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Study on Illumination Intensity and Duration of LED Light Sources for a Weaned Piglet House without Natural Light

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Abstract: Lighting is an important environmental parameter in livestock farming, which can affect the physiology and behavior of animals, and it can regulate animal production. To explore the comprehensive effects of light intensity and duration on the performance, behavior, and physiological indicators of piglets, a 3 × 2 two-factor experiment (three levels of lighting intensity × two lighting durations) was conducted. The three light intensities used were high (100–120 lux), medium (40–50 lux), and low (5–20 lux). The two lighting durations were 8 h and 10 h of light per day. The experiment used a total of six lighting combinations, which corresponded with the six test units. A total of 96 Landrace–Yorkshire hybrid piglets, with an initial body weight of 13.23 ± 0.18 kg, were randomly assigned to six lit units, four pens per unit, and four piglets per pen. The results showed that lighting intensity and duration had no significant effect on the average daily feed intake, average daily gain, feed/gain, or water consumption of pigs ($p > 0.05$). For IgM, the main effect caused by the light duration was significant. When the light intensity was 5–20 lux and 40–50 lux, the serum IgM levels of piglets in the 10 h/day light group were 45.80% and 39.54% higher than those in the 8 h/day group, respectively ($p < 0.05$). For SOD and GSH-Px, the interaction between the lighting duration and intensity was significant ($p < 0.05$). In the 8 h/day light group, the serum SOD levels of piglets at light intensities of 5–20 lux and 40–50 lux were significantly higher than those at 100–120 lux ($p < 0.05$). When the light intensity was 5–20 lux and 40–50 lux, the SOD level in the 8 h/day group was significantly higher than that of the 10 h/day group ($p < 0.05$). The main effect of lighting duration on lying down and abnormal behavior was significant ($p < 0.05$). In the 8 h/day light group, the abnormal behavior of piglets under a light intensity of 5–20 lux was twice that of 40–50 lux ($p < 0.05$), and the lying percentage of piglets under a light intensity of 40–50 lux was 14.03% higher than that of piglets under a light intensity of 5–20 lux ($p < 0.05$). Overall, under the conditions used in this study, although extending the duration of light with an intensity of 40–50 lux to 10 h can improve some immune-related indicators, the extent of this effect was limited. The recommended lighting scheme for piglet houses is a light intensity of 40–50 lux and a lighting duration of 8 h. However, the range of lighting conditions set in this study was still very limited, and various environmental factors must be comprehensively considered in an actual production setting.

Keywords: lighting; piglets; growth performance; physiological properties; behavior

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1. Introduction

With the development of large-scale and intensified pig farming in China, managing pig house environments has become particularly important. Lighting is one of the main components of the environmental management of livestock houses. The vision, physical development, neurodevelopment, and behavior of animals are affected by lighting systems [1–3]. Light mainly regulates the physiological and behavioral rhythms of animals through the retina–hypothalamic suprachiasmatic nucleus (SCN)-pineal axis [4]. Light intensity and the photoperiod can affect pigs. Appropriate lighting can promote the deposition of minerals and proteins in the body, which is beneficial for the growth and development of pigs [5].

