

Effects of Light Intensity and Photoperiod on Reproductive Performance of Lion Head Geese in Off-Season Production

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Abstract: In order to investigate the impact of different light intensities and photoperiods on the reproductive performance of Lion Head Geese in off-season breeding, this study employed artificial light sources with intensities of 30lux, 40lux, and 50lux, along with three photoperiod treatments: 6 hours of artificial light+8 hours of natural light, 8 hours of artificial light+6 hours of natural light, and 10 hours of artificial light+4 hours of natural light. Lion Head Geese were grouped accordingly, and their egg production, egg weight, fertilization rate, and hatchability were observed. Experimental Results: In the group exposed to 50lux light intensity with 6 hours of artificial light+8 hours of natural light, lion head geese exhibited the optimal reproductive performance, with average values of egg production (per goose): 35.31 ± 5.04 , egg weight: 200.15 ± 16.68 grams, fertilization rate: $84.62 \pm 4.23\%$, and hatchability: $85.92 \pm 3.9\%$. Conclusion: Light intensity and duration significantly affect the reproductive performance of Lion Head Geese, emphasizing the irreplaceable impact of natural light sources.

1. Introduction

The Lion Head Goose, primarily found in the Chao-Shan region of Guangdong, China, is characterized by its robust physique and prominent facial lumps on the forehead and sides. The distinctive appearance, resembling a lion when viewed from the front, gives rise to its name "Lion Head Goose." This breed holds significant local cultural value and serves as the predominant goose species raised by the local population. Lion Head Geese are classified as short-day breeding animals, displaying distinct seasonality. The normal laying season for breeding geese occurs from September to April of the following year, with an approximate four-month resting period. This results in a large number of goslings hatching during the spring and winter seasons, leading to a concentrated market supply of meat geese from early spring to early summer. Conversely, there is a shortage of meat geese from late summer to winter, disrupting the regular production cycle. Additionally, the low

survival rate of goslings during winter and the higher costs incurred make winter breeding less economically viable compared to other seasons throughout the year. Off-season breeding of Lion Head Geese involves strategically retaining breeders, controlling lighting and temperature conditions, optimizing feed nutrition, and employing artificial forced molting, enabling geese to lay eggs during non-reproductive seasons, thereby providing the market with off-season goslings[1-3].

The egg-laying rate of normal Lion Head Geese is higher during the short daylight hours of the winter season (December to February of the following year), indicating that shorter light exposure stimulates egg production and reproductive activities in Lion Head Geese. Conversely, longer daylight hours inhibit egg production and reproductive activities. Therefore, the seasonal nature influencing the reproduction of Lion Head Geese highlights the crucial role of variations in light duration. Adjusting both the intensity and duration of light exposure emerges as a significant factor in implementing off-season breeding for Lion Head Geese.

2. Materials and Methods

2.1. Experimental Site and Selection of Geese

The experiment was conducted from July 2021 to December 2022 at the Weibin Livestock Farm in Fengtang, Chaozhou City. Two-year-old healthy Lion Head Geese, totaling 900 individuals, were chosen for the experiment, divided into nine groups with each group comprising 100 geese. The male-to-female ratio was maintained at 1:5.

2.2. Feeding Management

Feeding management adhered to the off-season production techniques for Lion Head Geese as outlined by Huang Deyi and Shi Zhendan [3-4].

2.3. Experimental Design

A total of 900 geese were randomly divided into 9 groups, with each group consisting of 100 geese and maintaining a male-to-female ratio of 5:1. The experimental design is outlined as follows:

Group A: 30lux light intensity with 6 hours of artificial light followed by 8 hours of natural light. Group B: 30lux light intensity with 8 hours of artificial light followed by 6 hours of natural light. Group C: 30lux light intensity with 10 hours of artificial light followed by 4 hours of natural light. Group D: 40lux light intensity with 6 hours of artificial light followed by 8 hours of natural light. Group E: 40lux light intensity with 8 hours of artificial light followed by 6 hours of natural light. Group F: 40lux light intensity with 10 hours of artificial light followed by 4 hours of natural light. Group H: 50lux light intensity with 6 hours of artificial light followed by 8 hours of natural light. Group G: 50lux light intensity with 8 hours of artificial light followed by 6 hours of natural light. Group K: 50lux light intensity with 10 hours of artificial light followed by 4 hours of natural light.

