Research Note: Comparison on laying behavior and clutch traits among Zhedong white geese (*Anser cygnoides*), Sichuan white geese (*Anser cygnoides*), and Hungarian geese (*Anser anser*)

Qiang Bao,* Ying Yao,* Kaiqi Weng,* Ming Zheng,* Yu Zhang,* Yang Zhang,* Guohong Chen,*+ and Qi Xu*,†

*Key Laboratory of Animal Genetics and Breeding and Molecular Design of Jiangsu Province, College of Animal Science and Technology, Yangzhou University, Yangzhou 225009, China; and †Joint International Research Laboratory of Agriculture and Agri-Product Safety, the Ministry of Education of China, Yangzhou University, Jiangsu Yangzhou 225009, China

ABSTRACT Egg laying is an important reproductive behavior of female poultry. Here, we investigated the laying behavior and clutch traits of different goose breeds, specifically, Zhedong white geese (*Anser cygnoides*), Sichuan white geese (*Anser cygnoides*), and Hungarian geese (*Anser anser*). A total of 108 geese in their first laying year were selected. Their laying rhythm was monitored daily by video cameras during the egg-laying period. The results showed that the prenatal behavior included nest hunting, nest site selection and nesting, as well as laying behavior included prenatal crouching, anal contraction until oviposition and postnatal resting. There were some differences in laying times among the 3 breeds. Approximately 70% of the eggs were laid between 03:00 and 12:00 in Zhedong white geese and Sichuan white geese, while the Hungarian geese laid throughout the day. Also, the clutch length and the oviposition interval differed among these 3 breeds. Their average clutch lengths were approximately 14.07, 12.14 and 19.15 days in Zhedong white geese, Sichuan white geese, and Hungarian geese, respectively. While their oviposition intervals showed 2 peaks (39 and 47 h), 3 peaks (41, 50 and 53 h), and 1 peak (46 h). Moreover, there were significant correlation between egg yield and clutch length in Zhedong white geese (*r* = 0.951), Sichuan white geese (*r* = 0.987) and Hungarian geese (*r* = 0.991), respectively. Taken together, the difference in laying behavior among the breeds was mainly reflected in laying time and oviposition intervals, Zhedong white geese and Sichuan white geese have egg laying time preference and short oviposition intervals, which was helpful not only to understand egg-laying process, but also to manage egg-laying geese scientifically and improve egg production.

Key words: goose, laying behavior, clutch trait, reproductive performance

INTRODUCTION

The laying ability of a female fowl is defined by the length of her egg clutches and the oviposition interval between them. The layers with high egg production have long egg-clutches with short intervals (Bednarczyk et al., 2000). Moreover, the laying behavior appears to be different within different breeds. The clutch length of White Leghorn hens was approximately 5 to 6 d, while that of Rhode Island white hens was approximately 11 to 17 d (Icken et al., 2012). The time of day that oviposition occurred also varied in different strains: almost 90% of white egg strain of Lohmann origin laid their eggs within a three-hour period in the morning, while the time of day in which oviposition occurred in brown egg strain was more variable (Icken et al., 2012). In addition, it has been noticed that older hens had shorter clutch lengths than younger hens. The corresponding value was 2.6 d vs. 7.7 d, respectively (Tumová and Gous, 2012). The laying behaviors have been not only well characterized in hens, but also used as an index to improve egg yield in poultry breeding (Icken et al., 2012). The lengthening of the oviposition interval resulted in shorter clutch length, which caused a decrease in the egg-laying performance (Bednarczyk et al., 2000).

Geese are accompanied by a variety of different reproductive performance among breeds, but there has been little research into the laying behavior and clutch traits...
of geese. Generally, geese have a low egg yield in comparison to other poultry species. It has been reported that White Italian geese laid most of their eggs (on average 70.2%) singly rather than in clutches (Rosiński et al., 2006). Of the eggs laid in clutches, 85.3% of the clutches consisted of 2 eggs (Rosiński et al., 2006). The production system also had a profound effect on the laying behavior of geese (Sheng et al., 2002). Geese reared in mating pens with natural lighting had, on average, a shorter laying duration (92.3 vs. 156.2 d) and a shorter clutch length (4.4 vs. 7.7 eggs) than geese reared in individual cages under controlled lighting conditions, and the differences were significant (Rosiński et al., 2006).

Although there have been some studies of laying behavior in European geese (Rosiński et al., 2006), it is not clear whether Chinese and European geese have similar egg-laying behavior. In this study, 2 Chinese goose breeds (Zhedong white geese and Sichuan white geese, *Anser cygnoides*) and one European goose breed (Hungarian geese, *Anser anser*) were selected and their laying behavior and clutch traits were investigated. It may provide valuable information for breeding programs and management practices to improve egg production and quality.