Light intensity and the photoperiod are the two main factors controlling artificial light in pig houses. The minimum light intensity required in the pig house is based on the light intensity detected by the pig's eyes, and the minimum recommended light intensity differs depending on the country/region. The German Animal Welfare legislation stipulates that the illumination intensity in a pig house should be at least 80 lux over 8 h. The EU and other countries recommend a minimum light intensity of 40 lux, which is in accordance with Pig Welfare Law. The light intensity standard for pigs at different stages of production (formulated by the American Society of Engineering) is 50 lux for nursery houses. Canada recommends a light intensity of 54–108 lux for nursery houses [4,6,7]. There have been many studies on lighting conditions in pig houses. Studies such as the one conducted by Scaillierez et al. have shown that ≥16 h of light per day can increase the feed intake, growth, and health of growing pigs compared with 8 h of light per day [8]. Martelli et al. concluded that under a light intensity of 40 lux, pigs with 16 h/d of light duration presented with a greater live weight, and they spent more time resting and less time pseudo-rooting compared with those subjected to 8 h/d of light duration. ($p < 0.01$) [9]. Nieuwamerongene et al. found that fecal and urine pollution in pens was not affected by light intensity. The percentage of pigs lying in the rest area under medium intensity light (203 lux) was higher than that under low intensity light (46 lux) and gradient intensity light (ranging from 72 lux in the feeding area to 331 lux in the dunging area) ($p < 0.05$) [10]. Larissa et al. found that leukocyte counts under short-day conditions (8 h/d light) were generally more rhythmic in domestic pigs [11]. Appropriately prolonging the duration of light, or increasing light intensity, can improve the immunity of piglets, enhance digestive function, promote appetite, increase the speed of weight gain, and increase the survival rate of piglets [12]. In a pen unit where one side was permanently illuminated with 600 lux, and the other was darkened to almost 0 lux (~0 lux), the piglets initially preferred to lie in the 600 lux illuminated compartments; this preference reversed over time in the darkened compartments [13]. Although an appropriate increase in light intensity is beneficial to the growth of pigs, if the light is too strong, pigs show restlessness, respiratory and blood circulation disorders, and symptoms of dermatitis, keratitis, and conjunctivitis [14]. Studies have also shown that providing long-lasting light for weaned piglets increases their daily feed intake and gain, reduces maintenance energy, and improves energy utilization and feed conversion efficiency. This is because light stimulates piglets through the optic nervous system, reduces the secretion of melatonin and other neuroinhibitory transmitters, increases the feeding activity of piglets, prolongs their feeding time, and improves their digestion and absorption capacity [15]. In addition, the photoperiod also influences the pig immunity status. Niekamp et al. reported that weaning at 28 d, and a long-day photoperiod (16 h of light/d), was most physiologically beneficial to piglets [16].

Although some research on the impact of light intensity and duration on piglets has been conducted, most of these studies only focused on single factors under light conditions. Comprehensive research on the effects of light conditions on piglets is scarce. This study considered light intensity and duration, and it explored the effects of the interaction between the two lighting factors on growth performance, serum physiological indicators, and the behavioral expressions of weaned piglets. This study provides a theoretical basis and reference for the selection of artificial light environments in pig houses.

2. Materials and Methods

2.1. Experimental Design and Management

This study was conducted in a pig house with a controllable lighting system at the Chongqing Academy of Animal Sciences, Chongqing City, China, from December 2022 to January 2023, and it lasted for 10 weeks. During the test, the ambient temperature in the pig house was 22.04 ± 1.60 °C, and the relative humidity was 50.23 ± 7.17%. The experimental pig house consists of six small units of 9.2 m × 6.0 m, each unit with six pens. The layout diagram of the experimental unit and pens is shown in Figure 1. The building dimensions of each pen were 3.75 m × 2 m, and the floor was designed with a 55% solid concrete floor and 45% slatted floor. One round plastic feeder was installed on the solid floor, and two nipple drinkers were installed on the slatted floor. As the air cooler was installed above the two pens at one end of the unit, the lights were easily blocked, therefore, the remaining four pens were used as the test pens. Eight light emitting diode (LED) intelligent control tri-proof lights (LZJ0212003602, Suzhou Opal Lighting Co., Ltd., Suzhou, China) were suspended at a height of 1.8 m from the ground, above the test pens of each unit, and they were arranged evenly in two rows and four columns. To avoid the influence of natural light, all windows in the lighting units were shaded, and the light intensity and duration of each unit were adjusted through the Opple online system website (https://iot2.opple.com/, (accessed on 10 November 2022)).

