Effect of stocking density on growth performance, feather quality, serum hormone, and intestinal development of geese from 1 to 14 days of age

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ABSTRACT This study was conducted to investigate the effect of stocking density on growth performance, feather quality, serum hormone, and intestinal development of geese from 1 to 14 d of age. A total of 450 one-day-old geese were randomly allotted to 45 battery cage (0.65 m × 0.62 m) pens according to 5 stocking densities (15, 20, 25, 30, and 35 birds/m^2). The results showed that ADG and ADFI were reduced ($P < 0.05$) as stocking density increased from 15 to 35 birds/m^2, but increasing stocking density did not influence ($P > 0.05$) feed conversion ratio (**FCR**) and body measurement traits. High stocking density significantly decreased ($P < 0.05$) the feather quality of back, thoracoabdominal, wing, and tail. No significant difference ($P > 0.05$) was found in serum concentration of adrenocorticotrophic hormone, cortisol, corticosterone, triiodothyronine, and thyroxine. The weight of cecum and intestine decreased ($P < 0.05$) as the stocking density increased. Increasing stocking density decreased ($P < 0.05$) jejunal villus height and villus height-to-crypt depth ratio, and increased ($P < 0.05$) jejunal crypt depth and ileal crypt depth in geese. Consequently, the high stocking density could depress the growth and impaired feather quality and intestinal development of geese. Under our experimental conditions, we recommend that the stocking density of geese from 1 to 14 d of age should not more than 20 birds/m^2.

Key words: goose, stocking density, growth performance, feather quality, intestinal development

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INTRODUCTION

Stocking density for poultry is defined as total live weight or number of birds in a fixed space (Estevez, 2007), is an important environment factor for production and welfare. Therefore, many producers adopt the highest possible stocking density in production, as the economic benefit per square meter is often higher if the birds are stocked more densely. However, if stocking density exceeds over the proper range, the productivity is rather decreased because of increased health problems and decreased performance of birds (Estevez, 2007). In chickens, it has been documented that high stocking density decreased feed intake, body weight, weight gain, and feed conversion (Zuowei et al., 2011; Tong et al., 2012; Sun et al., 2013; Cengiz et al., 2015; Goo et al., 2019). In addition, high stocking density increased physiological and oxidative stress levels (Mashaly et al., 1984; Simitzis et al., 2012), decreased immunity (Houshmand et al., 2012), and had greater incidence of foot-pad dermatitis, scratches, bruising, poorer feathering, and condemnations (Estevez, 2007). Moreover, high stocking density was reported to decreases the absorptive capacity by impairing villus structures of the small intestine in broiler chickens (Shakeri et al., 2014; Li et al., 2017). In ducks, high stocking density causes growth depression (Xie et al., 2014), decrease of breast and leg meat yield (Osman, 1993), inflammation and chronic liver disease trend (Wu et al., 2018).

With the development of animal husbandry in China, geese production is becoming specialized and more widespread. However, there is very little applied research on how to manage stocking density such that optimum welfare and production efficiency are achieved. Studies suggested that high stocking density diversely influenced thyroid function and growth performance of geese (Lin et al., 2016; Yin et al., 2017a) and the stocking density should be kept to 5 or fewer birds/m^2 for Yangzhou geese from 28 to 70 d of age (Yin et al., 2017a). In geese production, multiple-phase feeding strategy is generally

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adopted when considering the long raise period for geese. Our laboratory (Wang et al., 2019) reported that the stocking density of female White Sichuan geese from 49 to 70 d of age was 3.50 and 3.57 birds/m^2 for weight gain and feed/gain, respectively, yet the parameters for starter period White Sichuan geese are still missing. Therefore, the objective of the current experiment was to investigate the effect of different stocking density on growth performance, feather quality, intestinal development, and serum hormone and evaluated the optimum stocking density of geese from 1 to 14 d of age. An understanding of the effect and importance of stocking density can help to optimize stocking density recommendations for commercially housed geese.

MATERIALS AND METHODS

Experimental Design, Bird, and Management

This study was approved by the Animal Care and Welfare Committee of the Chongqing Academy of Animal Science (**CAAS**), China. All geese used in this study were obtained from the CAAS goose-breeding center.