Artificial light was evenly distributed in the morning and evening periods. The experiment was conducted in well-equipped shaded greenhouses, each equipped with ventilation, cooling facilities, and other breeding amenities. The geese were free to move outside the shed, engaging in activities such as feeding, drinking, water activities, and mating.

2.4. Observation and Recording Items

Record the monthly average egg production, average egg weight, and statistics of fertilized eggs

and hatchability for each group of geese.

2.5. Data Processing

Data processing was conducted using SPSS 22.0 statistical software. Multiple-factor analysis of variance was applied to the data from each group, and the results were expressed as mean \pm standard deviation. Line graphs were generated using Excel software.

3. Experimental Results

3.1. Impact of Light Intensity and Artificial Light Duration on Off-Season Egg Production in Lion Head Geese

Table 1: Effect of high light exposure and length of artificial light on egg production of lion head geese.

Time of light Egg production Light exposure	6h(A)+8h(N)	8h(A)+6h(N)	10h(A)+4h(N)
30lux	32.15 \pm 3.72	25.39 \pm 3.4	24.23 \pm 2.89
40lux	33.69 \pm 4.68	27.39 \pm 4.21	25.85 \pm 3.05
50lux	35.31 \pm 5.04	29.08 \pm 3.09	27.62 \pm 3.64

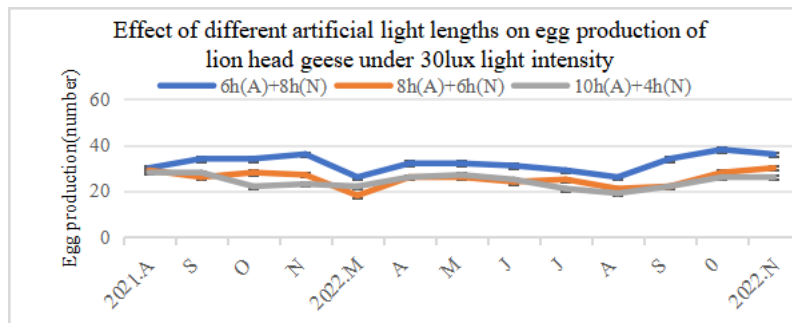


Figure 1: Effect of different artificial light lengths on egg production of lion head geese under 30lux light intensity.

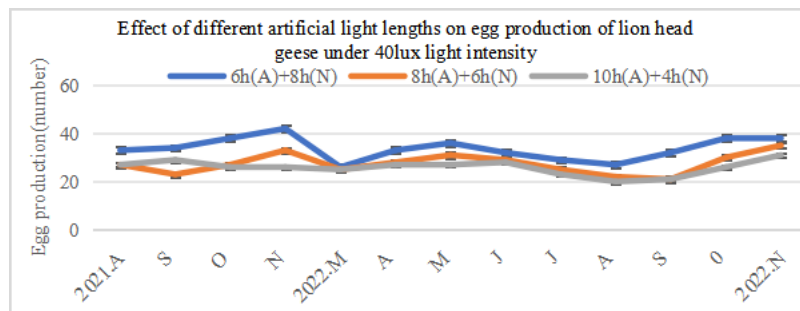


Figure 2: Effect of different artificial light lengths on egg production of lion head geese under 40lux light intensity.

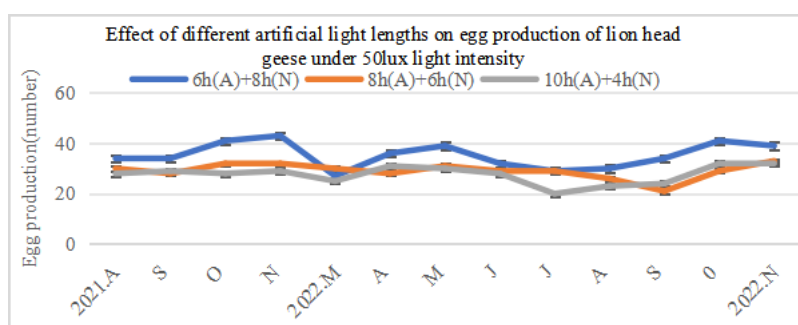


Figure 3: Effect of different artificial light lengths on egg production of lion head geese under 50lux light intensity.