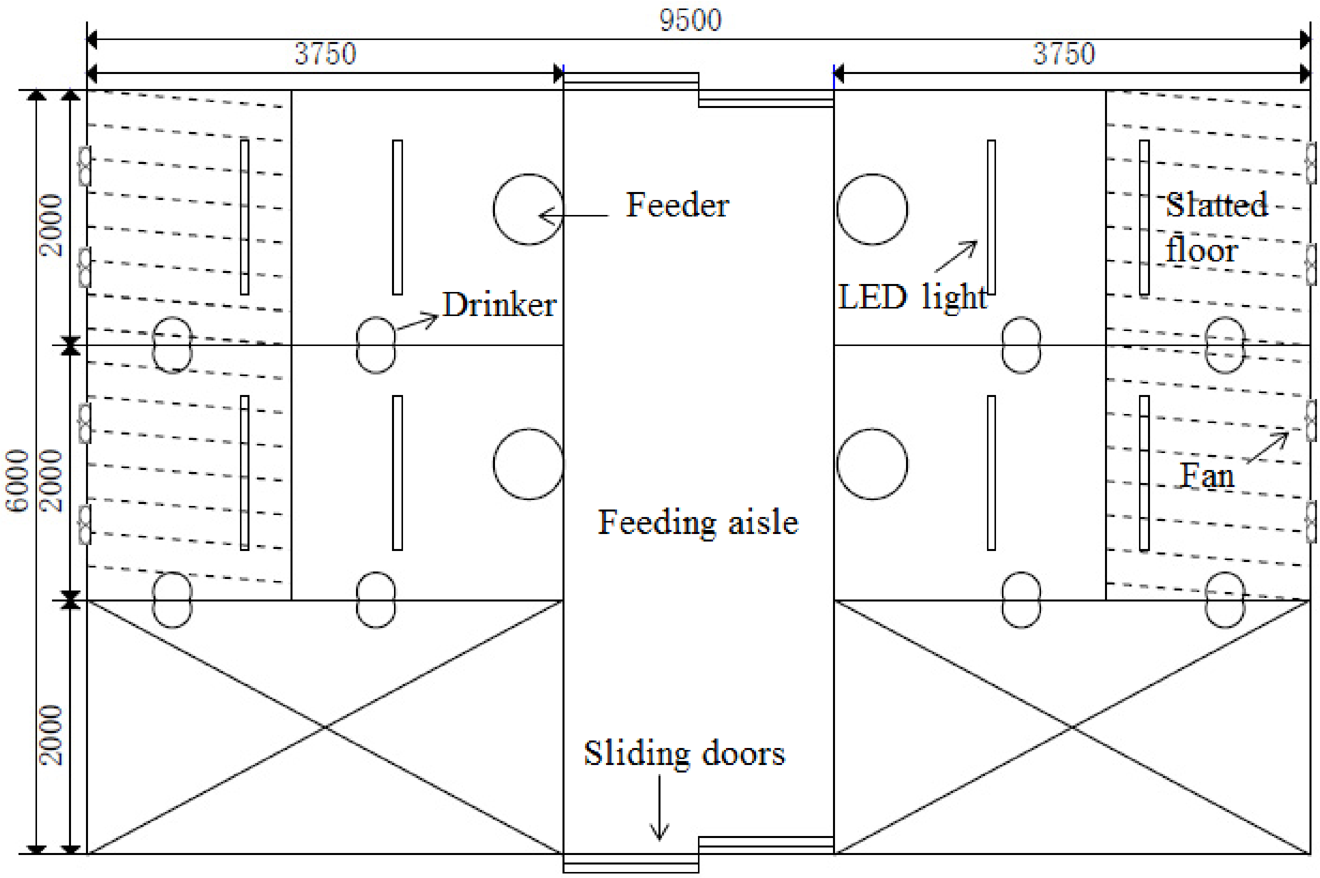

Figure 1. The layout diagram of the experimental unit and pens.

A 3 × 2 two-factor experimental design (three levels of lighting intensity × two lighting durations) was used with four replicates per treatment. Based on the international minimum requirements concerning light intensity and duration in pig houses (40–50 lux and 8 h) [4,6,7], our lighting scheme considered increasing the light intensity and prolonging the light duration; the lighting scheme is shown in Table 1. The three lighting intensities used were high (100–120 lux), medium (40–50 lux), and low (5–20 lux). The two lighting durations were 10 h of light per day (lighting from 0800 to 1800 h, interrupted by a 14 h dark period) and 8 h of light per day (lighting from 0900 to 1700 h, interrupted by a 16 h dark period). The lighting regimens of the test units are presented in Table 1. A total of 96 Landrace–Yorkshire hybrid piglets (live weight 13.23 ± 0.18 kg, 32~40 days of age) were randomly assigned to 24 pens in six lit units, in accordance with the principle of male–female balance, with four piglets per pen. Feed was delivered twice daily (10:00 h and 16:00 h), and water was available ad libitum. Two fans were installed on the wall, at the back end of the pen, for ventilation purposes. The pens were cleaned manually before 17:00 h every day, and below the slatted floor, the manure in the ditch was cleared regularly using mechanical scrapers.

Table 1. Lighting regimens for the test units.

