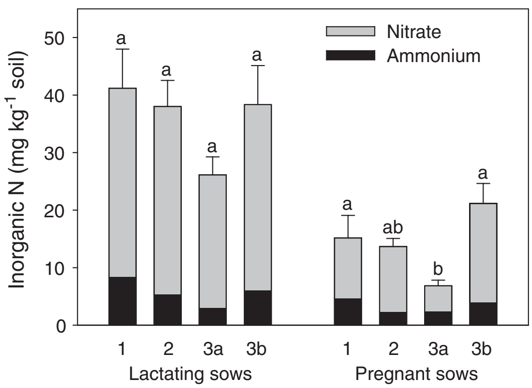

Fig. 6. Concentration of soil inorganic N in autumn (end of experiment). Bars with the same letter within each sow type are not significantly different ($P<0.05$). Error bars: S.E.

3) there were significantly higher N content in the one most recently used (3b) compared to the abandoned paddock (3a). There were indications of a similar effect in lactating sow paddocks. The explanation may be that more N was assimilated by plants due to better grass cover in the abandoned paddocks (Fig. 5) but some leaching of nitrate to deeper soil layers during the July drainage incident cannot be excluded.

Fig. 7 shows the relationship between grass cover and soil inorganic N content in localised areas in the paddocks. Soil inorganic N may be seen as the net difference between N deposition in excreta and N taken up by the grass. In lactating sow paddocks no significant relationship was found and high soil N content was observed even at high grass coverage. In pregnant sow paddocks the soil inorganic N content was significantly reduced by increased grass cover and at 60% grass cover soil inorganic N content was down to low levels. This relationship explained 35% of the variation in soil inorganic N and was probably caused by (1) lower N inputs as indicated by the N balance (Table 4) and (2) more uniform distribution of excreta (Fig. 7), both conditions leading to a higher proportion of excreted N being absorbed by the grass.

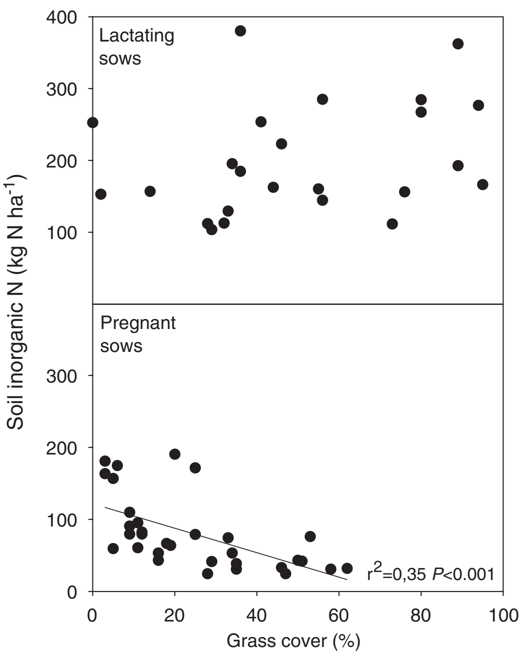

Fig. 7. Relationship between grass cover and soil inorganic N in autumn (end of experiment) in localised areas of lactating and pregnant sow paddocks.

4. Discussion

4.1. Behaviour

It has been demonstrated that rooting is the preferred explorative behaviour of pigs (Studnitz et al., 2003) and it is often referred to as a behavioural need (Horrell et al., 2001). However, it has also been found that when ringed gilts were unable to root, they substituted their rooting behaviour with grazing, chewing, sniffing and eating without showing signs of frustration or abnormal behaviour (Studnitz et al., 2003). On the basis of this it was concluded that ringing of pigs did not cause suffering during grazing, but it may still compromise the welfare of the pigs because positive experiences, such as rooting, are an important concern as regards welfare. Whether rooting may or may not be a behavioural need, the ring reduces the possibility for the sows to behave naturally, which must be taken into consideration, especially in organic production systems. The importance of ringing was also confirmed by our results as unringed sows rooted more than other sows, which is in accordance with previous studies (Edwards et al., 1996; Horrell et al., 2000, 2001; Studnitz et al., 2003).

Rooting was always accompanied by soil throwing, but never by pawing. In agreement with Horrell et al. (2001) it was only the ringed sows that pawed. It therefore seems reasonable to assume that the sows pawed instead of rooting. This may be seen as a confirmation that the sows prefer to root and if this is difficult due to ringing, they try in alternative ways. When the ringed sows paw in the wallow, it is presumably as an alternative to ‘comfort rooting’ (see below) with the purpose to cool down. If the purpose is to ‘remove earth’ pawing may actually be a functional–although much less efficient–alternative to rooting (Horrell et al., 2001). Lactating ringed sows walked more than other sows, but beside this, nose ringing did not affect other behavioural elements than rooting, throwing and pawing.