A total of 450 one-day-old Sichuan White geese with a similar initial average body weight were randomly allocated to 5 treatments with 9 replicate pens. Geese housed in 0.4 m^2 pens. Density treatments (15, 20, 25, 30, and 35 birds/m^2) were created by stocking the pens with a different number of birds (6, 8, 10, 12, and 14). All these geese were fed on starter diets from 1 to 14 d of age. The birds were fed commercial corn-soybean-based diets formulated according to breed requirement with 19% crude protein (**CP**), 11.75 MJ/kg metabolizable energy (**ME**), and 1% calcium during 1 to 14 d of age. All geese had free access to water and feed. Water was provided by drip-nipple water supply lines (3−7 birds/nipple) and pellet feeds were provided in feed troughs on the one side of each pen (4.6−10.8 cm/bird). In the bird-house, lighting was continuous and the temperature was kept at 31°C from 1 to 3 d of age. Temperature was decreased 1°C each 2 d until a temperature of 26°C was reached.

Data Collection and Measurements

Growth Performance At 14 d of age, live weight and feed intake for all geese were measured and recorded. ADG, ADFI, and feed conversion ratio (**FCR**) were calculated throughout the experimental period.

And 2 geese were randomly selected from each pen to body measurement traits at the age of 14 d. The measured items of body size included half-diving depth (distance from tip of the mouth to the mid-point of the 2 hips), body slope length (distance between the shoulder joint and ischial tuberosity), fossil bone length (distance from the tip to the end of the fossil bone), breast depth (distance from the first thoracic vertebra to the leading edge of the fossil bone), breast width (distance between the 2 shoulder joints) shank length (length of shank), and shank circumference (perimeter of the middle part of the shank). All measurements were conducted on the body surface of the goose.

Feather Quality Feather quality was assessed by 2 types of measurements: back-feather damage rate, and feather contamination degree which was carried out by feather scoring. The higher the feather score, the worse the goose welfare. At 14 d of age, 2 geese from each pen were randomly selected to feather cleanliness and feather damage scored. The feather cleanliness scoring was based on the degree of feather surface contamination and was conducted by the same person, who was blind to the treatment. The areas which were scored included the back, wings, tail, and thoracoabdominal area of each selected goose, and a scoring system from 0 (completely clean), 1 (less than 1/4 of the area was contaminated), 2 (between 1/4 and 1/3 of the area was contaminated), 3 (between 1/3 and 1/2 of the area was contaminated) to 4 (more than 1/2 of the area was contaminated) was used (Yin et al., 2017b). The damage of feather was scored only included back area, using a scoring system from 0 (perfect plumage), 1 (feather damaged, no skin area denuded), 2 (denuded area up to 3 cm × 3 cm), 3 (denuded area greater than 3 cm × 3 cm) to 4 (complete visible skin) points for back region (Wechsler and Huber-Eicher, 1998). Approximately 3 d after starting our experiment, we noticed that the goose back skin in some treatments was bared, so at 14 d of age, the number of the geese with or without a back feather damage in each pen was recorded, and the back-feather damage rate was calculated as the proportion of geese with back-feather damage in each pen. Data are presented as the back feather damage rate in each pen.

Serum Hormone At the age of 14 d, a total of 60 birds (12 birds per treatment) after 12 h feed withdrawal were randomly selected from all cages and designated for serum parameters. Blood samples (5 mL) were collected from the neck veins into a heparinized (50 IU/mL) monovette tubes. The blood samples were immediately placed on ice, transported to the laboratory within 3 h of collection, and centrifuged at 3,000 × g for 15 min in a refrigerated centrifuge at about 4°C to separate the serum and stored at −20°C awaiting analysis for the serum hormone. Serum concentration of adrenocorticotropic hormone (**ACTH**), corticosterone (**CORT**), cortisol (**COR**), triiodothyronine (**T_3**), and thyroxine (**T_4**) were determined by using commercial goose analytical ELISA kits according to the manufacturer's recommendations (Jian Cheng Bioengineering Institute, Nanjing, China).

Intestinal Development At the age of 14 d, a total of 30 birds (6 birds per treatment) after 12 h feed withdrawal were randomly selected to measure intestinal development. In this study, 3 evaluation methods were used to assess the development of the intestinal tract: the length, weight, and morphology of the intestine. The lengths (±0.01 cm) of the duodenum (from the pyloric junction to the most distal point of insertion of the

Table 1. Effect of stocking density on growth development of geese from 1 to 14 d of age.[1]