	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6
Light intensity	5–20 lux	40–50 lux	100–120 lux	5–20 lux	40–50 lux	100–120 lux
Lighting duration	8 h/day	8 h/day	8 h/day	10 h/day	10 h/day	10 h/day

2.2. Determination of Indicators

2.2.1. Growth Performance

The growth performance of the test pigs was reflected in the average daily feed intake (ADFI), average daily gain (ADG), feed/gain (F/G), and average daily water consumption. On the first and twenty-eighth days of the experiment, the pigs in each pen were weighed using a mobile individual weighing scale (accuracy: 0.5 kg, Meier-Brakenberg, Extertal, Germany), and the ADG was calculated. Additional amounts of feed were recorded for each pen during the trial, and the ADFI and F/G were calculated. The water consumption of the pigs was recorded weekly using flow meters (accuracy: 10^{-4} m^3), which were installed in the drinking water pipes of each pen.

2.2.2. Serum Immunity and Antioxidant Indicators

On the twenty-eighth day of the experiment, one piglet whose body was in good condition, and close to the average weight from each replicate, was selected for the collection of blood samples. Blood was drawn from the anterior vena cava by an experienced technician using 20 mL disposable syringes. It took less than 2 min to complete the blood collection from one pig; this was necessary to reduce the impact of stress on the blood indicators. After the blood was static for 20 min, it was centrifuged at 1500 rpm for 5 min, and the serum was collected, divided into centrifuge tubes, and stored at −20 °C.

Before analysis, the serum was thawed at 4 °C and mixed evenly. A kit (Nanjing Jiancheng Bioengineering Institute, Nanjing, China) was used to measure the total antioxidant capacity (T-AOC), superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GSH-Px) activity, and malondialdehyde (MDA) content. An enzyme-linked immunosorbent assay (ELISA) kit (Jiangsu Jingmei Biotechnology Co., Ltd., Yancheng, China) was used to determine the serum immunoglobulin A (IgA), immunoglobulin G (IgG), and immunoglobulin M (IgM) levels. The instruments used in the test included a microplate reader (THERMO FISHER, Waltham, MA, USA), a constant-temperature drying oven (Tianjin Test Instrument Co., Ltd., Tianjin, China), micropipettes (THERMO FISHER, Waltham, MA, USA), and a constant-temperature water bath (Tianjin Test Instrument Co., Ltd., Tianjin, China). All the detection steps were performed in strict accordance with the manufacturer's instructions.

2.2.3. Behavioral Recording and Analysis

The pigs' behavior was automatically recorded using a high-definition wide-angle camera system installed above each pen—the video recordings of the thirteenth day after group stabilization were selected for the statistical analysis of the pigs' behavior. Behavioral indicators included excretion, lying, drinking, and abnormal behaviors (fighting, biting railings, and tail biting). The behaviors were assessed using the method described by Zhou et al. [17,18]. When counting behaviors, the first 10 min of every 30 min of the lit period, and the first 10 min of every 60 min of the dark period, were selected from the video recordings. A team of experienced research assistants calculated how often each behavior occurred, as percentages.

The occurrence of certain behavior, as a percentage = total duration of the occurrence of a certain behavior/total observation duration × 100.

2.3. Statistical Analysis

Our experiments analyzed growth and behavioral indicators in pens, with four replicates per treatment. The blood index uses an individual pig as the statistical unit, and the number of repetitions of each treatment is the number of sampling objects. The experimental data were statistically analyzed and charted using Excel 2010, SPSS 20.0 and OriginPro 9.0. A univariate two-way ANOVA in the general linear model was used to analyze the effects of lighting intensity and duration on growth performance, serum physiological indicators, and the behaviors of piglets. Statistical significance was considered to be $p < 0.05$, and the results are expressed as the mean ± SE.

3. Results

3.1. Growth Performance of Pigs

The light intensity and photoperiod had no significant effect on ADFI, ADG, F/G, or the water consumption of pigs, and the interaction effect was not significant ($p > 0.05$) (Table 2).

Table 2. Effect of light regime on the growth performance of piglets.

Lighting Duration	Light Intensity (lux)	ADFI (kg)	ADG (kg)	F/G	Water Consumption ($L \cdot pig^{-1} \cdot d^{-1}$)
8 h/day group	5–20	0.97 ± 0.05	0.44 ± 0.05	2.19 ± 0.14	6.28 ± 1.67
	40–50	0.93 ± 0.05	0.42 ± 0.02	2.24 ± 0.19	5.8 ± 1.57
	100–120	0.96 ± 0.03	0.42 ± 0.06	2.33 ± 0.4	4.74 ± 1.4
10 h/day group	5–20	0.94 ± 0.02	0.40 ± 0.05	2.35 ± 0.29	6.01 ± 1.48
	40–50	0.93 ± 0.01	0.39 ± 0.08	2.47 ± 0.4	5.89 ± 2.01
	100–120	0.91 ± 0.05	0.45 ± 0.07	2.04 ± 0.22	4.65 ± 2.36
Interacting effects (*p*-value)		NS	NS	NS	NS

Note: ADFI = average daily feed intake, ADG = average daily gain, F/G = feed/gain. "NS" means that the difference is not significant ($p > 0.05$), and this meaning is also applicable for the following tables.

