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Impact of Stocking Density on Welfare, Behavior, and Growth Performance of Large White Yorkshire Pigs under Indian Condition

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aim: This study aimed to evaluate the effects of varying stocking densities on the welfare, behaviour, and production performance of growing Large White Yorkshire pigs.

Study Design: The research focused on assessing the influence of decreasing floor space allowance per pig on welfare indicators, including behavioural patterns, growth metrics, and feed efficiency. Seventy-four weaned pigs were randomly divided into four treatment groups with stocking densities ranging from 0.3 m²/pig to 0.21 m²/pig. Behavioural data were recorded using smartphone cameras and CCTV, while growth and feed metrics were systematically measured.

Place and Duration of Study: The experiment was conducted from 2020 to 2023 at the Piggery Farm, Department of Livestock Production Management, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, India (Latitude: 30°54' North, Longitude: 75°48' East).

Methodology: A corn-soybean meal-based diet was provided ad libitum, and body weight, feed intake, and behavioural observations were recorded weekly. Negative and positive social behaviours, exploratory activities, and lying duration were documented for each group. Statistical analyses were performed using ANOVA and Duncan's Multiple Range Test to compare treatment effects at a significance level of $P \leq 0.05$.

Results: Growth performance, including body weight and average daily gain (ADG), showed no significant differences between groups; however, a linear increase in body weight was observed over time. Feed intake and feed conversion ratio (FCR) differed significantly, with pigs at higher stocking densities consuming more feed and displaying higher FCR values. Behavioural analysis revealed increased negative behaviours such as aggression and tail biting in higher stocking density groups, while exploratory and positive social behaviours were more frequent in these groups. Lower stocking density groups displayed more lying behaviour, particularly towards the end of the study.

Conclusion: Decreasing floor space allowance significantly impacted pig behaviour, increasing stress-related activities and negative social interactions without significantly affecting growth performance. These findings emphasize the importance of optimizing space allocation in intensive pig farming systems to balance welfare and productivity.

Keywords: Behavioural activity; feed intake; growth performance; pig welfare; space allowance; stocking density.

1. INTRODUCTION

Stocking density is defined as the space allowance per pig within a pen, is a critical factor influencing the welfare, behaviour, and productivity of pigs. In intensive farming systems, where overcrowding can result in worsened stress, decreased growth performance, and increased aggression, it is especially crucial to maximize floor space. In India, where pig farming is gaining popularity for its economic benefits, traditional housing standards (IS: 3916-1966) are outdated and do not fully address the demands of modern production systems (Patel & Kaswan, 2019; Sandeep Kaswan et al., 2017). In addition to decreasing growth rates and feed efficiency, high stocking densities have a negative impact on animal well-being by increasing stress-related behaviours including aggression and tail biting. Overcrowded conditions lead to competition for resources like feed and water, often reducing overall productivity. Furthermore, these conditions can increase the susceptibility of pigs to diseases due to poor hygiene and stress (Huang & Miller, 2005).

There are few studies on stocking density conducted in India, and the majority of the recommendations are based on out-of-date guidelines or international studies. Comprehensive information on the behavioural and production results of pigs raised in different space allowances catered to Indian breeds and climates is lacking. This disparity emphasizes the necessity of doing regional research in order to develop evidence-based housing rules (Patel & Kaswan, 2019). Pig productivity may be increased in India by having a better understanding of how different stocking levels affect pig welfare and production. In order to adapt home rules to the demands of contemporary farming, the results of this study may prove beneficial.

This study aims to evaluate the effects of decreasing stocking density on the welfare, behaviour, and growth performance of Large White Yorkshire pigs under Indian conditions.

