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GENETIC ASSOCIATIONS BETWEEN EARLY AND LATE GROWTH WITH SEXUAL MATURITY IN THAI NATIVE CHICKENS

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SUMMARY

The associations between early and late growth rates with sexual maturity of Lueng Hang Kao Kabinburi (LHKK) native chicken in Thailand were explored. Five generations of data from 2003 to 2007, involving 11,588 chickens, were collected at Kabinburi Livestock Research and Breeding Centre (KLRBC). Body weight measured from day-old (BW1D) to 24 weeks of age at 4 weekly intervals of 4 (BW4), 8 (BW8), 12 (BW12), 16 (BW16), 20 (BW20), 24 (BW24) weeks, and sexual maturity traits, age at first egg (AFE) and egg weight at first egg (EWFE), were recorded. The growth rates were grouped into 5 categories: BW1D to BW8 (Growth_1), BW4 to BW12 (Growth_2), BW8 to BW16 (Growth_3), BW12 to BW20 (Growth_4), and BW16 to BW24 (Growth_5). Growth_1 to 3 represented early growth and Growth_4 and 5 represented late growth. Genetic correlations were estimated between early and late growth rates against AFE and EWFE using Restricted Maximum Likelihood. Growth_1 had a favourable genetic correlation of -0.15 with AFE and a high positive (favourable) genetic correlation of 0.42 with EWFE. Growth rate between Growth_4 and Growth_5 had unfavourable genetic correlations of 0.08 and 0.30, respectively, with AFE, and favourable genetic correlations of 0.28 and 0.31, respectively, with EWFE. This study indicated that selecting for higher growth rate between day-old to 8 weeks of age would also improve sexual maturity by reducing the AFE and increasing the EWFE of LHKK chicken in Thailand.

INTRODUCTION

The Thai native chicken, Lueng Hang Kao Kabinburi (LHKK), is a dual-purpose chicken breed used to produce meat and eggs. However, the growth and egg production rate of LHKK are low under the backyard production systems in Thailand. Therefore, there is a need to improve both growth and egg production to improve productivity and profitability of the LHKK chickens. Tongsiri *et al.* (2019) showed that body weights at various ages and sexual maturity traits are moderately heritable (0.10 to 0.37) and, therefore, selecting for higher body weight and early sexual maturity are expected to improve both traits of LHKK chickens. A number of studies have examined the genetic association between growth and egg production of native chickens at various ages. Bahmanimehr (2012) and Niknafs *et al.* (2012) found positive genetic correlations between early growth and egg weight first egg (EWFE) by 0.30 to 0.51 in Iranian native chickens. However, Niknafs *et al.* (2012) found an unfavourable genetic relationship between age at first egg (AFE) and body weight in the early growth period (day-old). By contrast, Bahmanimehr (2012) and Niknafs *et al.* (2012) concluded that both body weight and egg production could be improved simultaneously by selecting based on body weights measured during the early growth period.

Selecting replacement chickens based on growth information at an early age would decrease the number of chickens required to be kept as replacement stock and, thereby, reduce management cost and increase the profitability of the LHKK nucleus flock. Thus, a better understanding of the genetic relationship between growth rates during various growth periods and their relationship with sexual

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maturity will help to develop a suitable breeding program for the LHKK chickens. Therefore, the aim of this study is to identify an appropriate age range to select for higher growth and early sexual maturity to improve both growth and egg production in LHKK chicken.