Results indicate: Under a light intensity of 30lux, the average egg production for artificial light durations of 6, 8, and 10 hours was 27.26 ± 4.82^a , as shown in Figure 1. For a light intensity of 40lux, the average egg production for light durations of 6, 8, and 10 hours was 28.97 ± 5.22^{bc} , as shown in Figure 2. Under a light intensity of 50lux, the average egg production for light durations of 6, 8, and 10 hours was 30.67 ± 5.16^c , as shown in Figure 3. As indicated in Table 1, there was a significant difference between the light intensities of 30lux and 40lux/50lux, while no significant difference was observed between 40lux and 50lux light intensities. Additionally, for a 10-hour artificial light duration, the egg production was 25.9 ± 3.42^a , for an 8-hour duration it was 27.28 ± 3.82^a , and for a 6-hour duration, it was 33.72 ± 4.58^b . There was no significant difference between the 10-hour and 8-hour artificial light durations, but a significant difference was observed between both of these and the 6-hour artificial light duration.

3.2. Impact of Light Intensity and Artificial Light Duration on Off-Season Egg Weight in Lion Head Geese

Table 2: Effect of Light Intensity and Artificial Light Duration on Egg Weight in Lion Head Geese.

Time of lihg Egg weight(g) Light exposure	6h(A)+8h(N)	8h(A)+6h(N)	10h(A)+4h(N)
30lux	196.62 ± 14.56	187 ± 7.31	173.46 ± 9.78
40lux	188.54 ± 9.65	176.77 ± 7.81	164.92 ± 8
50lux	200.15 ± 16.68	166.77 ± 10.77	156.92 ± 12.67

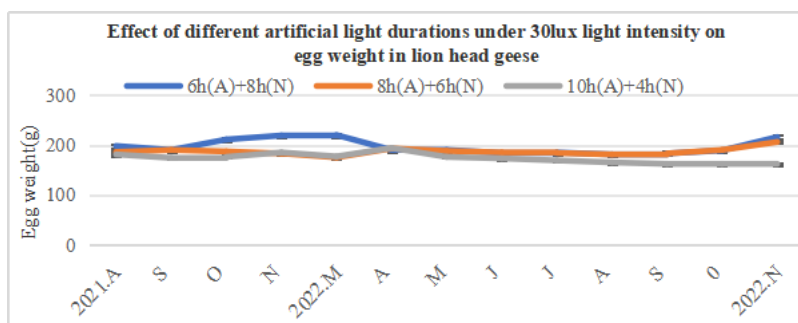


Figure 4: Effect of different artificial light durations under 30lux light intensity on egg weight in lion head geese.

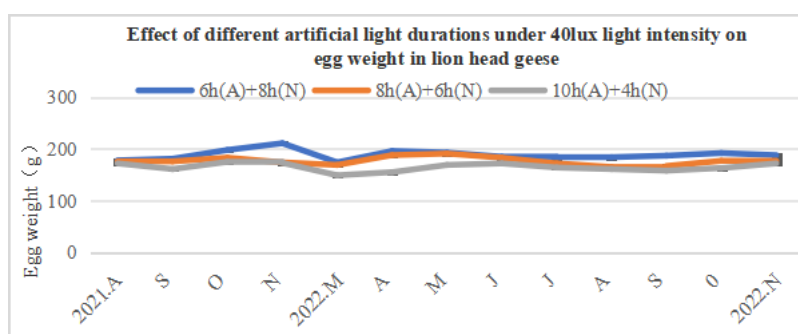


Figure 5: Effect of different artificial light durations under 40lux light intensity on egg weight in lion head geese.

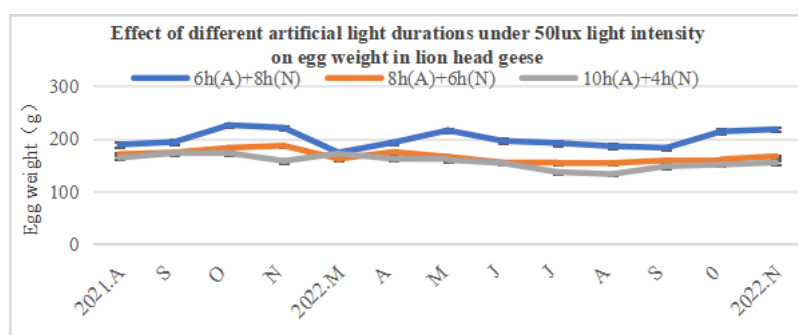


Figure 6: Effect of different artificial light durations under 50lux light intensity on egg weight in lion head geese.