2. MATERIALS AND METHODS

2.1 Experimental Animals and Design

The study employed an experimental design to evaluate the effects of varying stocking densities on the welfare, behaviour, and growth performance of growing pigs. Four treatment groups (T1, T2, T3, T4) were created with incremental decreases in floor space allowance (0.3 m², 0.27 m², 0.24 m², and 0.21 m² per pig, respectively). The pens are divided into ten pens of dimensions 10 x 8.9 foot (cover area) and 10 x 8.9 foot (open area) partition of permanent concrete of 4-foot height with an additional 1 foot of steel pipes going across each partition. Each cover area consists of a creep area of 5.4 x 3.4 x 3 feet; combining the manger and watering area, it is 5.1 x 3.1 x 1.5 foot. Each pen with a dimension of 89 square foot was utilized to stock the animals with a floor space of 3.2 square foot per piglet. Each group consisted of a defined number of weaned pigs randomly assigned to treatments based on body weight to ensure homogeneity. Behavioural and growth parameters were systematically recorded over the experimental period.

2.2 Study Area and Population of the Study

The experiment was conducted at the Piggery Farm of the Department of Livestock Production Management, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, India. The geographical coordinates are Latitude: 30°54' North, Longitude: 75°48' East. The study included a total of 74 weaned Large White Yorkshire pigs aged 60 days. These pigs were representative of the target population for similar farming practices in intensive pig farming systems in India.

2.3 Feeding

The corn-soybean meal-based diet was formulated as per the NRC-2012 grower ratio, and the calculated analyses of the same diet are given in Table 1. Daily feeding record was maintained separately for each group of the managemental weaning system. Feed and water were made available ad-libitum all the time. The body weight of all the pigs was recorded individually at weekly intervals.

2.4 Sampling Methods

The 74 weaned pigs male and female were randomly distributed across the four treatment groups, ensuring equal representation of body weight range and uniformity within the groups. Randomization aimed to eliminate selection bias, and pigs were grouped into pens constructed to meet the experimental stocking density requirements.

Table 1. Composition of grower ration and its nutrient composition

Ingredient	**Grower Ration (10-20 kg) (Kg)**
Maize	56.00
Soybean Meal	28.00
Wheat Bran	10.00
Fish Meal/GNC	4.00
Mineral Mixture	1.50
Salt	0.50
Calculated Nutrient Composition	
Moisture %	11.90
Dry Matter %	88.10
Total Ash %	6.05
Acid Insoluble Ash %	0.30
Crude Protein %	22.75
Ether Extract %	3.78
Calcium %	0.63
Phosphorus %	0.49

2.5 Data Collection and Observation

Behavioural activities were recorded using smartphone cameras (VIVO Y11 13 MP) and CCTV cameras (SONY DSC-HX10V). Observations were made thrice daily (9:00, 12:00, and 15:00 IST) on specific days (0th, 5th, 10th, and 15th). A comprehensive ethogram was used to categorize behaviours, including eating, drinking, social interactions, exploratory activities, and aggressive behaviours (Turpin et al. 2017). Growth performance was tracked through weekly body weight recordings and feed intake measurements.

2.6 Statistical Analysis

The collected data were subjected to statistical analysis using IBM SPSS Statistics 26. Behavioural observations were calculated as percentages of observation time, and the data were normalized using square root transformation. Analysis of Variance (ANOVA) was performed to determine the effects of stocking density on growth performance and behaviour, with significance defined as P ≤ 0.05. Treatment means were compared using Duncan's Multiple Range Test to identify differences between groups. (Snedecor & Cochran, 1994).

