

Effects of plastic antipecking devices on the production performance, beak length, and behavior in Chinese Wannan chickens

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ABSTRACT This study examined the effects of plastic antipecking devices (PAD) on the production performance, upper beak length, behavior, and plumage condition of a local Chinese chicken breed. Three hundred sixty 63-d-old Wannan chickens with intact beaks were randomly allocated into 3 groups. Birds were fitted with the PAD at 63 d (PAD63d) and at 77 d of age (PAD77d). Control birds were not fitted with PAD. The results showed that there were no significant effects of PAD on the BW, carcass traits, and meat quality ($P > 0.05$). The mortality in the PAD63d and PAD77d groups was lower than that in the control group. Compared with those in the PAD77d and control groups, the feed conversion ratio (FCR) from 63 to 112 d of age was lower in the PAD63d

group. The ADFI of birds from 63 to 112 d of age was lowest in birds in the PAD63d group, intermediate in birds in the PAD77d group, and highest in control birds ($P < 0.05$). Birds in the PAD63d and PAD77d groups showed a lower frequency of walking and running, a higher frequency of sleeping, and higher plumage scores of the back and tail than those of control birds ($P < 0.05$). Birds' daily walking steps in the PAD77d group decreased compared with that of birds in the control group ($P < 0.05$). The upper beak length at 91 d and 112 d of age was longest in birds in the PAD63d group and shortest in control birds ($P < 0.05$). Overall, PAD appeared to be effective at reducing mortality, FCR, overall activity, and plumage damage and increasing the upper beak length.

Key words: chickens, antipecking device, performance, behavior, plumage condition

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INTRODUCTION

Abnormal pecking behaviors, such as severe feather pecking, vent pecking, and cannibalism, are considered a serious problem, especially in large groups of furnished cages and noncage systems, in poultry production (Huber-Eicher and Sebö, 2001; Lay et al., 2011; Mench and Rodenburg, 2018). Abnormal pecking behaviors can impair birds' health and welfare, including feather loss, skin damage, pain, tissue injury, and inflammation, and even mortality (Buitenhuis et al., 2004; Stadig et al., 2016). Furthermore, abnormal pecking behaviors could

result in high feed intake because of poor plumage conditions caused by pecking, low production performance, and economic loss (Niebuhr et al., 2005; Van Krimpen et al., 2014). A large number of studies have reported that abnormal pecking behavior is a multifactorial problem and can be induced by many factors, such as feed, nutrition, and birds' housing environment (Bestman et al., 2009; Rodenburg et al., 2013; Nicol, 2018).

An antipecking device is one of the ways to reduce the occurrence of abnormal pecking behaviors. Several types of antipecking devices, such as contact lenses, rings, and bumpers, have been designed to reduce abnormal pecking (Adams, 1992; Savory and Hetherington, 1997). However, the effects of these antipecking devices are at times paradoxical; this may be due in part to inconsistencies of antipecking devices and differences in bird strain, as well as variations in both the age at which the antipecking devices are fitted and what parameters are observed (Adams, 1992; Gvoryahu et al., 1997). Generally,

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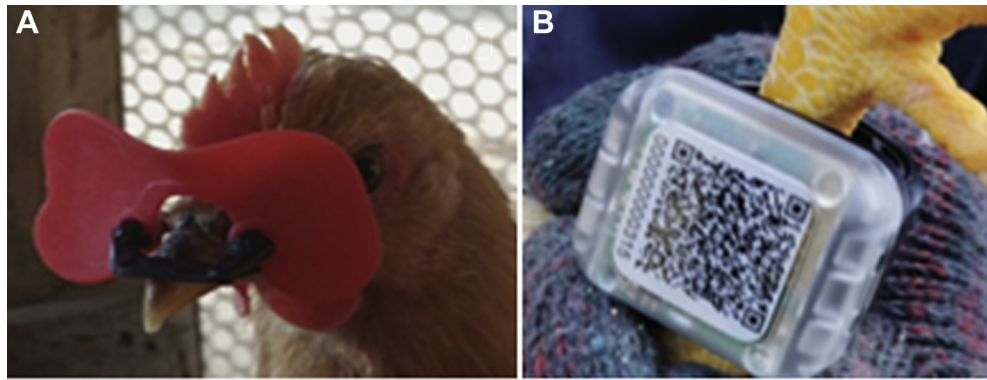


Figure 1. Plastic anti-pecking device (A) and pedometer (B) used in the trial.

anti-pecking devices may be beneficial to reduce the occurrence of pecking damage in commercial flocks.