3.2. Serum Physiological Indicators

3.2.1. Immunoglobulins

As shown in Table 3, light intensity and duration had no significant effects on IgG and IgA levels. Regarding IgM, the main effect of light duration was significant. When the light intensity was 5–20 lux and 40–50 lux, the serum IgM levels of piglets in the 10 h/day light group were 45.80% and 39.54% higher than those in the 8 h/day group, respectively ($p < 0.05$).

Table 3. Serum immune indicators in piglets under different light conditions.

Lighting Duration	Light Intensity (lux)	IgG (mg/mL)	IgA (µg/mL)	IgM (mg/mL)
8 h/day group	5–20	10.23 ± 0.90	1000.61 ± 60.98	18.95 ± 0.95
	40–50	11.86 ± 2.14	974.82 ± 42.72	18.97 ± 1.13
	100–120	11.11 ± 1.15	1014.46 ± 16.33	19.99 ± 1.45
10 h/day group	5–20	12.91 ± 5.33	1204.12 ± 191.19	27.63 ± 1.30
	40–50	12.79 ± 4.27	1021.65 ± 176.89	26.47 ± 6.23
	100–120	14.65 ± 3.62	899.21 ± 141.59	21.72 ± 2.23
p-value	Lighting duration	NS	NS	*
	Light intensity	NS	NS	NS
	Lighting duration × Light intensity	NS	NS	NS

Note: IgG, IgA and IgM means immunoglobulin G, A, and M. Lighting duration × Light intensity represents the interaction term of the two factors. And "*" means that the difference is significant ($p < 0.05$).

3.2.2. Antioxidants

The light intensity and duration exhibited no significant effects on the T-AOC, MDA, or CAT levels in piglets ($p > 0.05$) (Table 4). In the 8 h/day light group, the serum SOD levels of piglets, at light intensities of 5–20 lux and 40–50 lux, were significantly higher than those of piglets at a light intensity of 100–120 lux ($p < 0.05$). When the light intensity was 5–20 lux and 40–50 lux, the SOD level in the 8 h/day group was significantly higher than that of the 10 h/day group ($p < 0.05$). Regarding GSH-Px, the main effects of light intensity and duration were not significant ($p > 0.05$), but the interaction was significant ($p < 0.05$). In the 10 h/day light group, the light intensity increased from 5–20 lux to 100–120 lux, and GSH-Px decreased by 9.55% ($p < 0.05$). When the light intensity was 100–120 lux, the serum GSH-Px level of piglets in the 8 h/day group was significantly higher than that of the 10 h/day group ($p < 0.05$).

Table 4. Serum anti-oxidation indicators of piglets under different light conditions.

Lighting Duration	Light Intensity (lux)	T-AOC (U/mL)	MDA (nmol/mL)	SOD (U/mL)	GSH-Px (μmol/L)	CAT (U/mL)
8 h/day group	5–20	1.99 ± 0.46	1.39 ± 0.42	89.4 ± 3.07	302.65 ± 25.91	3.12 ± 0.9
	40–50	2.05 ± 0.98	1.18 ± 0.63	86.88 ± 3.72	302.5 ± 5.49	1.96 ± 1.65
	100–120	1.63 ± 0.57	1.5 ± 0.33	67.76 ± 5.58	319.71 ± 8.45	1.73 ± 0.26
10 h/day group	5–20	1.33 ± 0.91	1.82 ± 1.1	76.68 ± 9.55	320.59 ± 10.11	1.57 ± 1.32
	40–50	1.36 ± 0.21	1.54 ± 0.47	73.45 ± 4.32	309.41 ± 16.71	0.9 ± 0.48
	100–120	1.57 ± 0.47	2.64 ± 0.97	73.45 ± 4.13	292.65 ± 4.88	2.2 ± 1.24
p-value	Lighting duration	NS	NS	*	NS	NS
	Light intensity	NS	NS	*	NS	NS
	Lighting duration × Light intensity	NS	NS	*	*	NS