3. RESULTS AND DISCUSSION

The growth performance (Table 3) reveals that there was no statistical significance between the treated groups, but there was a linear increase in body weight till the end of the study period. Previous studies found that stocking density or group size has been shown to affect the growth performance and health status of grower pigs (Funk et al., 2007; White et al., 2008). Grower pigs raised in 1.3 m^2/pig showed a better growth performance compared with those in 1.0 m^2/pig (Nannoni et al., 2019). In contrast to their finding, we observed that there was no difference in body weight till the end of the study period. The weekly body weight gain and average daily gain (ADG) show no statistical significance among the treatment groups. Though the result reveals no statistical significance there was a numerical change in the daily gain and it was observed that there was a linear increase in the daily gain showing an increasing trend in the weight gain. Overall ADG also reveals no statistical significance but numerical higher body gain was observed in lower stocking rates as compared to pigs at higher stocking density. Deen, (2005) observed that increasing the space allowance by 0.88 m^2/pig (SA0.88) has a higher ADG of 1.08 kg/day. Reducing stocking density from 0.93 to 0.66 m^2/pig reduced BW by 4.0%, ADG by 17.0%, ADFI by 10.7%, and G: F ratio by 7.8% as observed by White et al. (2008). Similar findings were also reported by Gonyou et al. (2006); Laskoski, (2017) who observed that for every 0.001 decrease in k (approximately 3% of the critical k value), ADG decreased by 0.56 to 1.41%, with an average value of 0.98% for the 5%-based analyses. In contrast to this Li et al. (2020); and Potter et al. (2010) found no significant differences were noted among ADG, ADFI, or F: G ratio of growing pigs 128 after 30 d of treatment ($P > 0.05$).

The ADFI reveals a statistically significant difference ($P<0.05$) between the treatment groups (Table 4). We also observed a linear increase in the feed intake where pigs under higher stocking density pigs consumed more feed as compared to those under lower stocking density of 0.3 and 0.27 m^2/pig. The increase in feed intake might be due to the high stocking rate as high stocking density may cause a behavioural problem for pigs. At higher stocking densities, the likelihood of developing crowding stress occurs. Also, due to the high temperature and humidity difference during rearing the pigs are subjected to heat stress which results in higher feed intake. In our present study, the ADFI and ADG were increased with increasing stocking density, and it is generally thought that the reduction in body weight gain is the consequence of reductions in feed intake. Breinekova et al. (2007) stated that increases in physiological response to stressors (such as heat and spatial restriction) result in activation of the sympathetic nerves and the release of catecholamines and glucocorticoids reduces body weight. The present finding was in accordance with the findings of Brumm et al. (2001); Gonyou et al. (2006); Kim et al. (2016); and Potter et al. (2010) where they observed that when growing-finishing pigs are given less than optimal space per pig, feed intake always decreases.

The data reveals a statistically significant difference ($P<0.05$) between the groups. In the first week, the pigs under low stocking density (0.3m^2/pig and 0.27 m^2/pig) were observed to have a statistically higher FCR of 1.29±0.13 and 1.27±0.15, respectively as compared to the higher stocking density group (0.24m^2/pig and 0.21m^2/pig) of 1.43±0.14 and 1.77±0.14, respectively. However, in the second week, it was observed that there was a significant difference ($p<0.05$) in the FCR where the heavier stocking density group T4 had the best stocking density when compared with the other stocking density. The lower FCR during the first week might be due to the stress of the animals, where animals are new to their surroundings and to their pen mates, which reflects on the FCR as shown by our experiment. Later when the animals get acclimatized, they regain their feed activeness and get less stress which may have resulted in the changes in the FCR.

The overall FCR reveals statistical significance ($P<0.05$) between the treatment groups; better FCR were observed in pigs under low stocking density and on heavier stocking the FCR increases. This might be due to stress within larger groups reducing growth potential, and hence ADG, which in turn reduces appetite and ADFI. Stress within the group might be the result of physical restrictions, as discussed above, or from the social stress inherent to interaction with more pigs. Though there is no significant difference between treatment groups, there was a numerical difference between the treatment groups where T_1 (0.3 m^2/pig) had the lowest FCR (3.19). Kim et al. (2016) observed that no significant effect of stocking density on FCR in FP was observed; the FCR was highest in the group (P>0.1). These results suggest that a high density could retard the growth rate due to lower nutrient availability and chronic stress caused by the social hierarchy and interaction among individuals. Similar to our findings, Carpenter et al. (2018); and Zhang et al. (2013) observed a higher G: F ratio among pigs reared in pens with a density of 0.48 m^2/pig compared to pigs reared in 0.38 m^2/pig.