The Wannan chicken is a medium-sized local chicken breed that is produced for meat and eggs and is well known for its yellow feather, yellow skin, and yellow shank in the south of Anhui province in China. Traditionally, this local chicken breed is reared mixed sex in free-range systems, and the birds are usually on the market, weighing approximately 1.2 to 1.5 kg from 14 to 18 wk according to the market demands. With increasing market demand, Wannan chickens are now raised on an intensive industry scale. In this production practice, anti-pecking devices are used to reduce feather pecking, aggression, and cannibalism among chicks raised in a noncage system. Although anti-pecking devices help control feather pecking and cannibalism, there is no available information on the effects of anti-pecking devices on the production performance, plumage condition, and behavior of this local chicken breed at present. Thus, the objective of this study was to investigate the effects of an anti-pecking device on the growth performance, upper beak length, behavior, plumage condition, carcass traits, and meat quality of Wannan chickens reared in floor pens.

Table 1. Ethogram of behaviors recorded in Wannan chickens.

| Behavior | Definition |
|----------------------|--|
| Sitting | Sitting with hocks resting on litter without any other activity and with eyes open |
| Sleeping | Lying down with the head flat on the litter, or with the head under a wing or on the body with eyes closed |
| Standing | Standing stationary without performing any of the activities listed below |
| Drinking | Pecking at water in the drinker |
| Feeding | Pecking at food or having their head above or in the feeder |
| Walking and running | Moving around the pen at any speed |
| Preening | Manipulating or removing litter from own feathers |
| Object pecking | Pecking at the cages, litter, pen walls, and other objects |
| Bird-to-bird pecking | Includes both nonaggressive pecking (directed toward feathers or litter on the feathers of other birds, feather pulling, and manipulation) and aggressive pecking (forceful pecks directed toward the head, neck, or tail of other birds causing them to flinch and/or vocalize) |
| Other activities | All other behaviors not mentioned above; for example, vocalization, dust bathing, or stretching |

MATERIALS AND METHODS

Birds and Housing

All animal experimental procedures were carried out in accordance with the Regulations for the Administration of Affairs Concerning Experimental Animals (Ministry of Science and Technology, China) and were approved by the Committee for the Care and Use of Experimental Animals at Anhui Agricultural University (Permit No. AHAU20101025).

A total of 360 63-d-old untrimmed Wannan chickens (half male and half female) with similar BW and plumage conditions were randomly allocated into 3 groups. Birds were fitted with medium-sized plastic anti-pecking devices (PAD) (Qingdao Xinke Agricultural Technology Co., Ltd., Qingdao, China) at 63 d of age (PAD63d) and at 77 d of age (PAD77d). Birds in the control group were not fitted with PAD. Each group was represented by 3 replicates with 40 birds per replicate. The PAD consisted of an open plastic ring and a piece of red soft plastic (3.3-cm wide and 5.3-cm long) and could be fastened to the beak by plastic clips without piercing the nasal septum (Figure 1A). Birds were raised in litter pens at 1,000 cm² per bird. The litter height in each indoor floor pen was approximately 8 cm. One 5-kg feeder and one Plasson water fountain were located inside each pen. The temperature was maintained at 15°C to 25°C until the end of the experiment. Birds were given 12 h of light per day. Birds had *ad libitum* access to water and a pellet diet (CP: 17.0%, ME: 11.75 MJ/kg).

Growth Performance

The BW for each bird was measured at 63, 91, and 112 d of age. The feed intake was recorded daily, and mortality was recorded when it occurred. The ADFI, feed conversion ratio (FCR), and mortality rate were calculated.

Behavior and Daily Walking Steps

Behaviors were observed in the first and second week after the PAD were fitted. Four birds (2 males and

Table 2. Effects of PAD on the production performance of Wannan chickens.

| Items | Age (d) | PAD63d | PAD77d | Control |
|------------|---------|-----------------------------|-----------------------------|-----------------------------|
| BW (g) | 63 | 640.5 ± 9.9 ^a | 653.8 ± 10.7 ^a | 639.0 ± 10.4 ^a |
| | 91 | 992.4 ± 17.1 ^a | 993.2 ± 18.9 ^a | 1,024.6 ± 18.5 ^a |
| | 112 | 1,223.0 ± 25.0 ^a | 1,221.0 ± 25.6 ^a | 1,264.5 ± 26.6 ^a |
| ADFI (g/d) | 63–91 | 55.7 ± 1.4 ^c | 66.9 ± 2.9 ^b | 79.3 ± 1.9 ^a |
| | 92–112 | 75.0 ± 1.1 ^b | 72.8 ± 1.0 ^b | 79.6 ± 1.3 ^a |
| | 63–112 | 63.9 ± 1.7 ^c | 69.4 ± 1.7 ^b | 79.4 ± 1.2 ^a |
| FCR (g/g) | 63–91 | 4.45 ± 0.07 ^b | 5.62 ± 0.15 ^a | 5.73 ± 0.29 ^a |
| | 92–112 | 6.84 ± 0.22 ^a | 6.72 ± 0.16 ^a | 7.01 ± 0.30 ^a |
| | 63–112 | 5.37 ± 0.02 ^b | 6.03 ± 0.13 ^a | 6.25 ± 0.26 ^a |