MATERIALS AND METHODS

Animal and Data. Five generations of growth and egg production data from 2003 to 2007 on 11,588 individual chickens were collected. The chickens were descendants of 486 cocks and 1,461 hens. The pure-bred dual-purpose LHKK chickens were housed on a Thai government farm at the Kabinburi Livestock Research and Breeding Centre (KLRBC) in the Eastern region of Thailand. The chickens were subjected to the management and vaccination program (Marek's disease, New Castle disease (ND), Infectious Bronchitis disease (IB) and Fowl Pox disease) recommended by the Department of Livestock Development, Thailand. All chicks were wing-banded on day-old and body weights were measured from day-old to 24 weeks of age at 4 weekly intervals (day-old (BW1D), 4 (BW4), 8 (BW8), 12 (BW12), 16 (BW16), 20 (BW20) and 24 (BW24)). The sexual maturity was measured as AFE and EWFE. The number of chickens measured for body weight at different ages reduced gradually as age increased (Table 1). This is mainly due to selective culling of chickens based on phenotypic characteristics such as colour of face, eyes, beak, skin, shank, body plumage, neck, tail, saddle and type of comb.

Statistical analyses. Genetic parameters and variance components were estimated using a mixed linear model using Restricted Maximum Likelihood (REML) in the WOMBAT software (Meyer 2007). For growth rate, model included year and hatch within year and sex as fixed effects, and direct additive genetic, maternal genetic, maternal permanent environmental and residual as random effects. For AFE and EWFE, sex, maternal genetic and maternal permanent environmental were not fitted (Tongsiri *et al.* 2019). A series of bivariate analyses between growth rate at different ages and AFE and EWFE were conducted using REML in WOMBAT. Five growth periods were identified: Growth_1 was between BW1D and BW8, Growth_2 was between BW4 and BW12, Growth_3 was between BW8 and BW16, Growth_4 was between BW12 and BW20, and Growth_5 was between BW16 and BW24. Growth_1, Growth_2 and Growth_3 were grouped as 'Early growth' and Growth_4 and Growth_5 were grouped as 'Late growth'. Body weight measured at various ages was used to calculate growth rates for early and late growth periods. Genetic correlations (r_g) between early and late growth rates with AFE and EWFE were estimated.

RESULTS AND DISCUSSION

Estimated heritabilities for body weight were constant across the different ages, except for BW1D and BW4 (Table 1).

Early growth rate and AFE. Genetic correlations between early growth rates and AFE ranged from -0.15 to 0.07 (Table 2). Growth rates in Growth_1 and Growth_2 were negatively correlated with AFE, indicating that chickens with higher growth rates during these periods will grow faster and reached sexual maturity earlier than their contemporaries. The favourable associations of early growth rate in Growth_1 and Growth_2 with AFE agreed with the correlations reported by El-Dlebshany (2008) for native chickens in Egypt.

Late growth rate and AFE. Estimated genetic correlations between late growth and AFE ranged from 0.08 to 0.30, indicating that chickens with higher growth rates after 16 weeks of age will have older age at sexual maturity. Sang *et al.* (2006) reported unfavourable correlations ranging from 0.14 to 0.72 between late growth and AFE on native chickens in Korea. Kinney (1969) observed a favourable association of growth rate with AFE and the magnitude of the association reduced with increasing age. In contrast, Lwelamira *et al.* (2009) estimated genetic correlations between growth and AFE on two native chicken breeds in Tanzania, and they reported the associations were more favourable with increasing age (-0.03 to -0.23). Overall, the magnitude of the genetic association of growth rate with AFE increased when growth reached its final stage.

The results of this study indicate that growth rate and AFE are genetically related. Therefore, selecting chickens with higher growth rates during the early growth periods (Growth_1 and Growth_2) will also reduce AFE. Selecting for higher growth rates in the late growth periods will delay sexual maturity in LHKK chickens.