There was a statistically significant difference in the negative behaviour during the day of grouping/mixing (Fig. 1). On the 0^{th} day, the percentage of negative behaviours (e.g., aggression) increased significantly with increasing the stocking density. T4 (0.21 m^2/pig) showed the highest negative behaviour (7%) compared to T1 (0.3 m^2/pig), which exhibited the least (2%) this might be because the group pigs were not familiar with their new pen mates and the increase in aggression might be due to establishing a new social hierarchy. This suggests that higher stocking density might lead to stress or discomfort. However, negative behaviours declined uniformly across all groups by the 5^{th} day and remained low through the 15^{th} day, indicating a possible adaptation to the stocking densities over time. The positive behaviour (e.g., social interaction) was higher on the 0th day in T1 and T3 (14%) but slightly lower in T4 (12%). By the 15th day, positive behaviour increased significantly in T4 (9%) compared to T1 (7%), indicating that pigs in denser spaces might eventually compensate for reduced space

Table 2. Ethogram of the pig

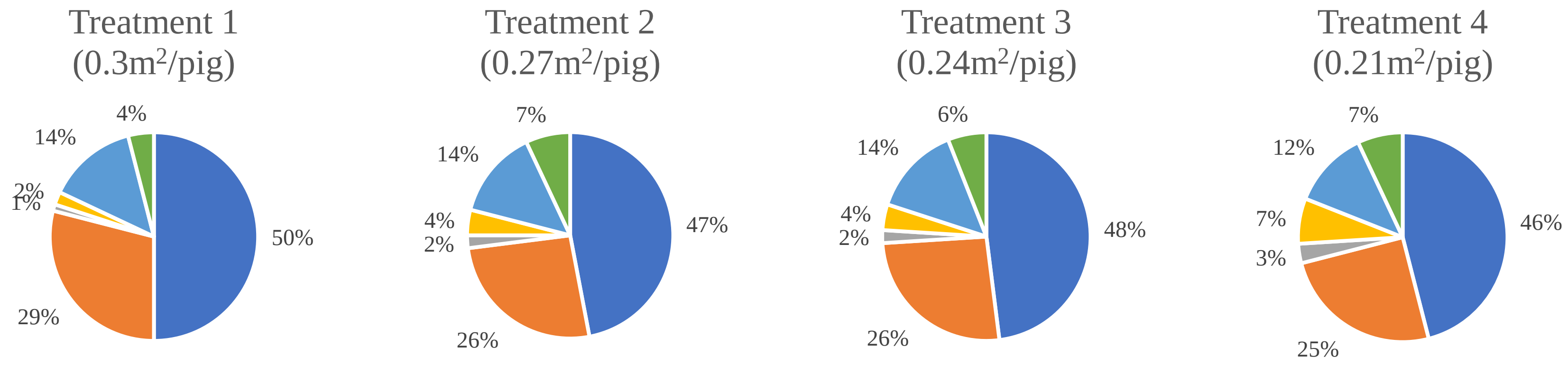
Item	Description
Lying (duration)	Lying without investigation
Eating	With their head in the feeder
Drinking	Pigs making oral contact with the nipple drinkers
Negative social behaviour	Aggressive behaviour, including social behaviour with fight aggressive or flight reaction of the other pig
Positive social behaviour	Sniffing, nosing, licking, and moving gently away from the pig without an aggressive or flight reaction from this individual
Exploratory behaviour	Floor, wall, and pen fittings investigation
Other active behaviour	Other active behaviour except for the above 6 types