^{a–c}Means within a row lacking a common superscript differ significantly ($P < 0.05$). Values are presented as the mean ± SE.

Abbreviations: PAD, plastic anti-pecking device; PAD63d, birds fitted with PAD at 63 d of age; PAD77d, birds fitted with PAD at 77 d of age; FCR, feed conversion ratio.

2 females) per replicate were randomly selected, and the back and wings of the body part were marked with animal markers for behavior observation. Behavior observation was performed twice daily from 09:00 h to 11:00 h and 14:00 h to 16:00 h. The behaviors of focal birds were observed every 5 min, and behavioral data were collected 24 times per observation session using instantaneous scan sampling. The focal birds were observed outside of the pens at a distance of 1.0 m to avoid disturbance of their normal behavioral repertoire. The ethogram is given in Table 1, which is revised according to Bokkers and Koene (2003) and Gentle and McKeegan (2007). Data are presented as the proportion of observed behaviors out of the total number of observed behaviors.

At 77 d of age, 26 birds (13 males and 13 females) in the PAD77d group and 26 birds (13 males and 13 females) in the control group were fitted with pedometers (Shanghai QST Corporation, Shanghai, China) (Figure 1B). The birds fitted with pedometers were healthy with similar BW, not including the birds used for behavior observation. Daily walking step counts were recorded from 77 to 112 d. Average daily walking steps were calculated every week.

Upper Beak Length

The upper beak length of all birds was measured from the nares to the tip of the upper beak at 63, 91, and 112 d of age using a vernier caliper (16ER, Mahr Precision Metrology Suzhou Ltd., Suzhou, China). The PAD were not taken off when the upper beak length of birds was measured.

Plumage Condition Score

At 112 d of age, the plumage condition scores of the backs, tails, and bellies of all birds were estimated from 1 to 4 according to Tauson et al. (2005). One meant that the skin of the body part was almost naked and was without feathers, and 4 meant good plumage coverage without observed damage. The assessment of the plumage condition was carried out by an experienced person who was blinded to the treatments to ensure maximum consistency when scoring. The PAD were

not taken off when the plumage condition was estimated.

Carcass Traits and Meat Quality

At 112 d of age, after fasting for 12 h, 15 randomly selected male birds from each group were weighed and then manually processed for assessment of carcass traits and meat quality. Birds were slaughtered by unilateral neck cutting followed by manual evisceration. The carcass, eviscerated carcass, abdominal fat, breast muscle (including the pectoralis major and pectoralis minor), and leg muscle (including the thigh and drumstick) were weighed. Carcass yield and eviscerated carcass yield are expressed as a % of the BW. The yields of breast muscle, leg muscle, and abdominal fat were calculated as a % of the eviscerated carcass weight.

The meat color (L^* , a^* , and b^* values) and pH of the right breast muscle were determined immediately after slaughter. The left breast muscle was collected and kept in a portable refrigerator at 4°C and transported to the laboratory for analysis of cooking loss and shear force. The meat color was determined by a Tristimulus Colorimeter (CR-410, Konica Minolta (China) Investment Ltd., Shanghai, China). The pH value was determined using a pH meter (PHB-4, INESA Scientific Instrument Co., Ltd., Shanghai, China). The shear force was measured with a digital meat tenderness meter (C-LM3, Northeast Agricultural University, Harbin, China). The measurements of meat color, pH, and shear force were conducted according to the procedures described by Guo et al. (2017). A total of 45 breast muscle filets were used for cooking loss analysis. Filets were placed on aluminum trays, cooked for 30 min at 80°C with steam, allowed to cool for 30 min, and reweighed to calculate the cooking loss.

Statistical Analyses

All data were analyzed using one-way ANOVA followed by Duncan's multiple range tests by SPSS, version 16.0, software (SPSS Inc., Chicago, IL). The threshold for significance was set at $P < 0.05$. The data are expressed as the mean ± SE.

