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Comparison of Natural Mating and Artificial Insemination on Laying Performance, Egg Quality and Welfare of Fast Feathering Huainan Partridge Chickens

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Authors' Contribution
KZ conceived and designed the entire experimental plan. YL performed the animal trail, statistically analyzed the data and drafted the manuscript. JL, WL, RM and SL participated in egg quality analysis and welfare assessment. TH, SL, SW and YH provided essential experimental animals.

Key words
Natural mating, Artificial insemination, Laying performance, Welfare, Huainan partridge chicken.

ABSTRACT

A comparison has been made between natural mating (NM) and artificial insemination (AI) in fast feathering Huainan partridge chickens. A total number of 360 fast feathering Huainan partridge hens and 40 roosters were randomly divided into two equal groups. For NM, 4 mating cages were maintained each with 5 roosters and 45 laying hens. The other birds were reared in 3-layer complete ladder cages for AI, for which 180 hens were maintained in 60 cages with 3 hens/cage and 20 roosters in 20 cages. Laying performances, mortality, egg quality characteristics and welfare level of birds were measured during the study period. Compared with AI birds, NM birds laid the first egg significantly earlier age, and had significantly lower laying rate, mortality and body weight of hens. NM birds however had significantly higher albumen height, Haugh units and yolk colour. No significant differences were found in other laying performances and egg quality characteristics. Except for the back region of AI females which had better feather cover, the average feather score for most body parts of AI and NM hens was not significantly different. An overall feather score of NM females was significantly lower than that of AI ones. The average feather score for each individual part of the body and an overall average score for roosters remained unchanged between two groups. Additionally, NM birds showed a higher level of fear than AI. Our overall results suggest that reproduction technique may be an important factor affecting some layer performances, egg quality characteristics and welfare in local poultry breeds. These findings are expected to provide a theoretical guide to choice of breeding methods for poultry enterprises.

INTRODUCTION

Breeding is an essential component of breeder farm and the right selection of breeding methods would greatly reduce farm costs and risks, and increase their economic performance. To date the reproduction techniques most commonly applied in poultry breeding are artificial insemination (AI) and natural mating (NM). In AI the female birds are artificially inseminated with fresh undiluted semen to achieve fertilization of eggs. However, NM is the one in which male and female birds are raised together and naturally mated by virtue of their sexual instinct. Both these techniques have their own unique advantages and characteristics. Hughes and Hollman (1976), Hughes (1978), Brillard (1993) and Koohpar *et al.* (2010) have already compared the two modes of breedings. For example, AI enables the wide use of males with valuable genetic characteristic to any female and expand the fertility power of outstanding males, reduces the number of feeding roosters and prevents the spread of sexually transmitted diseases. Conversely, NM could significantly reduce labour costs, enhance land use efficiency and improve poultry welfare. Moreover, several researchers have also compared their differences in sperm storage and transport (Brillard, 1993), the fertility and hatchability traits (Hughes, 1978; Koohpar *et al*., 2010). All of these evidences suggest that reproduction technique is an important factor affecting chicken production performance. Little information is currently available regarding the local poultry breeds. The objective of this study was to compare the effect of NM and AI on laying performance, egg quality characteristics and welfare of fast feathering Huainan partridge chicken.