Table 3. Growth performance of weaned at different stocking densities

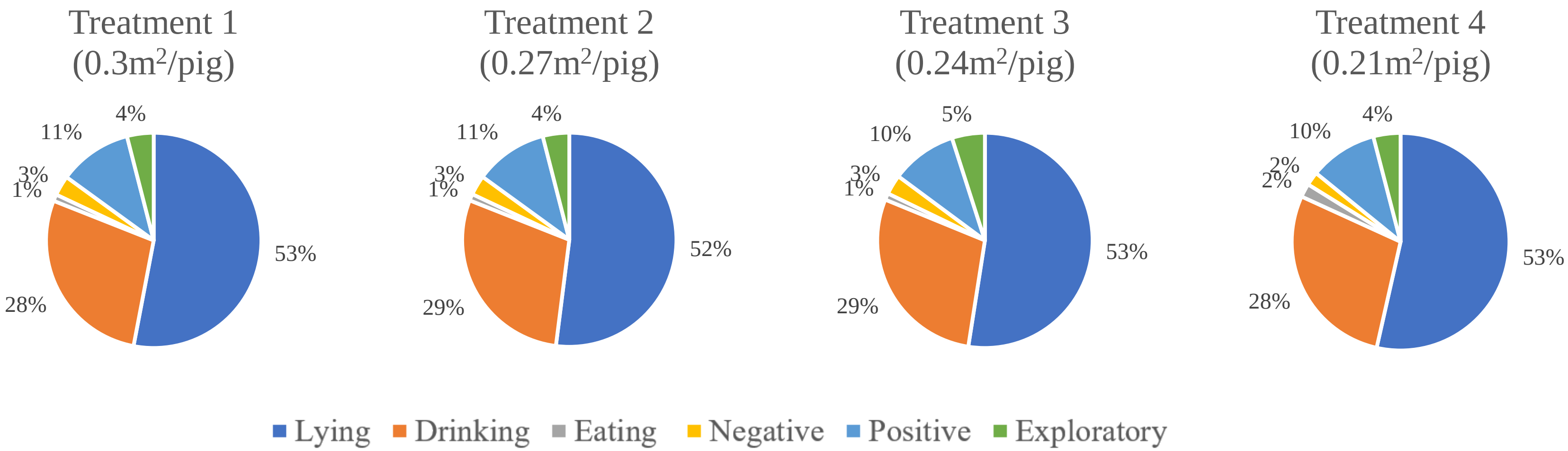
Age (Days)	Treatments				
	Control (T_1) (N=16)	**Stocking Density 10% (T_2) (N=18)**	**Stocking Density 20% (T_3) (N=19)**	**Stocking Density 30% (T_4) (N=21)**	**p-value**
	Average Body weight, Kg				
Initial (60)	9.31±0.27	9.32±0.36	9.31±0.31	9.32±0.38	1.00
67	10.30±0.24	10.39±0.34	10.74±0.40	10.45±0.60	0.91
74	11.80±0.25	12.18±0.36	11.78±0.32	12.04±0.66	0.86
81	13.73±0.28	14.27±0.38	14.12±0.30	14.56±0.46	0.92
90	16.22±0.23	16.68±0.46	16.55±0.31	16.45±0.51	0.91
	Average Daily Weight Gain (g)				
67	179.38±14.51	213.99±22.90	162.84±14.13	160.41±23.04	0.15
74	204.81±9.18	220.32±20.96	197.11±24.88	213.10±10.80	0.53
81	286.50±26.73	300.06±20.32	308.63±26.00	312.26±32.76	0.96
90	342.30±31.04	344.54±35.14	347.25±31.10	328.16±42.52	0.90
Overall ADG (67-90)	254.07±6.10	262.98±12.89	258.42±11.64	253.25±19.77	0.96

Mean values bearing different superscripts in a row differ significantly (p<0.05), SE-standard error

0


Treatment 1 (0.3m²/pig)
50%
29%
1%
2%
14%
4%
Treatment 2 (0.27m²/pig)
47%
26%
2%
4%
14%
7%
Treatment 3 (0.24m²/pig)
48%
26%
2%
4%
14%
6%
Treatment 4 (0.21m²/pig)
46%
25%
3%
7%
12%
7%

5


Treatment 1 (0.3m²/pig)
53%
28%
1%
3%
11%
4%
Treatment 2 (0.27m²/pig)
52%
29%
1%
3%
11%
4%
Treatment 3 (0.24m²/pig)
53%
29%
1%
3%
10%
5%
Treatment 4 (0.21m²/pig)
53%
28%
2%
2%
10%
4%
Lying
Drinking
Eating
Negative
Positive
Exploratory