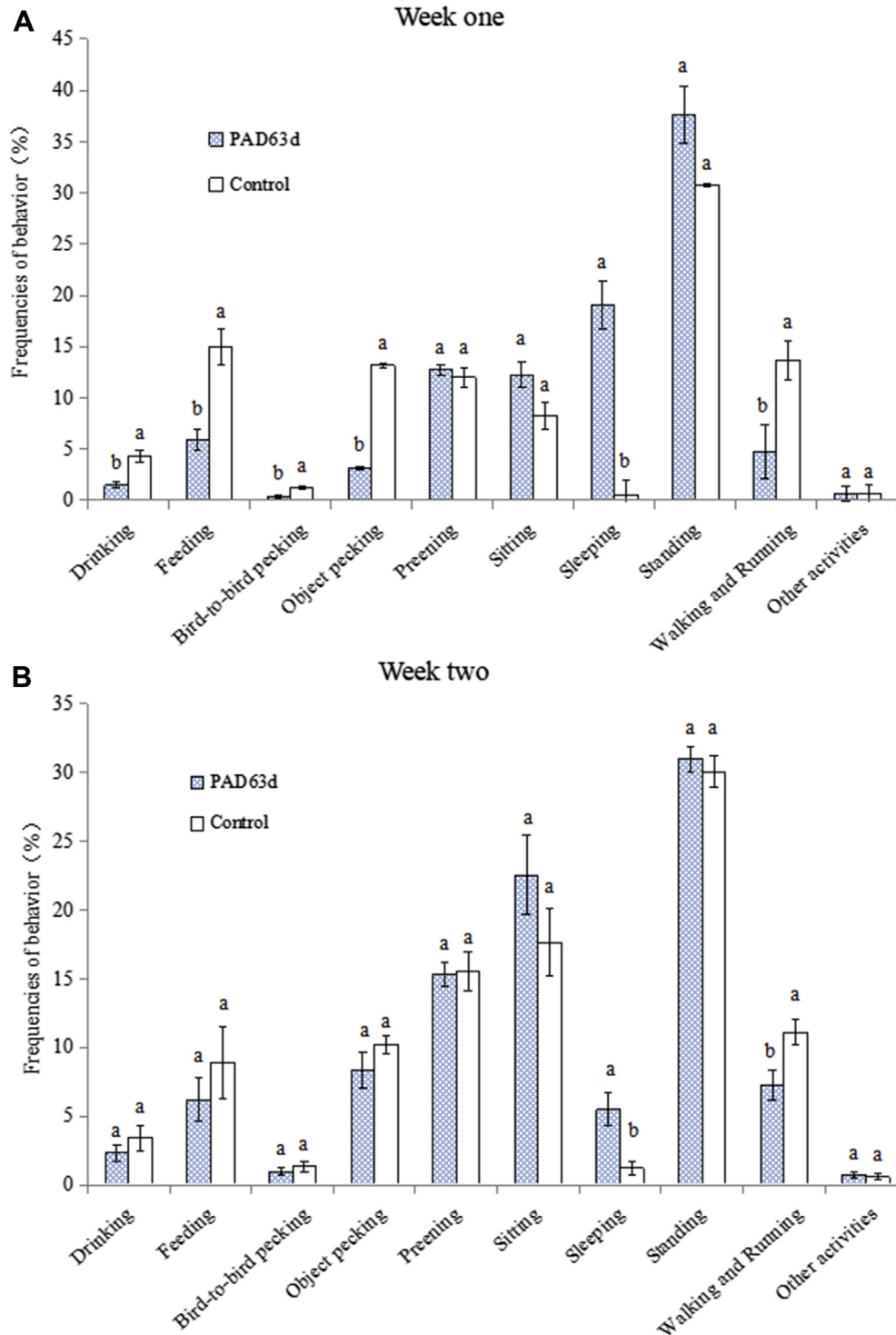


Figure 2. Behaviors expressed by birds in the PAD63d and control groups in the first week (A) and second week (B) after birds were fitted with PAD based on observation. Each bar presents the mean \pm SE ($n = 12$ birds per treatment). The means are presented as the proportion of observed behaviors out of the total number of observed behaviors. The “ab” represents a significant difference between the PAD63d and control groups ($P < 0.05$). Abbreviations: PAD, plastic anti-pecking device; PAD63d, birds fitted with PADs at 63 d of age.