Results show: As shown in Figure 4, under 30lux light intensity, the average egg weight for artificial light durations of 6, 8, and 10 hours was 185.69 ± 14.38^a . For 40lux light intensity, the average egg weight for light durations of 6, 8, and 10 hours was 176.74 ± 12.82^b , as shown in Figure 5. Under 50lux light intensity, the average egg weight for light durations of 6, 8, and 10 hours was 174.62 ± 22.95^{bc} , as shown in Figure 6. There was a significant difference between the light intensities of 30lux and 40lux/50lux, while no significant difference was observed between 40lux and 50lux light intensities. Additionally, for a 10-hour artificial light duration, the average egg weight was 165.1 ± 12.16^a , for an 8-hour duration it was 176.85 ± 11.95^b , and for a 6-hour duration, it was 195.1 ± 14.44^c . There was an extremely significant difference among these three durations, as indicated in Table 2.

3.3. Impact of Light Intensity and Artificial Light Duration on Off-Season Fertilization Rate in Lion Head Geese

Table 3: Effect of Light Intensity and Artificial Light Duration on Fertilization Rate in Lion Head Geese.

Time of lihgt Fertilization rate (%) Light exposure	6h(A)+8h(N)	8h(A)+6h(N)	10h(A)+4h(N)
30lux	80±6.43	73.69±6.81	54.62±13.58
40lux	82.92±5.85	69.08±5.02	44.85±13.75
50lux	84.62±4.23	63.54±8.93	45.62±11

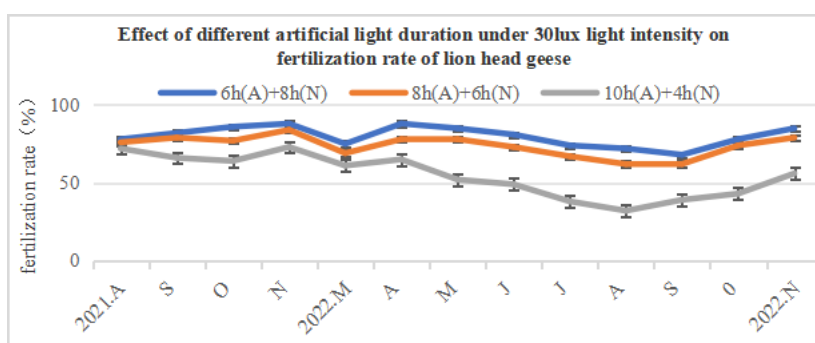


Figure 7: Effect of different artificial light duration under 30lux light intensity on fertilization rate of lion head geese.

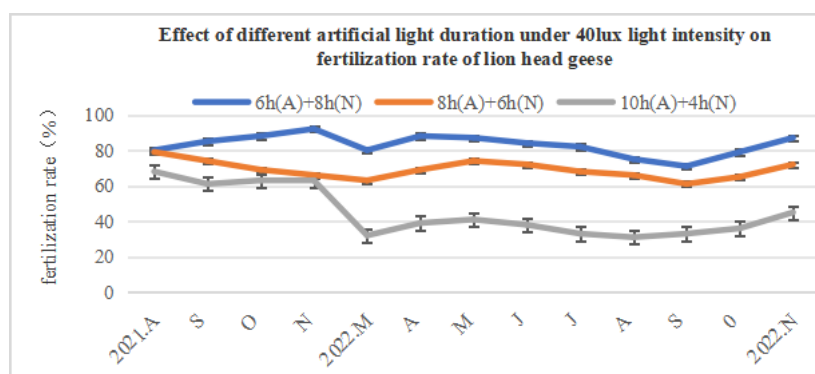


Figure 8: Effect of different artificial light duration under 40lux light intensity on fertilization rate of lion head geese.

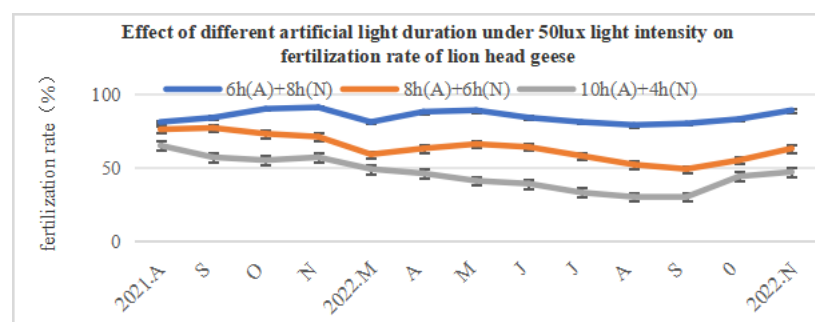


Figure 9: Effect of different artificial light duration under 50lux light intensity on fertilization rate of lion head geese.