Item	Stocking density (birds/m^2)					SEM	*P*-value
	15	20	25	30	35		
Average daily feed intake (g)	53.48[a]	53.18[a]	49.84[b]	49.44[b]	48.87[b]	0.58	0.015
Average daily gain (g)	39.68[a]	39.08[ab]	35.92[b]	35.86[b]	36.04[b]	0.55	0.037
Feed conversion ratio (feed/gain)	1.35	1.36	1.39	1.38	1.36	0.01	0.888

[a, b]Means with different superscripts within the same column differ significantly ($P < 0.05$).
[1]Each value represents the mean of 9 replicates.

duodenal mesentery), jejunum (from the most distal point of insertion of the duodenal mesentery to the junction with Meckel's diverticulum), ileum (from the junction with Meckel's diverticulum to the ileocecal junction), and cecum were determined. After division and freeing of each intestinal segment, separating all connective tissue and fat, and removing the content with ice-cold saline flushing, the empty weights (±0.01 g) of each intestinal segment were determined. To minimize the impact of the salt water on intestinal weight, we removed residual water with filter papers after the saline flushing.

One centimeter sections from the midpoint of the duodenum, jejunum, and ileum tissues of geese were carefully taken and immediately fixed in 10% formaldehyde phosphate buffer, embedded in paraffin, and 5-μm-thick cross-sections were sliced and mounted on polylysine-coated slides for the microscopic assessment of mucosal morphology. Slides were then stained with hematoxylin and eosin for histological evaluation. The measurements of villus height (from the villus tip to the villus-crypt junction), crypt depth (from this junction to the base of the crypt), villus width (width of the villus at one-half of the villus height), and muscularis thickness were performed on stained sections under the microscope with an ocular micrometer and 40 × combined magnification (Shen et al., 2014). A total of 10 well-oriented and intact villi and their associated crypts were measured in each slide.

Statistical Analysis The data obtained from the experiment were analyzed by one-way ANOVA using SPSS statistical software (Ver. 19.0 for Windows, SPSS, Inc., Chicago, IL). The significance of differences among treatments was tested using Duncan's Multiple Range Test. Statistical significance was established at $P < 0.05$.

Table 2. Effect of stocking density on body measurement traits (cm) of geese from 1 to 14 d of age.[1]

Item	Stocking density (birds/m^2)					SEM	*P*-value
	15	20	25	30	35		
Body slope length	14.28	14.30	14.25	14.44	14.22	0.04	0.556
Fossil bone length	6.31	6.07	6.03	6.03	6.03	0.04	0.080
Breast width	4.11	4.21	4.06	4.09	4.13	0.03	0.522
Breast depth	3.54	3.71	3.52	3.72	3.68	0.03	0.096
Shank circumference	3.33	3.36	3.33	3.35	3.36	0.01	0.883
Shank length	6.31	6.39	6.23	6.37	6.23	0.03	0.245
Half-diving depth	28.50	28.67	28.19	28.25	27.97	0.12	0.394

[1]Each value represents the mean of 9 replicates.

RESULTS

Growth Performance

As shown in Table 1, the ADFI in 15 and 20 birds/m^2 group were higher than those in 25, 30, and 35 birds/m^2 groups ($P < 0.05$), the ADG in 15 birds/m^2 group was higher than those in 25, 30, and 35 birds/m^2 groups ($P < 0.05$), whereas FCR showed no difference in 5 stocking density groups ($P > 0.05$). As shown in Table 2, stocking density did not influence body slope length, fossil bone length, breast width, breast depth, shank circumference, shank length, and half-diving depth of geese from 1 to 14 d of age ($P < 0.05$).

Feather Quality

As shown in Table 3, the score of back feather quality in 15 birds/m^2 group was lower than those in 25, 30, and

Table 3. Effect of stocking density on feather quality of geese from 1 to 14 d of age.[1]

Item	Stocking density (birds/m^2)					SEM	*P*-value
	15	20	25	30	35		
Back	1.23[d]	1.56[cd]	2.22[bc]	3.11[ab]	3.28[a]	0.18	<0.001
Thoracoabdominal	1.56[c]	2.39[b]	2.52[b]	3.44[a]	3.56[a]	0.15	<0.001
Wing	1.00[b]	1.33[b]	1.76[b]	2.89[a]	3.21[a]	0.18	<0.001
Tail	1.00[c]	1.22[c]	1.84[bc]	2.67[ab]	2.98[a]	0.17	<0.001
Feather injury rate (%)	69.44	68.41	62.50	70.00	82.48	5.55	0.860
Feather exposure score	2.59	2.68	2.57	2.73	2.78	0.11	0.978

[a, b, c, d]Means with different superscripts within the same column differ significantly ($P < 0.05$).
[1]Each value represents the mean of 9 replicates.