RESULTS

Growth Performance

The BW, ADFI, and FCR are shown in Table 2. The PAD did not cause a difference in the BW at 63, 91, and 112 d of age ($P > 0.05$). The ADFI from 63 to 91 d and

from 63 to 112 d was lowest in birds in the PAD63d group, intermediate in birds in the PAD77d group, and highest in control birds ($P < 0.05$). The ADFI from 92 to 112 d of age in birds in the PAD63d and PAD77d groups was lower than that in control birds ($P < 0.05$). The FCR from 63 to 91 d and from 63 to 112 d of age in the PAD63d group were lower than those

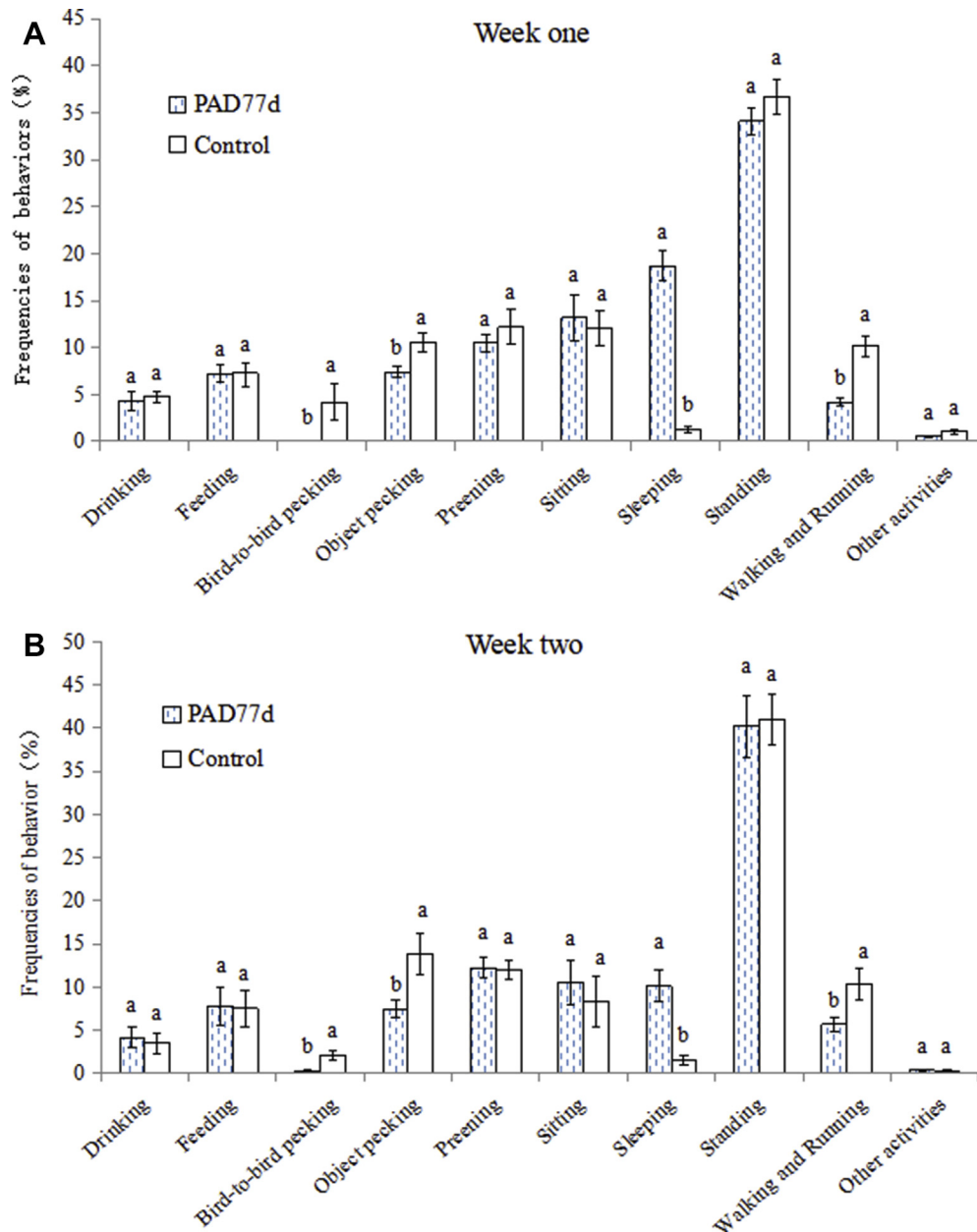


Figure 3. Behaviors expressed by birds in the PAD77d and control groups in the first week (A) and second week (B) after birds were fitted with PAD based on observation. Each bar presents the mean \pm SE ($n = 12$ birds per treatment). The means are presented as the proportion of observed behaviors out of the total number of observed behaviors. The “ab” represents a significant difference between the PAD77d and control groups ($P < 0.05$). Abbreviations: PAD, plastic antipecking device; PAD77d, birds fitted with PAD at 77 d of age.

in the PAD77d and control groups ($P < 0.05$); however, there was no effect of PAD on the FCR from 92 to 112 d of age ($P > 0.05$). The mortality from 63 to 112 d of age was 0 in the PAD63d group, 3.3% in the PAD77d group, and 13.3% in the control group, which was mainly caused by vent pecking in the trial. The mortality in the PAD77d group was 0 after birds were fitted with PAD.