Table 1. Descriptive statistics with number of records, mean, standard deviation (SD), minimum (Min), maximum (Max), direct additive genetic variance (σ^2) and heritability (h^2) estimated for body weight and sexual maturity traits of LHKK chickens

Traits	Number of records	Mean	SD	Min	Max	σ^2	h^2
BW1D (g)	11,588	30.93	3.38	22	40	1.20	0.10±0.02
BW4 (g)	11,201	218.9	56.7	46	379	232.7	0.20±0.03
BW8 (g)	10,807	642.1	139	260	1,034	2,646	0.34±0.03
BW12 (g)	9,777	1,098	210	520	1,673	10,503	0.37±0.03
BW16 (g)	8,948	1,486	306	586	2,376	12,076	0.30±0.03
BW20 (g)	7,643	1,809	406	640	3,000	18,814	0.30±0.03
BW24 (g)	6,157	2,123	470	893	3,520	28,242	0.30±0.04
AFE (day)	1,395	199.1	21.0	138	260	40.49	0.16±0.06
EWFE (g)	1,393	36.94	4.85	26	48	3.03	0.16±0.05

Early growth rate and EWFE. Estimated genetic correlations between early growth rate and EWFE ranged from 0.19 to 0.42 (Table 2). Moderate to high genetic correlations between early growth rate and EWFE indicated that chickens with higher growth rate at Growth_1 are expected to lay heavier eggs at the onset of lay. Positive genetic correlations between early growth rate and EWFE is in agreement with the values of 0.30 to 0.39 reported by Niknafs *et al.* (2012) for native chickens in Iran. The lowest correlation was observed between growth rate measured at Growth_3 and EWFE indicating that selecting on growth rate between 8 to 16 weeks will have less favourable response on EWFE compared with selecting on Growth_1. This finding agrees with those published by Hosseini and Tahmoorespur (2013).

Late growth rate and EWFE. Positive genetic correlations were estimated between late growth rate and EWFE which ranged from 0.28 to 0.31 (Table 2). Kinney (1969) also reported moderate positive correlations (0.13 to 0.29) between late growth and EWFE. This finding indicates that the genetic correlation growth rate has with EWFE was moderate when chickens reached maturity. Thus, selecting heavy chickens in the late growth period, especially between 16 and 24 weeks of age, would lead to chickens laying heavier eggs at the onset of lay. Both early and late growth rates had positive genetic relationships with EWFE. However, selection based on Growth_1 to improve EWFE would be expected to reduce production costs associated with keeping extra-replacement chickens.

Growth rate and sexual maturity traits. Selection for earlier AFE would be achieved more effectively by selecting chickens with higher growth rates at earlier ages (between day-old and 8 weeks). Growth rate in this early growth period is also favourably related to EWFE. Estimated heritabilities listed in Table 1 suggest that both body weight and sexual maturity are heritable. Therefore, both growth and sexual maturity traits could be improved by selection. Thus, selection based on early growth rate will increase AFE and EWFE simultaneously. Bahmanimehr (2012), El-Dlebshany (2008) and Magothe *et al.* (2006) also suggested that selecting heavy weight juvenile chicks may help the breeder to increase the final weight and egg weight while the chickens reach early sexual maturity.

Table 2. The genetic correlations between growth rates in the early and late growth periods and sexual maturity traits

Body weight	Genetic correlations (r_g)	
	AFE	EWFE
	Early growth period	
BW1D to BW8 (Growth_1)	-0.15±0.15	0.42±0.13
BW4 to BW12 (Growth_2)	-0.12±0.15	0.27±0.14
BW8 to BW16 (Growth_3)	0.07±0.18	0.19±0.16
	Late growth period	
BW12 to BW20 (Growth_4)	0.08±0.19	0.28±0.17
BW16 to BW24 (Growth_5)	0.30±0.25	0.31±0.20

CONCLUSIONS

This study showed that growth rates in the early and late growth periods had different associations with sexual maturity of LHKK chickens. Selecting chickens for early growth is the most economically attractive option because the trait is favourably correlated with sexual maturity, which provides greater potential for improvement of meat and egg productivity compared to selecting for late growth (between 16 and 24 weeks of chicken age). Late growth expressed an unfavourable relationship with AFE, as it delayed the onset of AFE but it increased EWFE. Moreover, selection in early growth between day-old and 8 weeks would reduce the number of chickens required as replacements, therefore, there would be less need to measure body weight in the later growth periods, which would reduce management cost in LHKK nucleus flock.

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