Table 4. Effect of stocking density on serum hormone of geese at 14 d of age.[1]

Item[2]	Stocking density (birds/m^2) 15	20	25	30	35	SEM	P-value
ACTH (pg/mL)	33.28	25.66	32.43	31.52	23.48	1.79	0.322
COR (pg/mL)	3,858.05	2,817.69	3,465.80	2,743.41	2,397.48	199.68	0.148
CORT (ng/mL)	66.65	44.42	58.61	47.60	48.79	3.74	0.329
T_3 (nmol/L)	3.08	2.05	2.47	2.09	2.42	0.17	0.344
T_4 (nmol/L)	83.25	70.09	78.05	77.45	72.97	3.62	0.842

[1]Each value represents the mean of 6 replicates.
[2]Abbreviations: ACTH, adrenocorticotropic hormone; COR, cortisol; CORT, corticosterone; T_3, triiodothyronine; T_4, thyroxine.

35 birds/m^2 groups ($P < 0.05$), the score of back in 20 birds/m^2 group was lower than those in 30 and 35 birds/m^2 groups ($P < 0.05$), the score of back in 25 birds/m^2 group was lower than those in 35 birds/m^2 group ($P < 0.05$). The score of thoracoabdominal in 15 birds/m^2 group was lower than those in 20, 25, 30, and 35 birds/m^2 groups ($P < 0.05$), the score of thoracoabdominal in 20 and 25 birds/m^2 groups were lower than those in 30 and 35 birds/m^2 groups ($P < 0.05$). The score of wing in 15, 20, and 25 birds/m^2 groups were lower than those in 30 and 35 birds/m^2 groups ($P < 0.05$). The score of tail in 15 and 20 birds/m^2 groups were lower than those in 30 and 35 birds/m^2 groups ($P < 0.05$), the score of tail in 25 birds/m^2 group was lower than those in 35 birds/m^2 group ($P < 0.05$).

Serum Hormone

As shown in Table 4, the differences in the serum concentration of ACTH, CORT, COR, T_3, and T_4 were not significant among treatments ($P > 0.05$). The stocking density did not affect the serum hormone of geese at 14 d of age.

Intestinal Development

As shown in Table 5, the cecum weight in 15 birds/m^2 group was higher than those in 25, 30, and 35 birds/m^2 groups ($P < 0.05$). The total intestine weight in 15 birds/m^2 group was higher than those in 20, 25, 30, and 35 birds/m^2 groups ($P < 0.05$).

As shown in Table 6, the jejunal villus height with 15, 20, and 25 birds/m^2 groups were higher than those in 30 and 35 birds/m^2 groups ($P < 0.05$). The jejunal crypt depth in 35 birds/m^2 group was higher than those in 15, 20, 25, and 30 birds/m^2 groups ($P < 0.05$). The jejunal villus height-to-crypt depth ratio in 15, 20, and 25 birds/m^2 groups were higher than those in 30 and 35 birds/m^2 groups ($P < 0.05$). The ileal crypt depth in 35 birds/m^2 group was higher than those in 15 and 20 birds/m^2 groups ($P < 0.05$).

DISCUSSION

Growth Performance

In our study, increasing stocking density had a negative effect on growth performance of starter geese. High stocking density decreased the ADFI and ADG of geese from 1 to 14 d of age but not for FCR, which was in agreement with the results observed in starter ducks (Xie et al., 2014) and broilers (Li et al., 2019; Goo et al., 2019). The reason for these results has been associated with various environmental and behavioral factors. High stocking density disturbs the birds' movements in a given space, and therefore, the birds raised at a high stocking density have more difficulty accessing to feeders and drinkers (Cengiz et al., 2015). However, our results were partially different from the publication on broilers and ducks. In their study, there were no significant differences in 42 d BW, ADG, FCR, and mortality among broilers raised at different stocking densities (30, 35,

Table 5. Effect of stocking density on intestinal weight and length of geese at 14 d of age.[1]