Behavior and Daily Walking Steps

The behavior expressed by birds in the PAD63d group is presented in Figures 2A, 2B. Compared with birds in the control group, birds in the PAD63d group showed

lower frequencies of drinking, feeding, walking and running, bird-to-bird pecking, and object pecking ($P < 0.05$) and a higher frequency of sleeping ($P < 0.05$) in the first week after treatment. During adaptation of birds to the PAD, birds also showed lower frequencies of walking and running and a higher frequency of sleeping than those in the control group ($P < 0.05$); however, no effect of PAD on the frequencies of drinking, feeding, bird-to-bird pecking, object pecking, preening, sitting, and standing was found ($P > 0.05$) in the second week after treatment.

The behavior expressed by birds in the PAD77d group is presented in Figures 3A, 3B. The frequency of sleeping of birds in the PAD77d group was higher than that of

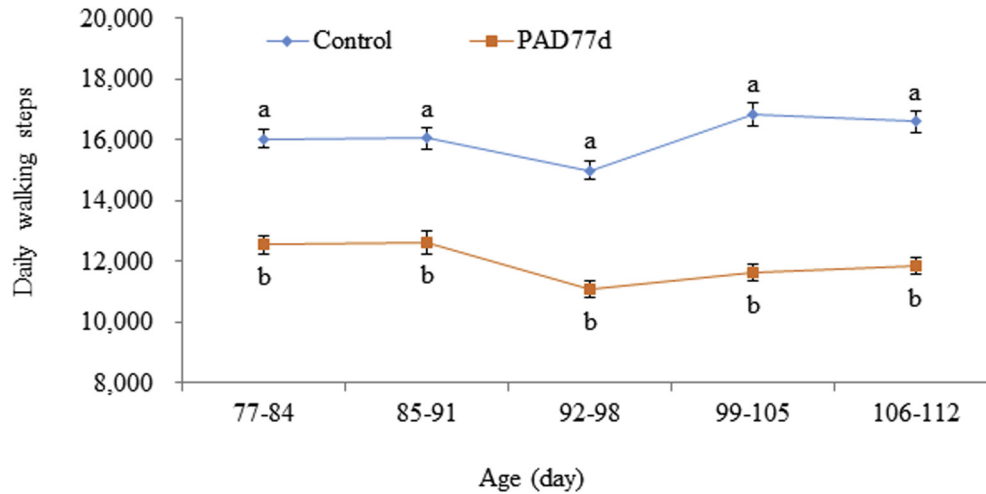


Figure 4. Daily walking steps of birds in the PAD77d and control groups from 77 to 112 d of age based on pedometers. Values are presented as the mean \pm SE (n = 26 birds per treatment). The “ab” represents a significant difference between the PAD77d and control groups ($P < 0.05$). Abbreviations: PAD, plastic anti-pecking device; PAD77d, birds fitted with PAD at 77 d of age.

control birds after treatment ($P < 0.05$), and the frequencies of bird-to-bird pecking, object pecking, and walking and running in the PAD77d group were lower ($P < 0.05$). The birds’ daily walking steps in the PAD77d group decreased by 21.3% to 31.0% compared with that of birds in the control group during the experiment ($P < 0.05$) (Figure 4).

Upper Beak Length

The upper beak length of birds is shown in Table 3. The upper beak lengths of birds in the treatments were similar at the onset of the trial ($P > 0.05$). The upper beak length of birds at 91 d and 112 d of age was longest in the PAD63d group, intermediate in the PAD77d group, and shortest in the control group ($P < 0.05$).

Plumage Condition Score

The plumage condition scores are shown in Figure 5. The plumage condition scores of the backs and tails of birds in the PAD63d and PAD77d groups were higher than those of control birds ($P < 0.05$). However, there was no effect of PAD on the plumage condition scores of bellies of the birds ($P > 0.05$).