**MATERIALS AND METHODS**

**Experimental Design and Facilities**

The investigation was conducted in the National Waterfowl Germplasm Resources Pool (Taizhou, China) from November 1, 2016, through June 15, 2017. All experimental procedures performed in this study were approved by the Institutional Animal Committee of Yangzhou University (Permit Number: YZUDWSY, Government of Jiangsu Province, China). The three goose breeds at 210-day-old including Zhedong white geese (*Anser cygnoides*), Sichuan white geese (*Anser cygnoides*), and Hungarian geese (*Anser anser*) were raised in 9 separate pens (3 biological replicates/breed, 4.5+12.6/pen). The geese were reared in a 2.5×14.0 m pen, included 2.5×5.0 m house, 2.5×5.0 m “playground” and 2.5×4.0 m “pool” area. Each pen was equipped one laying nest (96×85cm) with rice husks to hold 4 to 6 geese laying eggs at once. All pens were in one shed with cement type floor, and 2 trough-type feeders were equipped in the house and bell-type drinker in playground. An infrared video camera (Jindun, 720p, resolution: 1280×960, frame Rate: 25 frame/s, Nanjing, China) was set up above the laying nest in the pen of each group. Colored paint was applied to the neck and back as a marker to identify birds during observations of laying behaviors.

All geese were provided with the same diet in egg-laying period (Crude protein: 17%, Metabolizable energy: 10.45 MJ/kg), which was combined with coarse and concentrated material and fed ad libitum. Mash feed and fresh water were consistently available for all birds. The geese were kept in a standard light regimen of 14 h light (14L:10D) during the laying period.

**Behavior Observation**

The laying behaviors of 108 layers were monitored in real time daily. Laying behaviors were observed from the onset of nest hunting until the geese left the nest after oviposition. Most female geese exhibited prenatal behaviors, which included nest hunting, nest site selection, and nestling. The laying process consists of at least 3 behaviors: prenatal crouching, anal contraction until oviposition, and postnatal resting. Throughout the prenatal crouching, the geese turning around continuously in the nest, squatting quietly after feeling comfortable, and then holding the rice husk to their sides. After that, the anal contraction until oviposition was described as the anal sphincter and arrectores pilorum contracted repeatedly, until the eggs were slowly laid. The postnatal resting was defined as geese put their eggs under their abdomen and laying quietly.

In addition, we measured the time during the 24-h d that eggs were laid during the laying period. The behaviors of clutch, clutch pause and oviposition interval were observed. The clutch was defined as eggs laid by the goose consecutively, in which the period of time separating the placement of each egg was less than 72 h. The period of time between successive clutches was defined as a clutch pause. Also, the oviposition interval was defined as the duration between 2 consecutive ovipositions in the same clutch.

**Data Collection**

Daily, throughout the 210-d observation period, a copy of all videos recorded were stored on a computer. The laying behavior and clutch behavior were observed and evaluated by one observer, respectively. Clutch length was expressed as the average duration of a clutch and was estimated for each female. Also, pause length between clutches expressed as the average number of days between clutches per goose. In addition, egg yield was accumulated during 210-d observation period, and laying intensity was calculated as the proportion of the clutch number taken up by the clutch length. Daily laying rate was defined as the percentage of egg production over the number of total female geese per day.

**Statistical Analysis**

Statistical analyses were performed with SPSS statistical software (v22, IBM Corp, Armonk, NY). All data were tested for normal distribution and homogeneity of variance. Relationships between breeds and laying behavior were investigated using General Linear Mixed Models (*GLMM*) for continuous normally distributed data, and the data was submitted to Generalized Linear Mixed Models (*GLIMM*) with a binary logistic or multinomial logistic link function when the assumptions of normality and homogeneity of variance of the variables were not met. Breed and pen were included as a main effect and random effect in the model, respectively. The laying intensity and daily laying rate were analyzed...
with Chi-squared tests. The Pearson correlation was used to assess the relationship between egg yield and clutch traits. The results are shown as means with corresponding standard errors. A level of $P \leq 0.05$ was set as the criterion for statistical significance.

RESULTS AND DISCUSSION

Laying Behavior

In this study, the behavior of nest hunting, nest site selection and nesting were found before egg laying, and the geese were quiet and clustered together without singing (data not shown). Their prenatal behaviors were some different from that of hens. The hens often appeared anxious (Lay and Wilson, 2002). The prenatal crouching, anal contraction until oviposition and postnatal resting were observed during laying process (Figure 1A). The time of prenatal crouching ($F(df) = 4.34(2)$, $P = 0.015$), anal contraction until oviposition ($F(df) = 18.20(2)$, $P < 0.001$) and postnatal resting ($F(df) = 13.91(2)$, $P < 0.001$) were the longest in Sichuan white goose comparison with the two other breeds. Moreover, the ages of first egg of different goose breeds were also investigate. Hungarian geese showed a later age of the first egg-laying compared with other breeds (Figure 1D). In general, the slow development of oviduct in heavy weight geese resulted in the delayed sexual maturity and the first egg-laying. Among these three goose breeds, Hungarian geese exhibited the heaviest bodyweight. Hence, it was reasonable for Hungarian geese to have a later age of first egg. Despite the significant difference of bodyweight between Zhedong white geese and Sichuan white geese, their ages of first egg were similar, possibly due to artificial selection for sexual maturity traits in Zhedong white geese. Also, the time preferences of laying were investigated (Figure 1B). Sichuan White geese began laying eggs at about 03:00, however after 12:00 the occurrence dropped to less than 2.5%. Approximately 70% of the eggs were laid between 03:00 and 12:00 in Zhedong white geese, while the Hungarian geese laid throughout the day. The peak laying times of Zhedong white geese and Sichuan white geese were approximately 6:00 and 5:00, respectively. While the corresponding value was approximately 11:00 in Hungarian geese. Those results hinted that we should make reasonable feeding and management plans according laying time preference of different goose breeds. Hungarian geese, as an exotic breed, had been raised under the same lighting system as Chinese geese since they were introduced into China. However, Hungarian geese might not have fully adapted to the longer light regime and thus exhibit a different laying rhythm from the Chinese geese. Another study also noted that the change of photoperiod will affect the egg laying rhythm of geese, resulting in the diversity of egg laying rhythm (Sheng et al., 2002; Chang et al., 2016).