Item	Stocking density (birds/m^2) 15	20	25	30	35	SEM	P-value
Duodenum weight (g)	5.55	5.34	5.05	4.85	4.72	0.12	0.168
Jejunum weight (g)	15.58	14.45	13.90	13.13	13.91	0.33	0.233
Ileum weight (g)	10.12	9.24	9.88	8.92	9.78	0.24	0.531
Cecum weight (g)	3.18^{a}	2.62^{ab}	2.13^{b}	2.04^{b}	2.30^{b}	0.11	0.006
Total intestine weight (g)	36.17^{a}	31.64^{b}	30.96^{b}	28.95^{b}	30.72^{b}	0.77	0.031
Duodenum length (cm)	23.50	23.67	24.17	25.00	23.17	0.31	0.401
Jejunum length (cm)	63.40	59.25	60.17	58.67	58.66	0.74	0.270
Ileum length (cm)	52.92	51.08	52.17	51.17	52.83	0.89	0.949
Cecum length (cm)	15.08	13.67	13.75	13.83	14.58	0.23	0.219
Total intestine length (cm)	151.20	147.67	150.25	148.67	149.25	1.34	0.948

[a, b]Means with different superscripts within the same column differ significantly ($P < 0.05$).
[1]Each value represents the mean of 6 replicates.

Table 6. Effect of stocking density on intestinal morphology of geese at 14 d of age.[1]

Item	Stocking density (birds/m^2)					SEM	P-value
	15	20	25	30	35		
Duodenum							
Villus height (μm)	726.95	642.89	557.83	595.56	663.60	24.28	0.224
Crypt depth (μm)	173.49	169.90	169.67	182.34	173.58	3.81	0.855
Villus width (μm)	148.86	139.63	153.20	162.58	161.70	3.96	0.339
Muscularis thickness (μm)	334.19	319.64	300.29	298.48	283.06	7.98	0.297
Villus height/crypt depth	3.98	3.74	3.30	3.28	3.83	0.12	0.270
Jejunum							
Villus height (μm)	676.96[a]	743.15[a]	704.24[a]	525.20[b]	587.52[b]	26.28	0.042
Crypt depth (μm)	170.40[b]	169.13[b]	176.68[b]	185.91[b]	244.73[a]	8.15	0.007
Villus width (μm)	100.02	89.02	92.06	90.69	106.81	3.44	0.455
Muscularis thickness (μm)	334.12	299.11	323.36	302.80	312.28	6.12	0.358
Villus height /crypt depth	4.17[a]	4.40[a]	4.35[a]	2.81[b]	2.47[b]	0.24	0.007
Ileum							
Villus height (μm)	711.17	673.29	767.80	887.77	837.24	34.68	0.278
Crypt depth (μm)	155.56[b]	152.20[b]	173.66[ab]	173.23[ab]	209.73[a]	6.70	0.040
Villus width (μm)	115.75	119.80	110.84	125.08	108.47	4.00	0.717
Muscularis thickness (μm)	281.74	273.12	306.58	273.70	289.55	4.79	0.147
Villus height /crypt depth	4.63	4.41	4.49	5.18	4.09	0.18	0.448

[a, b]Means with different superscripts within the same column differ significantly ($P < 0.05$).
[1]Each value represents the mean of 6 replicates.

40 kg/m^2) (Rambau et al., 2016), and no detrimental effects of high stocking density (16 birds/m^2) on growth performance or survivability (Najafi et al., 2015) in broilers. And some researchers found that increasing stocking density improved growth rate and feed conversion without any change in feed consumption of male broilers from 1 to 15 d of age (Dozier et al., 2006), high stocking density decreased FCR (Houshmand et al., 2012). In ducks, it is believed that increasing stocking density decreased ADG, increased feed/gain ratio (Zhang et al., 2018; Wu et al., 2018). The reason for these differences between their and our results may vary with breed, environment, rearing systems, experimental periods, and intensity of stocking density. And according to the result of growth performance, the maximum stocking densities for geese from 1 to 14 d of age should not exceed 20 birds/m^2. The result was partly consistent with the result of Xie et al. (2014), which indicated that the maximum stocking densities for ducks from hatch to 14 d of age should not exceed 19 birds/m^2. On the other hand, increasing stocking density didn't have negative effects on body measurement traits in the current experiment. This result was in agreement with the report of Yin et al. (2017a), who found that stocking density did not influence body size of geese from 28 to 70 d of age.