Table 3. Effect of PAD on the upper beak length (mm) of Wannan chickens.

| Age (d) | PAD63d | PAD77d | Control |
|---------|------------------------------|------------------------------|------------------------------|
| 63 | 14.8 \pm 0.09 ^a | 14.8 \pm 0.08 ^a | 14.7 \pm 0.09 ^a |
| 91 | 17.9 \pm 0.09 ^a | 17.4 \pm 0.09 ^b | 16.8 \pm 0.10 ^c |
| 112 | 19.5 \pm 0.10 ^a | 18.8 \pm 0.09 ^b | 17.4 \pm 0.10 ^c |

^{a-c}Means within a row lacking a common superscript differ significantly ($P < 0.05$). Values are presented as the mean \pm SE.

Abbreviations: PAD, plastic anti-pecking device; PAD63d, birds fitted with PAD at 63 d of age; PAD77d, birds fitted with PAD at 77 d of age.

Carcass Traits and Meat Quality

Carcass traits and meat quality are listed in Table 4. No difference was noted in carcass, eviscerated carcass, breast muscle, leg muscle, and abdominal fat yield among the treatments ($P > 0.05$). There was no effect of PAD on the meat color (L^* , a^* , and b^*), pH, cooking loss, and shear force among the treatments ($P > 0.05$).

DISCUSSION

In the present study, the effect of PAD on BW, ADFI, and FCR in a local Chinese chicken breed were evaluated. PAD had no effect on the BW in Wannan chickens from 63 to 112 d of age; however, birds fitted with PAD ate less and had a lower FCR, which was consistent with the study by Arbi et al. (1983), who found that feed efficiency could be improved when laying hens were fitted with vision-restricting plastic polypeepers at 20 wk of age. It can be inferred that improved feed efficiency was mainly caused by less feed waste and a decrease in daily walking steps due to the usage of PAD.

The pecking behavior can be affected by many factors, including genetics, feed and nutrition, environment and management measures, and even artificial marking (Dennis et al., 2008; Rodenburg et al., 2008; Wysocki et al., 2010; Brantsæter et al., 2018). It was expected that bird-to-bird pecking can be decreased to keep good plumage condition and low mortality when birds were fitted with PAD. Our results indicated that PAD resulted in behavioral changes, including a decrease in bird-to-bird pecking, object pecking, and walking and running and an increase in sleeping, which were somewhat consistent with the results of Arbi et al. (1983) and Savory and Hetherington (1997), who reported that anti-pecking devices could lead to reductions in activities such as feather pecking and agonistic acts in laying hens. Dennis et al. (2008) reported that the artificial marked birds (only 20 or 50% of individuals within a

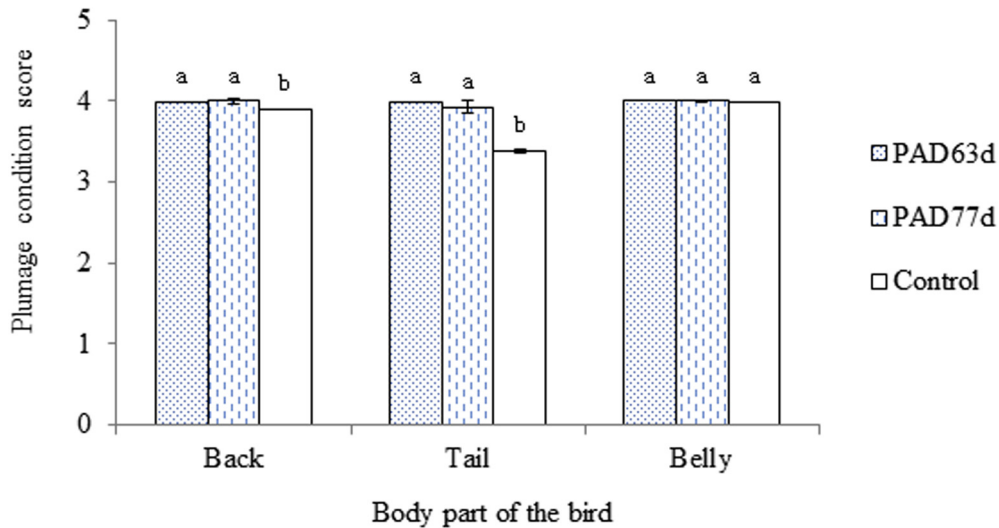


Figure 5. Plumage condition score of body parts at 112 d of age in Wannan chicken. Plumage conditions were evaluated by scoring individual birds on a 1-4 scale with 1 being almost naked without feathers and 4 being full feather coverage without damage. Each bar presents the mean \pm SE. The “ab” represents a significant difference among the treatments ($P < 0.05$). Abbreviations: PAD, plastic anti-pecking device; PAD63d, birds fitted with PAD at 63 d of age; and PAD77d, birds fitted with PAD at 77 d of age.