Note: T-AOC = total antioxidant capacity, MDA = malondialdehyde, SOD = superoxide dismutase, GSH-Px = glutathione peroxidase, CAT = catalase. Lighting duration × Light intensity represents the interaction term of the two factors. And "*" means that the difference is significant ($p < 0.05$)

3.3. Behaviors

The occurrence of each behavior, as exhibited by piglets, is shown in Figure 2 as a percentage. Light intensity and duration had no significant effect on piglet excretion or drinking behavior ($p > 0.05$). Regarding abnormal behavior, the main effect of the lighting duration was significant ($p < 0.05$). In the 8 h/day light group, the abnormal behavior of piglets under a light intensity of 5–20 lux was twice that of piglets under a light intensity of 40–50 lux, and the difference was significant ($p < 0.05$). Regarding lying behavior, the main effect of lighting duration was significant. In the 8 h/day light group, the lying rate of piglets under a light intensity of 40–50 lux was 14.03% higher than that of 5–20 lux ($p < 0.05$). Under a light intensity of 5–20 lux, the lying rate of pigs in the 10 h/day group was 15.48% higher than that of pigs in the 8 h/day group ($p < 0.05$).

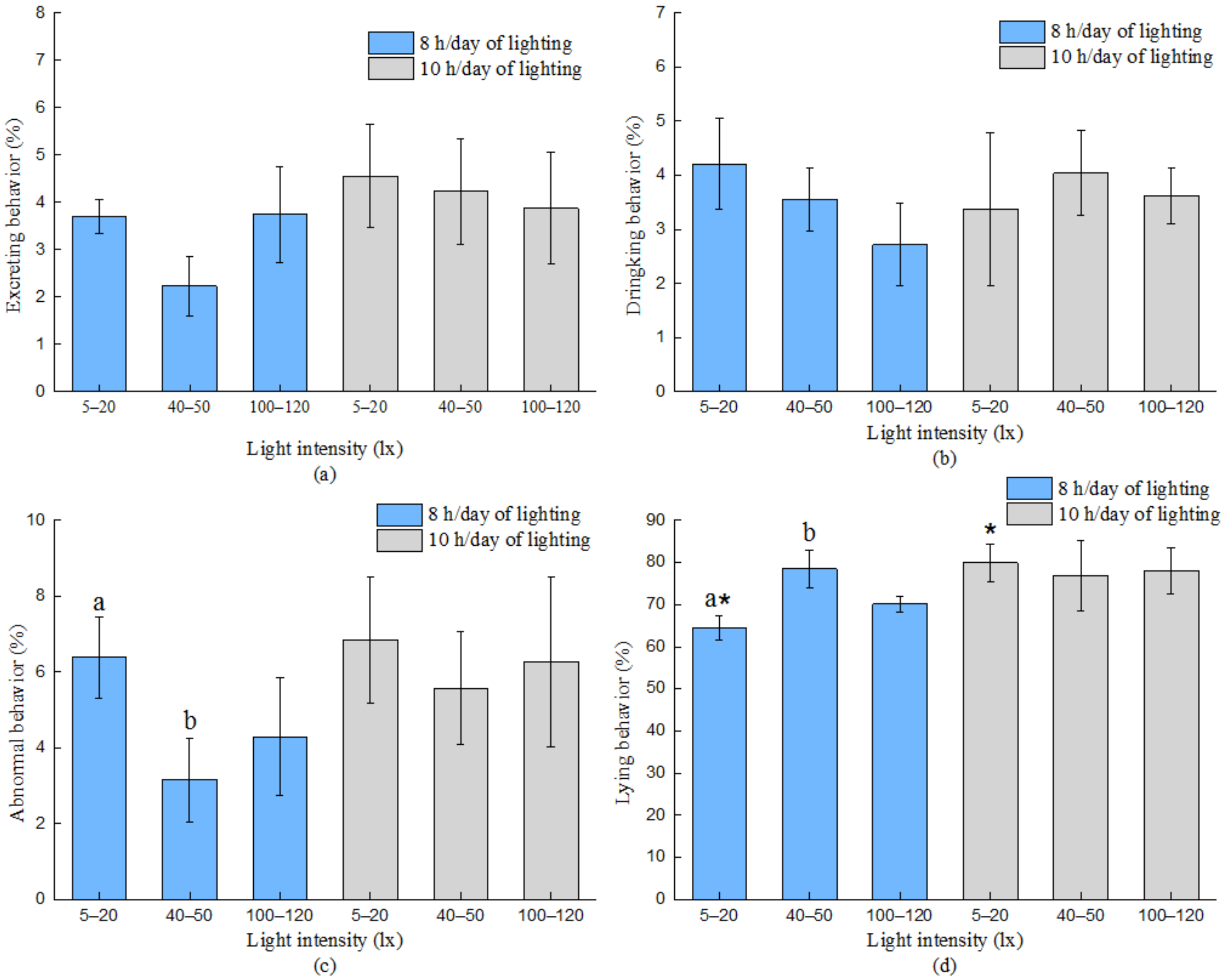

Figure 2. Percentage of excreting (**a**), drinking (**b**), abnormal (**c**), and lying (**d**) behaviors of piglets under different lighting schemes. Error bars indicate the standard error. Different letters represent significant differences in data, with regard to the different light intensity treatments within the lighting duration group ($p < 0.05$). "*" indicates significant differences in data between the different lighting duration groups at this lighting intensity level ($p < 0.05$). Abnormal behaviors include fighting, biting railings, and tail biting.

4. Discussion

4.1. Growth Performance

Regarding the effect of lighting on the production performance of pigs, some studies have suggested that different light intensities do not affect the production traits and feed consumption of pigs [13,19], whereas some scholars believe that the photoperiod affects the growth of pigs. Martelli et al. found that under long-term lighting (16 h) conditions, the body weight of the pigs decreased ($p < 0.01$). They also found that under a light intensity of 70 lux, the ADG of pigs significantly improved when the light duration was increased from 8 to 14 h [20]. Increasing the photoperiod, even at lower light intensity levels, still has beneficial effects on the growth parameters of heavy pigs under conditions that ensure an appropriate resting dark period for animals [9]. In the present study, no significant differences were observed with regard to the effects that different lighting regimes have on pig growth performance. According to the statistical data of the experiment, the ADFI and ADG of the pigs did not increase when the light duration (for the three light intensities) was prolonged. Perhaps increasing the light duration from 8 h/day to 10 h/day was not sufficient to improve the growth performance of pigs; this needs to be further explored.