Results show: As shown in Figure 7, under 30lux light intensity, the average fertilized eggs for artificial light durations of 6, 8, and 10 hours were 69.44 ± 14.33^a . For 40lux light intensity, the average fertilized eggs for light durations of 6, 8, and 10 hours were 65.62 ± 18.24^{abc} , as shown in Figure 8. Under 50lux light intensity, the average fertilized eggs for light durations of 6, 8, and 10 hours were 64.59 ± 18.16^{bc} , as shown in Figure 9. There was a significant difference between the fertilized eggs under 30lux light intensity and 50lux light intensity, while no significant difference was observed between 40lux light intensity and the other two light intensities. Additionally, for a 10-hour artificial light duration, the fertilized eggs were 48.36 ± 13.28^a , for an 8-hour duration, it was 68.77 ± 8.1^b , and for a 6-hour duration, it was 82.51 ± 6.77^c . There was an extremely significant difference among these three durations, as indicated in Table 3.

3.4. Impact of Light Intensity and Artificial Light Duration on Off-Season Hatchability of Eggs in Lion Head Geese

Table 4: Effect of light intensity and artificial light duration on hatchability of eggs in lion head geese

Time of lihg t Hatchability (%) Light exposure	6h(A)+8h(N)	8h(A)+6h(N)	10h(A)+4h(N)
30lux	80.77±4.19	73.54±7.61	61.77±6.58
40lux	81.54±5.49	65.23±8.41	58.46±6.01
50lux	85.92±3.9	81.92±2.56	49.85±10.65

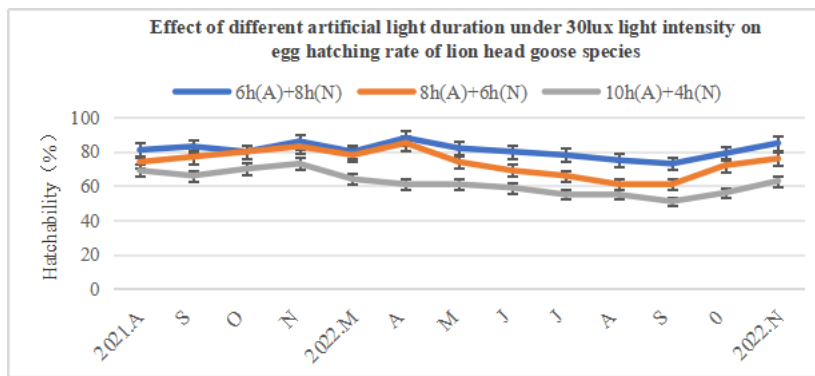


Figure 10: Effect of different artificial light duration under 30lux light intensity on egg hatching rate of lion head goose species

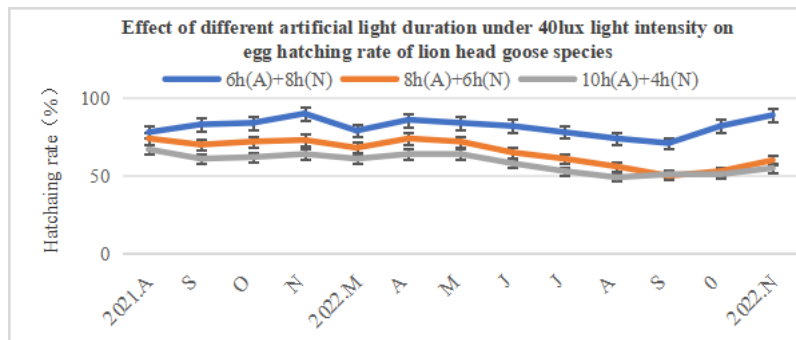


Figure 11: Effect of different artificial light duration under 40lux light intensity on egg hatching rate of lion head goose species