10

15

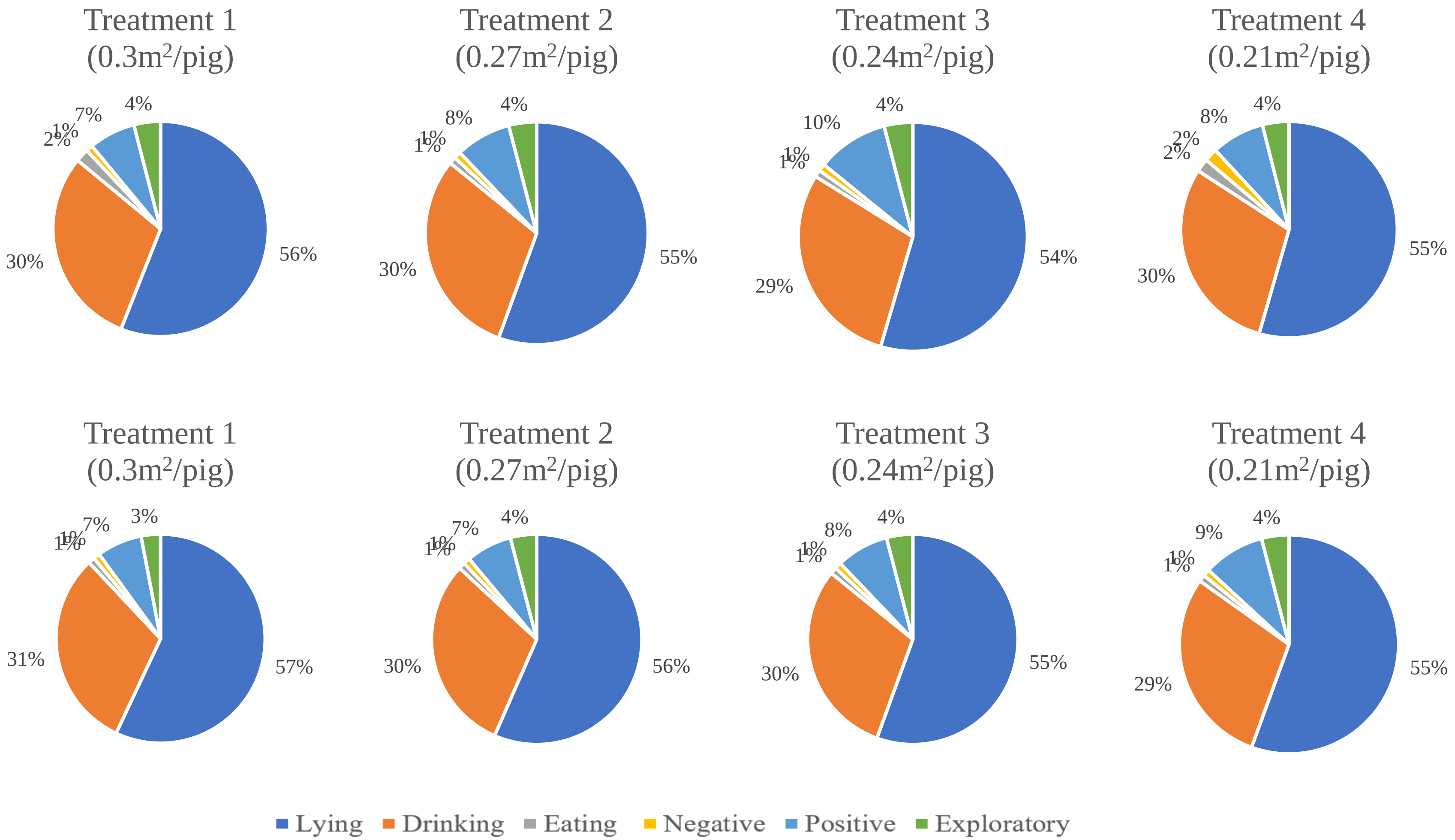


Fig. 1. Pie chart diagram represents behaviour

Table 4. Feed efficiency of weaned pigs when reared at different stocking densities