4.2. Serum Physiological Indicators

4.2.1. Immunoglobulins

Three categories of immunoglobulins are widely present in animal bodies, as follows: immunoglobulin (Ig) G, IgA, and IgM. They can combine with antigens and participate in humoral immunity. Their content directly reflects the strength of the body's immune ability [21]. IgM mainly exists in the early stages of immunity, and it functions to activate the complement. Both IgG and IgA are primary antibodies involved in body immunity. The study by Niekamp et al. noted that under a light intensity of 250 lux, compared with the short-day (8 h of light/d) photoperiod group, the total plasma IgG concentration of weaned piglets (28 days old) in the long photoperiod (16 h of light/d) group was less (p = 0.05) [16]. In our study, under both low light intensity (5–20 lux) and medium light intensity conditions (40–50 lux), the serum IgM of pigs in the 10 h illumination group was significantly higher than that of the 8 h group. Moreover, under high light intensity conditions (100–120 lux), the serum IgM level of piglets in the 10 h lighting group was also higher than that of the 8 h group, although the difference was not significant. This indicates that when the light intensity is within a certain range, extending the light duration can improve the immune-related indicators of piglets, which may be beneficial for improving their immunity. However, when the light intensity is too high, the opposite of this effect may be observed.

4.2.2. Antioxidants

Oxidative stress is one of the main pathological factors affecting animal growth performance. It is caused by the excessive production and accumulation of reactive oxygen species (ROS), leading to an imbalance in the oxidative system [22,23]. The activities of the antioxidants SOD and GSH-Px are typically used to evaluate the state of antioxidants in the body. When the body suffers from stress, SOD and GSH-Px can be generated to relieve the free radicals in the body to prevent damage or the apoptosis of macromolecules, thereby maintaining the balance between oxidation and antioxidant systems [24]. In the short-duration light (8 h/day) group, the serum SOD levels of piglets under low and medium light intensity (5–20 lux and 40–50 lux) conditions were significantly higher than those of piglets under high light intensity conditions (100–120 lux). Under low and medium light intensity conditions, the serum SOD level of pigs in the short-duration illumination group was significantly higher than that of pigs in the long-duration illumination group. The serum GSH-Px levels showed a similar pattern. This indicates that the serum SOD and GSH-Px levels of the piglets activated to a greater extent under low and medium light intensity conditions and when the light duration was shorter; these conditions were more beneficial to the antioxidant capacity of the piglets.