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MATERIALS AND METHODS

Birds and experimental design

A total of 360 fast feathering Huainan partridge hens and 40 roosters, 28 weeks of age were obtained from Anhui Wanxi Mahuangji Poultry Co. Ltd. (Lu'an, Anhui Province). All birds were randomly divided into two equal groups. For NM, 4 mating cages (240 × 120 × 80 cm) were used and each cage contained 5 roosters and 45 laying hens. For AI, 180 hens were reared in 60 3-layer complete ladder cages, (43 × 50 × 45 cm) with 3 hens/cage and 20 roosters in 38 × 56 × 60 cm cages for 20 cages. AI hens were inseminated once every five days with 0.03 ml of undiluted semen. AI was immediately done after semen was collected in the afternoon (13:00-15:00). The depth of insemination was approximately 2 cm into the everted vagina. The dietary nutrient concentration of commercial feed for Huainan partridge chickens comprises 11.50 MJ/kg Metabolizable energy, 15% crude protein, 0.62 % lysine, 0.31% methionine, 0.53% methionine + cysteine, 0.14% tryptophan, 3.20% calcium, 0.60% total phosphorus, 0.30% effective phosphorus and 0.25% sodium chloride. The entire experiment lasted for 6 consecutive weeks. All birds were managed according to the guidelines approved by Anhui Wanxi Mahuangji Poultry Co. Ltd. All experimental procedures involving animals were approved by the Animal Care and Use Committee of the Anhui Academy of Agricultural Sciences (approval number A11-CS06; date of approval 21 September 2011).

Measurement of laying performances and mortality

The performance parameters including hen-day egg production, egg weight and the number of dead and crippled birds were recorded daily in each cage, and all measurements were taken at approximately the same time of day. Average egg weight, mortality and laying rate were calculated by recorded data. Then, freshly qualified eggs were gathered and hatched in a commercial hatchery under the same conditions. The qualified eggs were distinguished with the standard as: clean and smooth surface, similar oval shape with with a big end and a small end. Finally, the number of fertilized eggs and live chicks were counted for the calculation of fertility and hatchability of fertile eggs.

Egg quality determination

Given the nutritional and economic importance of egg quality, major quality parameters of eggs (shell weight, yolk weight, shell thickness, shell colour, shell strength, egg shape index, albumen height, Haugh units and yolk colour) were measured in 30 eggs per replicate at the end of the experiment. Egg shell thickness and shell colour were measured in 3 different locations of the shell (top, bottom, and middle) using shell thickness meter (ESTG-1, ORKA Food Technology Co., Ltd. Ramat Hasharon, Israel) and reflectometer (PRS-Evans Electroselenium Ltd, Halstead, Essex) on a scale of 0 (black) to 79.9 (white), respectively. The mean of the 3 measurements was served as the representative value of parameter for statistical analysis. Shell strength was gauged with an egg shell force gauge (EGG-0503, Robotmation Co., Ltd, Tokyo, Japan). Length and width of each egg were determined with a digital vernier caliper (LRY1202, Shanghai LiangRen Tools Co., Ltd., Shanghai, China) and egg shape index was calculated. Yolk colour, albumen height and Haugh units were measured using automatic egg multitester equipment (EMT-5200, Robotmation Co., Ltd., Tokyo, Japan). Shell weight and yolk were separated and weighed using electronic scales (Jiming Weighing calibration equipment Co., Ltd., Yuyao, China).

Welfare assessment

To compare the effects of reproduction technique on bird welfare, feather cover and fearfulness were evaluated. Feather cover was estimated according to the scoring system described by Tauson (1986). The scoring system was applied to the neck, breast, back, wings and tail. A total of 30 birds (15 male and 15 female) per group were randomly scored. The average feather score for each individual part of the body and an overall average score were statisticed. Fearfulness of bird flocks was examined using a method similar to that described previously (Honaker and Ruszler, 2004). Ten independent observers were asked to walk by the cages and recorded fear level. Finally, the average of fearfulness score was calculated in each group.

Statistical analysis

Statistical analysis was performed using Origin Pro 8.0 software (Origin Lab Corporation, USA). Data were analyzed by Student's unpaired *t*-test. Results were expressed as mean ± standard error of the mean (SEM). Means followed by the same letter in a row were not significantly different at the 5% probability level.

RESULTS

Laying performances and mortality and egg quality

Table I summarizes the effects of reproduction technique on laying performances, mortality and egg quality. Compared with AI birds, NM birds had a significantly earlier age at the time of laying first egg, significantly lower egg laying rate, mortality and body

weight of hens and significantly higher albumen height, Haugh units and yolk colour ($P < 0.05$). No significant differences were found in egg weight, fertility, hatchability and mortality of roosters ($P > 0.05$).