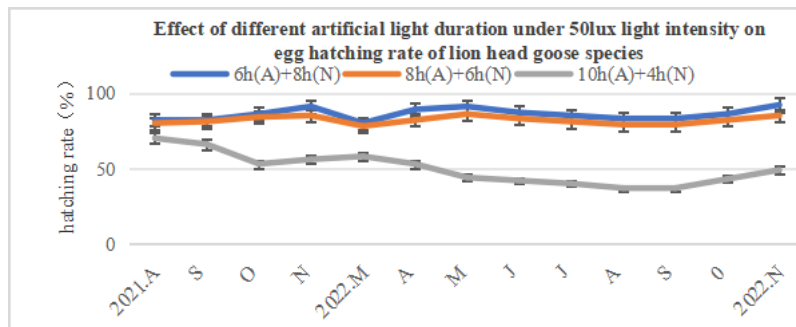


Figure 12: Effect of different artificial light duration under 50lux light intensity on egg hatching rate of lion head goose species

Results show: As shown in Figure 10, under 30lux light intensity, the average hatchability for artificial light durations of 6, 8, and 10 hours was 72.03 ± 10.02^a . For 40lux light intensity, the average hatchability for light durations of 6, 8, and 10 hours was 68.41 ± 11.81^b , as shown in Figure 11. Under 50lux light intensity, the average hatchability for light durations of 6, 8, and 10 hours was 72.56 ± 17.62^{ac} , as shown in Figure 12. There was a significant difference between 30lux and 40lux light intensities, while no significant difference was observed between 30lux and 50lux, and a significant difference was noted between 40lux and 50lux light intensities. Additionally, for a 10-hour artificial light duration, the hatchability was 56.69 ± 9.32^a , for an 8-hour duration it was 73.56 ± 9.51^b , and for a 6-hour duration, it was 82.74 ± 5.01^c . There was an extremely significant difference among these three durations, as indicated in Table 4.

4. Analysis and Discussion

Under the influence of different light intensities and artificial light durations, there is a significant impact on egg production and egg weight in Lion Head Geese. Notably, the most significant results were observed at a light intensity of 50lux with an artificial light duration of 6 hours followed by 8 hours of natural light, resulting in an egg production of 35.31 ± 5.04 eggs and an egg weight of 200.15 ± 16.68 grams. This suggests that light duration and intensity are crucial factors influencing the reproduction of Lion Head Geese [5-9]. Throughout the experiment, variations in egg production were also observed in different months. Notably, there was a decrease in egg production during the warmer months of June, July, and August, aligning with findings by Yang Haiming et. al[10].

Under 30lux light intensity, the lowest egg production was observed with an artificial light duration of 10 hours followed by 4 hours of natural light. This could be attributed to suboptimal environmental conditions inside the greenhouse during hot weather, and the use of LED lights in the experiment may differ from natural sunlight[11]. Furthermore, during the initial phase of the experiment (August 2021 to November 2022), egg production was significantly higher, possibly indicating that the earlier exposure to light intensity and duration had an impact on the endocrine system. Additionally, the influence of artificial light sources and natural light sources (sunlight) on Lion Head Geese may exhibit some differences, warranting further research[12-14].

In terms of fertilization rate and hatchability rate, the optimal conditions were observed at 50lux with 6 hours of artificial light followed by 8 hours of natural light, resulting in percentages of 84.62 ± 4.23 and 85.92 ± 3.9 , respectively. The study found that when there is sufficient natural light in terms of duration and intensity, both fertilization rate and hatchability rate are significantly higher compared to conditions involving artificial light, approaching almost double the rates. This suggests that the duration and intensity of natural light play a decisive role in fertilization and hatchability rates, and the specific mechanisms involved require further investigation.

The research also revealed a positive correlation between hatchability rate and fertilization rate, whether under natural or artificial light conditions. Even though fertilized eggs were lower under artificial light, the hatchability rate was comparable to conditions with high natural light involvement. Additionally, throughout the entire study, the impact of temperature on the reproductive performance of Lion Head Geese was significant. Higher reproductive performance was observed during colder months compared to warmer ones. This might be associated with prolonged periods of artificial light exposure and variations in greenhouse conditions, warranting further investigation.

5. Expectation

Light intensity and duration play a crucial role in the health, development, reproductive

performance, and immune functions of poultry during actual breeding processes [15]. This study has investigated the reproductive performance of Lion Head Geese under artificial light sources combined with natural light sources at intensities of 30lux, 40lux, and 50lux. The advantages of natural light sources are undeniable, and the specific reasons for this warrant further research. Due to the inherently high cost of raising Lion Head Geese, the experiment spanned one year and did not undergo repeated confirmatory experiments. Additionally, during hot summer months, artificial interventions in the greenhouse pose high demands on the facility and management, inadvertently increasing breeding costs.

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