Rooting behaviour in free-ranging sows has been studied by, e.g. Stolba and Wood-Gush (1989) and Buckner et al. (1998). In general these studies reported higher frequencies of rooting behaviour compared to what observed in this investigation—even in the unringed sows. However, our investigation was only carried out during summer where the topsoil is presumed to be less soft and as pigs prefer to root in lose and wet soils (Andresen and Redbo, 1999) this probably reduced rooting behaviour.

4.2. Grass cover

This experiment confirmed that grass cover is best preserved where sows are ringed, in accordance with Edwards et al. (1996) and Horrell et al. (2001). Especially unringed pregnant sows were able to seriously reduce the grass cover probably because they are more engaged in foraging behaviour due to more restricted feeding, as also observed by Buckner et al. (1998). The effect of ringing may have been even more pronounced if the experimental period had covered the entire year as it is especially difficult to maintain grass cover during autumn and winter (Eriksen et al., in press). One way of improving the overall grass cover in outdoor systems containing unringed sows could be time-restricted access to grassland, e.g. strip-grazing. Treatment 3 in this experiment represents the simplest version of such a system since initially sows had access to only one half of the paddock area and were transferred to the other half of the paddock halfway through the experiment. The potential of such strategies is clearly demonstrated in paddocks with pregnant sows as the re-growth of grass in the half-paddock used first was considerable and in the end made them even more grass-covered than those with ringed sows. This was possible even that the paddocks were grazed to the soil surface, so no grass was visible, because obviously the sward was not destroyed. The spectral reflectance technique used for evaluating grass cover does not distinguish between these two situations, as the relative vegetation index is proportional to green plant biomass (Petersen, 1992). In a practical farming situation we can imagine continuous introduction of sows to new land, e.g. gradual expansion of the paddocks throughout the year would improve grass cover and this would also be advantageous from a nutrient distribution point of view (see below). Furthermore, it would allow for silage production before paddock expansion.

Others have tried to reduce pasture damage by providing sows with fibrous feed and/or designated rooting areas. Thus, allocation of high-fibre diets (Braund et al., 1998; Edge et al., 2004), provision of sacrificial rooting areas (Bornett et al., 2003) separately or in combination (Edge et al., 2005) reduced the frequency of rooting behaviour but did not reduce paddock damage to an acceptable level. However, provision of a cool lying place and wallowing opportunities in a designated area during summer months decreased paddock damage significantly whereas a designated area with foraging possibilities but without a cool lying area did not (van der Mheen and Spoolder, 2005). The latter demonstrate that pigs not only perform 'foraging rooting' but also 'comfort rooting' as previously reported by, e.g. Andresen and Redbo (1999). It is therefore important to address both aspects when the aim is to reduce paddock damage without ringing of sows.

Alternatively, advantage could be taken of the rooting activities of the pigs. Andresen et al. (2001) showed that pigs could be used for mechanical tillage that even resulted in increased crop yield the following year. However, this requires a considerably higher stocking rate than in this experiment, as sward destruction is the point of such a treatment.

4.3. Nutrient excretion

The skewness in nutrient excretion is a feature found in most outdoor pig studies (e.g. Zihlmann et al., 1997; Stauffer et al., 1999; Eriksen and Kristensen, 2001; Watson et al., 2003) and it is an important aspect of farm nutrient management that this is dealt with. It has been shown that this can be done by regular moving of huts feeding and water troughs through the grazing period (Eriksen et al., 2002). On a light sandy soil as this there is a considerable risk that the main part of the soil inorganic nitrogen in autumn, mostly in the form of nitrate, will be leached out of the soil profile when water percolates through the soil during autumn and winter, unless it is retained by a grass cover. In this experiment we found a relationship between nose ringing, grass cover and loss potential in a situation when the N surplus was moderate. In paddocks with pregnant sows the grass was able to reduce the nitrogen loss potential, which was then a consequence of nose ringing. However, with lactating sows the inorganic N level (or loss potential) was independent of grass cover and here a reduction in dietary N input seems a much more efficient way of reducing the loss potential. The feed intake of outdoor reared lactating sows seems to be considerably higher than what is typical in indoor systems (Lauritsen, 1998). There is a need to evaluate if this will allow for feeding with lower protein concentrations in the feed. Another obvious option is to reduce the nutrient surplus per hectare by increasing the area to which the sows have access. However, for this to work it is important that excreted nutrients are evenly distributed on the land.

5. Conclusions

From the experiment it was evident that although ringing did have a positive environmental effect, it was not the main factor influencing potential losses. Management choices in terms of feeding, animal density and nutrient distribution are likely to be at least as important. Nose ringing may be considered one method of trying to maintain grass cover but without guaranteeing low environmental load. On the other hand, if outdoor sows without nose rings are the preferred option, this may be environmentally acceptable if sward damage is dealt with by, e.g. gradual expansion of the paddocks (strip-grazing) and a general increase in the area of grassland used for the sows.

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