Feather Quality

Feathers are an important economic character of geese (Kozák et al., 2010). Good feather coverage will optimize energy metabolism and feed efficiency (Leeson and Walsh, 2004). In our experiment, the feather cleanliness and damage were scored using a 5-point scale, and a higher score indicated a dirtier feather and poorer feather development. In present study, the feather contamination degree of back areas increased when the stocking density was 25 or more birds/m^2, the feather contamination degree of thoracoabdominal areas increased when the stocking density was 20 or more birds/m^2, the feather contamination degree of wing areas increased when the stocking density was 30 or more birds/m^2, the feather contamination degree of tail areas increased when the stocking density was 30 or more birds/m^2, indicating that the environmental hygiene of the higher stocking density groups (20 or more birds/m^2) was worse than of the other groups. Therefore, the stocking density should be kept to 20 or fewer birds/m^2 to avoid dirty feather and poorer feather development. Our results were in agreement with the results observed in broilers, hens and geese, which shown that feather performance was poor in high-stocking density group (Steenfeldt and Nielsen, 2015; Toghyani et al., 2016; Yin et al., 2017b; Wang et al., 2019).

Serum Hormone

High stocking density is well-known stressor of poultry, and was expected to have negative effects on poultry. In general, stress activates the hypothalamic-pituitary-adrenal axis, leading to the secretion of CORT from the adrenal gland (Elenkov and Chtousos, 2006), and resulting in the suppression of growth (Wingfield and Romero, 2011). Several researches have shown that high stocking density consistently increased the serum concentration of CORT (Türkyilmaz, 2008; Shakeri et al., 2014; Li et al., 2019). On the contrary, stocking density did not result in a recognizable trend in CORT concentration (Thaxton et al., 2006; Lee et al., 2017; Houshmand et al., 2012). T_3 and T_4 affect almost every physiological process in the body and are important hormones supporting chicken growth (Xiao et al., 2017). Increasing stocking density can cause stress in animals, and stress can increase the serum concentrations of T_3 and T_4 (Dai et al., 2011). Li et al. (2019) found that high stocking density significantly decreased serum T_4 levels, and did not affect serum T_3 levels in broilers. However, Yin et al. (2017a) indicated that high stocking density decreased serum concentrations of T_3 and T_4. In the present study, stocking density did not affect serum concentrations of ACTH, CORT, COR, T_3, and T_4. This result was consistent with the data of Tong et al. (2012), who found that ACTH, T_3, and T_4 concentrations in blood were not significantly affected by stocking density. Thus, it is clear from the current study that stocking density (15−35 birds/m^2) does not cause physiological stress in geese. The inconsistent effect of stocking density on growth performance and serum concentration could be attributed to variations in housing conditions and management practices.

Intestinal Development

Previous studies have demonstrated that high stocking density has negative influences on intestinal development. Shakeri et al. (2014) reported that high stocking density was detrimental to duodenal villi length, did not affect duodenal crypt depth in broiler chicken. Yin et al. (2017a) found that high stocking density (6 or more birds/m^2) decreased lengths and relative weights of jejunum and ileum, result in delayed the development of the small intestine in geese. Kridtayopas et al. (2019) reported that high stocking density significantly decreased villus height in the duodenum, jejunum, and ileum in broiler chickens. Furthermore, high stocking density impairs intestinal barrier function (Goo et al., 2019), decrease in cecum microbial diversity, depletes anti-inflammatory bacterial taxa and reduces bile acid metabolism-associated bacteria (Wu et al., 2018). Hence, high stocking density may negatively influence the intestinal development. Our data showed high stocking density (25 or more birds/m^2) decreased the weight of cecum in geese, did not change weight and length in the duodenum, jejunum, and ileum. Furthermore, with the stocking density increasing, the villus height and villus height-to-crypt depth ratio was decreased and the crypt depth increased in the jejunum, suggesting that high stocking density inhibit jejunal morphology of geese. High stocking density increased crypt depth in the ileum. The adverse effect of higher stocking density on intestinal morphology may have accounted for the poor growth performance of geese raised in crowded environment. Although high stocking density may affect jejunal and ileal morphology, the duodenal morphology in the present study was not affected by stocking density. The different results were observed in chicks, which showed that stocking density did not affect any parameters of ileal morphology (Lee et al., 2017). The discrepancies could be attributed to the difference in the bird breeds and housing system.

CONCLUSIONS

In conclusion, a suitable stocking density is essential for geese production because a high stocking density (more than 20 birds/m^2) will cause growth depression, poor feather quality, delay the cecum development, and adversely affect the intestinal morphology of geese. Therefore, under our experimental conditions, we recommend that the stocking density of geese from 1 to 14 d of age should be kept to 20 or fewer birds/m^2 to avoid the negative effects of a high stocking density on geese.

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DISCLOSURES

The authors declare that they have no conflicts of interest to disclose.

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