Table I.- Comparison of laying performances, mortality and egg quality characteristics between AI and NM.

Parameters	AI	NM
Laying performance		
Hen weight (g)	1840.00±10.00[a]	1802.50±13.09[b]
Egg weight (g)	41.06±0.39[a]	41.63±0.40[a]
Age at first egg (d)	131.83±0.63[a]	128.25±0.63[b]
Laying rate (%)	69.29±0.92[a]	63.44±2.04[b]
Fertility (%)	92.63±0.32[a]	90.13±1.22[a]
Hatchability of setting eggs (%)	86.00±0.00[a]	84.88±0.69[a]
Mortality (%)		
Mortality of laying hens	0.94±0.07[a]	0.26±0.10[b]
Mortality of roosters	0.00±0.00[a]	0.00±0.00[a]
Egg quality characteristics		
Shell weight (g)	6.46±0.12[a]	6.67±0.12[a]
yolk weight (g)	12.24±0.17[a]	12.34±0.20[a]
Shell thickness (mm)	0.40±0.00[a]	0.41±0.00[a]
Shell colour	37.05±0.84[a]	36.32±0.85[a]
Shell strength (kg/cm^2)	4.80±0.18[a]	5.11±0.13[a]
Egg shape index	1.26±0.01[a]	1.25±0.01[a]
Albumen height (mm)	7.25±0.16[a]	8.01±0.11[b]
Haugh units	89.92±0.87[a]	93.64±0.55[b]
Yolk colour	7.24±0.24[a]	7.97±0.21[b]

Means followed by the same letter in a row are not significantly different at the 5% probability level.

Welfare level

The results of welfare assessment demonstrated that the average feather score for most body parts of hens, except that the back region of AI females had better feather cover, was not significant difference between AI and NM ($P > 0.05$, Table II). An overall feather score of NM females was significantly lower than that of AI ones ($P < 0.05$). The average feather score for each individual part of the body and an overall average score for roosters remained unchanged between two groups ($P > 0.05$). Additionally, NM birds showed a higher level of fear, scoring mostly between 7.1 and 8.3, whereas the AI birds scored lower in the range of 2.1 to 2.7 ($P < 0.05$).

Table II.- Comparison of welfare level between AI and NM, as determined by the number of feathers on different parts of bodies.

Parameters		AI	NM
Hen	Neck	4.00±0.00[a]	4.00±0.00[a]
	Breast	4.00±0.00[a]	4.00±0.00[a]
	Back	4.00±0.00[a]	3.10±0.23[b]
	Wing	4.00±0.00[a]	3.80±0.13[a]
	Tail	4.00±0.00[a]	4.00±0.00[a]
	Overall feather	20.00±0.00[a]	18.90±0.31[b]
Rooster	Neck	4.00±0.00[a]	4.00±0.00a
	Breast	3.67±0.21[a]	3.83±0.17[a]
	Back	4.00±0.00[a]	4.00±0.00[a]
	Wing	4.00±0.00[a]	4.00±0.00[a]
	Tail	4.00±0.00[a]	3.67±0.21[a]
	Overall feather	19.67±0.21[a]	19.50±0.22[a]
Fearfulness evaluation		2.40±0.22[a]	7.70±0.56[b]

Means followed by the same letter in a row are not significantly different at the 5% probability level.