4.3. Behaviors

Different lighting durations and intensities affect the behavioral state of pigs. Taylor observed the behavior of pigs in their preferred rooms and found that pigs especially like to sleep in the dark [1]. Pigs in the medium intensity (198 lux) group expressed more play behavior than those in the other groups, especially social and individual locomotory play [25]. Longer photoperiods (14 vs. 8 h of light over 24 h) had some positive effects on the behavioral characteristics of pigs, and higher light intensities (80 vs. 40 lux) reduced the aggressive behavior of heavy pigs [19,20]. In our test, the main effect of lighting duration was significant for abnormal and lying behaviors. Abnormal behavior refers to behaviors that are contrary to biological behaviors; abnormal behavior occurs when animals receive adverse stimulation for a long time or live in a harsh environment [26]. Abnormal behaviors are caused by the various environmental factors to which pigs are exposed. In this study, when the light duration was 8 h, the percentage of pigs experiencing abnormal behaviors, such as fighting under darker light conditions (5–20 lux), was significantly higher than that of pigs under 40–50 lux light. Under the same light intensity conditions, the percentage of abnormal behaviors in pigs in the 10 h light duration group was higher than that of the 8 h light duration group. The study by Martelli et al. found that after 12 h of illumination, the agonistic interaction behavior among fattening pigs in the lower level of the illumination group was significantly higher than that of the higher level of the illumination group ($p < 0.05$) [19]; this was consistent with our results. This indicates that in darker light environments, pigs are more likely to exhibit abnormal behaviors, and increasing the duration of light does not reduce the number of times abnormal behaviors occur.

Lying behavior directly reflects the resting state of pigs, and it was chosen as an indicator of lying comfort and animal welfare [27,28]. In the 8 h light duration group, the lying behavior of pigs, as a percentage, under medium light intensity conditions (40–50 lux), was significantly higher than that of pigs under low light intensity conditions (5–20 lux). Pigs did not show a greater tendency to lie down in darker environments under shorter light durations; this differs from the results in the study by Taylor et al. They found that pigs (four weeks old) especially like to sleep in a dark room [1]. However, Tanida et al. found that piglets (one week old) significantly ($p < 0.05$) feared sleeping in darkness ($p < 0.05$) [29]. These differences may be due to inconsistencies in the research methods or experimental subjects. Taylor et al. observed the behavior of pigs during the day, whereas our study only assessed the behavior of pigs during the period when the lights were on. Tanida et al. used one week old piglets as their research subjects; they were physiologically and behaviorally different from weaned piglets. When the light intensity was 5–20 lux, the lying behavior of pigs, as a percentage, in the 10 h light duration group, was significantly higher than that of the 8 h light duration group. Increasing the duration of light in a dark environment can increase the lying rate of the pigs. Under the same light intensity conditions, the incidence of the lying behavior of pigs in all 10 h light duration groups was higher than that of the 8 h groups. Martelli et al. also found that when the light intensity was 70 lux, compared with 8 h of light, pigs in the 14 h group spent more time resting in sternal recumbency ($p < 0.01$) [20]. In subsequent studies, they also found that pigs in the group with a light intensity of 40 lux and a light duration of 16 h spent more time resting and less time pseudo-rooting ($p < 0.01$) [9]. These results are similar to those in our study. When the light intensity is constant (5–20 lux, 40–50 lux, or 100–120 lux), prolonging the light duration can increase the lying behavior of pigs. This phenomenon was more significant when the light intensity was low (5–20 lux).

5. Conclusions

In this study, no significant differences were observed in terms of the effects of light duration and intensity on pig growth performance. When the light intensity was within a certain range, extending the light duration could improve the immune-related indicators of piglets, which may be beneficial for improving their immunity. Higher light intensities and longer light durations may not be beneficial for the antioxidant capacity of piglets. In darker light environments, pigs are more likely to exhibit abnormal behaviors. When the light intensity is constant, prolonging the duration of light can increase the lying behavior of pigs. Under the conditions of this study, the recommended lighting scheme for piglet houses is a light intensity of 40–50 and a light duration of 8 h. However, the range of lighting conditions in this study was still very limited, and various environmental factors must be comprehensively considered in an actual production setting.

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