Clutch Traits

The clutch traits and oviposition intervals of the three breeds were also observed (Figure 1C). The oviposition interval of Zhedong white geese and Sichuan white geese showed 2 peaks (39 and 47 h) and 3 peaks (41, 50 and 53 h). While the corresponding value was 1 peak (46 h) in Hungarian geese. Results of the present study were similar to the findings of Qin et al. (2013), who reported that the oviposition intervals of geese were about 48 h. The average clutch length of Zhedong white geese were approximately 14.07 d, significantly shorter than Hungarian geese (19.15 d) ($F(df) = 6.49(2)$, $P = 0.003$), and the pause length between clutches in Hungarian geese

![Figure 1. Comparison of laying behavior and clutch traits among Zhedong white geese, Sichuan white geese and Hungarian geese. (A) Breed effects on the main behaviors involved in the laying process. (B and C) Oviposition time of day and oviposition interval for different goose breeds. The location of the maximum value of * is marked by an asterisk. (D) Laying rates of the different goose breeds($P < 0.001$). The dashed lines show the different egg laying rates, in which the red dashed line shows egg laying rate more than 10% and the green dashed less than 30%.](image-url)
and Sichuan white geese were shorter than Zhedong white geese ($F(df) = 110.53(2), P < 0.001$; Table 1). Zhedong white geese displayed strong broody behavior, which resulted in longer the pause length between clutches (Yao et al., 2019).

**Laying Rate**

The laying rate of those 3 breeds was also investigated over the 210-d laying season. The egg yields of the Hungarian geese and Sichuan white geese were greater than Zhedong white geese ($F(df) = 6.51(2), P = 0.003$). Sichuan white geese maintained a high rate of laying except at the end of the season (Figure 1D). More than 10% of Sichuan white geese and Zhedong white geese laid eggs every day. While Hungarian geese laid all their eggs within the first 160 days of the season.

In general, the egg yield was closely correlated with the clutch length, the interval length, and the laying intensity. In this study, there were significant positive correlation between the egg yield and the clutch length in Zhedong white geese, Sichuan white geese and Hungarian geese ($r = 0.951, P < 0.001; r = 0.987, P < 0.001; r = 0.991, P < 0.001$, respectively). Also, a significant positive correlation between the egg yield and the laying intensity were observed in the three breeds ($r = 0.622, P = 0.001; r = 0.662, P = 0.026; r = 0.708, P < 0.001$, respectively). As noted by Bednarczyk et al (2000), the egg yield was increased by selecting for average clutch length in Rhode Island White hens. Hence, clutch traits might be effectively applied to the improvement of the egg yield. Indeed, the clutch length has been used as a selective breeding index in laying hens (Icken et al., 2012). More studies of clutch traits in geese should expedite progress in breeding for increased egg production.

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**DISCLOSURES**

None of the authors involved in this research have any conflicts of interest to report.

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**Table 1. Comparison of clutch traits among different goose breeds.**

| Variable         | Breeds                  | Weight (kg) | Egg yield | Clutch length (days) | Pause length between clutches (days) | Clutch number | Laying intensity |
|------------------|-------------------------|-------------|-----------|----------------------|--------------------------------------|---------------|-----------------|
| Mean             | Zhedong white goose     | 3.96        | 17.50     | 14.07                | 80.97                                | 2.11          | 0.20            |
|                  | Sichuan white goose     | 3.41        | 26.73     | 12.14                | 10.62                                | 4.36          | 0.70            |
|                  | Hungarian goose         | 4.35        | 24.59     | 19.15                | 4.73                                 | 3.03          | 0.56            |
| Pooled SEM       |                         | 0.09        | 1.13      | 0.86                 | 5.32                                 | 0.17          | 0.03            |
| $F (Df)$         |                         | 3.58 (2)    | 6.51 (2)  | 6.49 (2)             | 110.53 (2)                           | 13.86 (2)     | 83.38 (2)       |
| $P$              |                         | 0.039       | 0.003     | 0.003                | 0.000                                | 0.000         | 0.000           |

$F$, $F$ statistic; $P = P$ value for $F$ statistic; $Df$ = degrees of freedom.

Within a column for each factor, different superscripts indicate significant differences ($P \leq 0.05$).