DISCUSSION

Laying performance and mortality, both are important economic performances, have been extensively investigated in previous studies. But, no data are available, until now, regarding their comparison under both reproduction techniques. In the current study, we examined laying performances and mortality in fast feathering Huainan partridge chickens. Our results showed that NM birds had a significantly earlier age at first egg than AI ones. This result is probably because the existence of mated roosters stimulate sexual maturation of hen in the same cage. Laying rate during the flock NM was less than AI**.** Taking into account the laying rate affected by various factors, the reason for this discrepancy is not completely understood. However, the current result insinuates an obvious deficiency in natural mating and it is necessary to optimize the parameters of natural mating system to achieve best possible output levels. Mortality of laying hens was significantly lower in NM than in AI, this phenomenon is perhaps best explained by the permanent insemination stress of AI flock. NM hens are inferior to AI hens in body weight. Our results are largely consistent with those of Koohpar *et al*. (2010). This is explainable as NM hens are kept in larger cages and have more physical activity, but in the AI, small cages restrict behavioral activities of laying hens, which might cause an increase in body weight. Additionally, no differences were observed

in egg weight, fertility, hatchability and mortality of roosters in both groups, suggesting that they are unaffected by reproduction technique.

Egg quality contains a number of characteristics, related to the yolk, the albumen and the shell, be divided into internal and external egg quality (Roberts, 2004; Englmaierová *et al*., 2014; Duman *et al*., 2016). Egg quality characteristics are not only important indicators for nutritional value, but they are also important for consumer appeal, egg price, hatchability performance, etc. (Blanco *et al*., 2014; Hrnčár *et al*., 2014; Zaheer, 2015; Adedeji *et al*., 2015; Blount, 2016; Duru *et al*., 2017). In the present work, egg quality characteristics were first examined under two breeding models. The results displayed that NM birds experienced significantly higher albumen height and Haugh unit. This is conceivable because Haugh unit is calculated based on albumen height and positively correlated with it (Eisen *et al*., 1962; Roberts, 2004; Yildiz *et al*., 2006). Albumen height and Haugh unit are generally considered as good indicators to evaluate egg's freshness. The higher the albumen height and the Haugh unit, the more freshness of egg. The results of this study suggest that eggs produced by NM birds are more freshness. Yolk colour was significantly higher in NM than in AI. Given that yolk colour is generally affected by the pigment content of feed (Spada *et al*., 2016), mark elevation of yolk colour may be thus associated with the differential absorption of pigment by the gut, although the direct evidence contributing to this phenomenon requires further investigation. Little variations were found in other egg quality characteristics, hinting that breeding effect is negligible in this respect.

The scientific study of animal welfare is interdisciplinary and many definitions of animal welfare have been proposed. It involves the animal's physical and psychological health, harmony with external environment and the animal's feelings (Kristensen and Wathes, 2000; Duncan, 2002). In this study, feather cover and fearfulness were quantitatively assessed. The average feather score of back region and an overall average score of NM hens were significantly lower than those of AI ones. This is probably the reason the back region of NM hen was trampled by rooster during the mating period. An overall score is sum of the feather score for each individual part of the body, long-term trampling appears to have a cumulative effect, which eventually causes a significant reduction in overall average score of hens. The average feather score for each individual part of the body and an overall average score for roosters did not change substantially under both methods. Understandably, NM males, having a high rank in the dominance hierarchy, are rarely attacked or scratched by other birds. Aggressive behavior scarcely occur in the flock AI as rooster is kept individually in single bird cage. Therefore, feather score of roosters was not significantly different. In addition, NM showed a higher level of fear than AI. This is probably because AI birds are artificially inseminated daily and establish a perfect or nearly perfect adaptation responding to common stumuli. However, none has occurred, except for natural mating in the flock NM. Briefly, the results suggest NM birds are more fearful to external stimuli.

CONCLUSIONS

We investigated the variations in laying performances, egg quality characteristics and welfare of fast feathering Huainan partridge chicken under both reproduction techniques. Our overall results suggest that reproduction technique may be an important factor affecting some layer performances, egg quality characteristics and welfare of local poultry breeds. These findings are expected to provide a theoretical guide to choice of breeding methods for poultry enterprises.

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Statement of conflict of interest

Authors declare that they have no conflict of interest.

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