Age (Weeks)	Treatments				
	Control (N=16)	**Stocking Density 10% (N=18)**	**Stocking Density 20% (N=19)**	**Stocking Density 30% (N=21)**	**p-value**
	Average Daily Feed Intake, Kg				
10th week	3.57 ±0.19[c]	4.29 ±0.15[b]	4.36 ±0.16[b]	5.14 ±0.19[a]	0.00
11th Week	4.21 ±0.21[b]	5.79 ±0.23[a]	5.64 ±0.18[a]	5.79 ±0.37[a]	0.00
12th Week	5.43 ±0.19[c]	7.50 ±0.11[b]	7.29 ±0.11[b]	9.07 ±0.23[a]	0.00
13th Week	6.43 ±0.18[c]	8.43 ±0.09[b]	8.29 ±0.14[b]	9.86 ±0.13[a]	0.00
Total Feed Intake (67-90)	17.19±0.69[c]	20.22±0.44[b]	18.85±0.15[b]	20.90±1.30[a]	0.00
Average Feed Conversion Ratio					
10th week	1.29±0.13[b]	1.27±0.15[b]	1.43±0.14[ab]	1.77±0.14[a]	0.05
11th Week	1.33±0.07[b]	1.64±0.15[ab]	1.78±0.17[b]	1.21±0.16[a]	0.03
12th Week	1.36±0.15	1.56±0.16	1.41±0.13	1.81±0.26	0.32
13th Week	1.34±0.16	1.66±0.19	1.47±0.14	2.01±0.27	0.13
Overall FCR (67-90)	2.44±0.06[a]	2.88±0.17[ab]	2.69±0.11[a]	3.42±0.34[b]	0.02

Mean values bearing different superscripts in a row differ significantly (p<0.05), SE-standard error

through more social interactions. The increase in positive and exploratory behaviours in denser conditions (T4) over time could indicate social compensation mechanisms, possibly mitigating some adverse welfare impacts. While the exploratory behaviour (e.g., rooting, sniffing) was generally stable across all stocking densities but was slightly higher in T2 and T4. On the 15th day, T1 showed a significantly lower percentage (3%) compared to T2 and T4 (4%), potentially suggesting that denser conditions may encourage such behaviours as a coping mechanism. Drinking and eating behaviours remained stable and did not show significant differences, indicating that feeding and hydration were not adversely affected by stocking density. During the observation, more negative behaviour was observed on tail biting, as crowding has been cited as a common cause for tail biting. Similar findings were reported by Prunier et al. (2020); Van de Weerd et al. (2005); Zonderland et al. (2011); and Zupan et al. (2012) who observed that aggressive tail bitters are from the lower body weight called ‘runt’ in the litter. These persistent biters, so-called ‘fanatical biters’, were described as hyperactive pigs going from one tail to another during a biting outbreak.

Towards the end of the observation, it was found that the duration of lying time also increased which indicates a reduction in other activity during the last day of behaviour observation. On the 15th day, the pigs in T1 (0.3 m^2/pig) were found to spend more time sleeping/lying down as compared to the higher stocking density. Though it was still observed that a statistically significant difference occurred in some of the actives like positive social behaviour and exploratory behaviour, these actives were found to be more in a heavier stocking density than in the lighter stocking density groups.

4. CONCLUSIONS

Based on the result, it may be concluded that though lowering the floor allowance per pig to 0.27 m² did not affect growth performance when compared to 0.3 m² per pig; however, it drastically raised the incidence of aggressive and tail-biting behaviours, which are obvious signs of welfare compromise. These behaviours not only reflect animal stress but also pose challenges to overall farm management, including increased risk of injury and potential impacts on productivity over time. Some ideas, such as improving the surroundings with toys or increasing the provision of feed, might lessen the pigs' infighting and improve their welfare. Further research on integrating environmental enrichment and stress mitigation measures is recommended to refine stocking density guidelines.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

ETHICAL APPROVAL

All authors hereby declare that all the guidance on experimental animals of CPCSEA.were followed, as well as specific national laws where applicable. All experiments have been examined and approved by the appropriate ethics committee Regd. No. GADVASU/2021/ IAEC/62/15.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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