group) received more aggression and delivered less aggression than the unmarked individuals within the same group. However, the impact of artificial marking on our experimental results is not unclear because of lack of behaviors expressed of unmarked birds within the same group, and further study needs to be conducted to determine the effect of artificial marking during the usage of PAD. In the present study, birds fitted with PAD had better plumage conditions than that of control birds, the reason is that less bird-to-bird pecking reduced plumage damage to the backs and tails of birds. Furthermore, the mortality caused by cannibalism was decreased by PAD, which was in disagreement with Gvaryahu et al. (1997), who found that contact lenses had no beneficial effect on mortality. In contrast, Adams (1992) reported that considerable mortality occurred because of an inability to find the feed when

pullets aged between 2 and 8 wk with plastic lenses were transferred to a layer facility. The underlying reasons for these discrepancies may be due to the difference in anti-pecking devices, bird breeds, and rearing environment in which the birds were housed.

Beak morphology is often closely adapted to the particular food resources available in bird’s environment (Bardwell et al., 2001; Temeles and Kress, 2003). The beak plays a critical role in feeding, drinking, defending and preening and is usually interpreted in relation to bird’s health, welfare, and performance (Clayton et al., 2005; Savas et al., 2007; Vezzoli et al., 2015). The beak length can be suppressed by beak trimming in pullets (Marchant-Forde et al., 2008); however, the beak length could be increased when birds were fitted with rings or bumpers (Savory and Hetherington, 1997). In the present study, the upper beak length was increased in birds fitted with PAD, which was consistent with the results of Savory and Hetherington (1997), and this may have been induced by the reduction in beak-related pecking.

Table 4. Effects of PAD on carcass traits and meat quality of Wannan chickens at 112 d of age.

| Items | PAD63d | PAD77d | Control |
|-------------------------|-----------------|-----------------|-----------------|
| Carcass traits | | | |
| Carcass (%) | 85.7 \pm 0.32 | 85.3 \pm 0.47 | 86.4 \pm 0.30 |
| Eviscerated carcass (%) | 65.2 \pm 0.45 | 65.2 \pm 0.43 | 66.1 \pm 0.30 |
| Leg muscle (%) | 21.9 \pm 0.34 | 22.4 \pm 0.34 | 22.2 \pm 0.28 |
| Breast muscle (%) | 16.8 \pm 0.42 | 16.5 \pm 0.38 | 16.0 \pm 0.33 |
| Abdominal fat (%) | 1.05 \pm 0.36 | 0.94 \pm 0.28 | 0.69 \pm 0.24 |
| Meat quality | | | |
| L* | 50.4 \pm 1.32 | 51.9 \pm 0.81 | 51.3 \pm 1.23 |
| a* | 8.9 \pm 0.56 | 9.4 \pm 0.48 | 8.1 \pm 0.58 |
| b* | 15.8 \pm 1.32 | 18.1 \pm 1.23 | 17.2 \pm 1.04 |
| pH | 6.08 \pm 0.07 | 5.97 \pm 0.06 | 6.10 \pm 0.07 |
| Cooking loss (%) | 22.8 \pm 0.50 | 23.7 \pm 0.67 | 23.2 \pm 0.64 |
| Shear force (kgf) | 2.57 \pm 0.12 | 2.66 \pm 0.13 | 2.65 \pm 0.21 |

^{a-c}Means within a row lacking a common superscript differ significantly ($P < 0.05$). Values are presented as the mean \pm SE ($n = 15$ birds per treatment).

Abbreviations: a*, redness; and b*, yellowness; L*, lightness; PAD, plastic anti-pecking device; PAD63d, birds fitted with PAD at 63 d of age; PAD77d, birds fitted with PAD at 77 d of age.

Carcass traits can be affected by genetics, feed, and environment (Mansour and Hosna, 2010; Cahyadi et al., 2014; Arowolo et al., 2019). Meat quality is important for consumers and product processing and can be influenced by genetics, age, sex, feed, and management (Fletcher, 2002; Frizzell et al., 2017). To the best of our knowledge, there was no report of effects of PAD on carcass yield and meat quality, which inhibits the comparison of our results with those of other research. In the present study, our data indicated PAD had no difference on carcass traits and meat quality in male Wannan chickens at 112 d of age.

In conclusion, the findings of this study suggested that PAD can reduce mortality, ADFI and FCR, overall activity and daily walking steps, and plumage damage and increase the upper beak length. No evidence was found that PAD caused changes in growth performance, carcass traits, and meat quality.

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Conflict of Interest: There are no known conflicts of interest associated with this publication.

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