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Original article

Genetic parameters of some growth and egg production traits in laying Brown Tsaiya (*Anas platyrynchos*)

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Summary – Five hundred and thirty seven female ducks from the native Brown Tsaiya in Taiwan, derived from 156 dams, 40 sires, 4 locations (sire origin), from five hatches were used in study. Fifteen traits were recorded. Average values of traits measured were the following: adult (30 weeks of age) body weight, 1397 ± 120 g; age at first egg, 121 ± 11 days; egg numbers up to 245, 280 and 360 days of age, 107 ± 13, 139 ± 15, 207 ± 26, respectively; egg shell strength, 3.8 ± 0.5 kg/cm2; egg shell thickness, 0.37 ± 0.02 mm; egg weight at 30 and 40 weeks of age, 64.2 ± 4.3 g and 67.8 ± 4.3 g. Genetic parameters were calculated: heritability estimate from the sire variance component (h_s^2), dam variance component (h_d^2). Body weights at 8, 16, 20, 30, 40 weeks of age showed high additive genetic variation ($h_s^2 = 0.36$ to 0.61). For egg weight at 30 and 40 weeks of age, $h_s^2 = 0.32$ and $h_s^2 = 0.24$. For traits related to egg number, h_s^2 values were low and increased with age, being 0.02, 0.12 and 0.14 respectively for 245, 280 and 360 days of age. But the respective heritabilities calculated from dam variance components were higher, being 0.32, 0.17 and 0.26. The non-additive genetic variation of these traits and perhaps the existence of maternal genetic variance indicate the possibility of conducting within line selection and cross-breeding between lines of the same breed.

laying duck – Brown Tsaiya – economical trait – genetic parameter

Résumé – **Paramètres génétiques de quelques caractères de croissance et de production d'œufs chez la cane pondeuse Tsaiya Brune (*Anas platyrynchos*).** *Cinq cent trente-sept femelles de la race locale de cane Tsaiya Brune à Taiwan, issues de 156 mères, 40 pères, 4 régions de Taiwan (origine des pères), nées dans 5 lots d'éclosion, sont utilisées dans cette étude, 15 caractères sont étudiés. Les poids des adultes (âge : 30 semaines) sont de 1397 ± 120 g. Les valeurs moyennes des caractères mesurés sont les suivantes : âge au 1er œuf, 126 ± 11 j. Pour les nombres d'œufs pondus aux âges de 245, 280 et 360 jours, on a respectivement 107 ± 13, 139 ± 15, 207 ± 26. Pour l'épaisseur de la coquille 0,37 ± 0,02 mm et pour sa solidité, 3,8 ± 0,5 kg/cm^2. Les poids de l'œuf, respectivement aux âges de 30 et 40 semaines sont 64,2 ± 4,3 g et 67,8 ± 4,3 g. Les paramètres génétiques ont été calculés: estimation des héritabilités à partir des composantes père (h_s^2)*

et mère (h_d^2) de la variance. Les poids corporels aux âges de 8, 16, 20, 30 et 40 semaines présentent une variabilité génétique additive forte (h_s^2 = 0,36 0,61). Pour le poids de l'œuf à 30 et 40 semaines d'âge, h_s^2 = 0,32 et 0,24. Pour les caractères de production d'œufs, les valeurs de h_s^2 sont faibles et s'accroissent avec l'âge : h_s^2 = 0,02, 0,12, 0,14. Par contre les héritabilités calculées à partir des composantes mères de la variance sont significatives : h_d^2 = 0,32, 0,17, 0,25. L'existence d'une variabilité génétique non additive pour ces caractères conduira à envisager une sélection de souches et leur croisement.

cane pondeuse – Tsaiya brune – caractère économique – paramètre génétique

INTRODUCTION

The estimation of genetic parameters for economically related traits has two main objectives: better understanding of the nature of genetic variation of these traits and optimization selection methods for their improvement. Few studies have been concerned with the estimation of genetic parameters in laying ducks, although Hutt (1952) pointed out that ducks have a high potential for egg production. Duck production is an important branch in the livestock industry of Taiwan, with produces including mule ducks, processed eggs, exported partially incubated eggs and frozen meat (Tai, 1985a). The native breed Tsaiya (*Anas Platyrynchos* var. *domestica*) is the major breed of laying duck. Before 1970, Tsaiya was also the only dam line for a two-way cross mule duck (Muscovy male × Tsaiya female). For centuries, selection in Brown Tsaiya was carried out only by duck farmers. The Duck Research Center of Taiwan Livestock Research Institute (TLRI) started a breeding project of laying ducks in 1984 (Tai, 1985b).

The genetic improvement of laying traits in ducks can include two components: egg production or meat production in a dam line. The purpose of the study reported in this paper is to estimate and to discuss the genetic parameters of some growth and laying traits of Brown Tsaiya in Taiwan.

MATERIALS AND METHODS

Ducks

Two hundred Tsaiya ducks and 60 Tsaiya drakes from four different locations around Taiwan were collected in 1984 and divided into four sire origins. Five hatches derived from 156 ducks and 40 drakes were used in this study. The genetic parameter estimates were obtained from the performance data of 537 female ducklings. Within each sire origin, 10 sires were mated to 2 to 5 dams and each dam had 3 to 5 daughters, with a few cases of only 1 or 2 daughters. The total number of dams for each of the sire origins was 36, 41, 39, 40 and the corresponding number of daughters was 118, 140, 139, 140, respectively. Hence with dams being nested within sires, the genetic relationship structure was hierarchical. While sires were nested within sire origins they were cross-classified with hatches.

Management

Ducklings were raised in brooders until 4 weeks of age, after which they were moved to floor houses with swimming pools ($3 \times 9m^2$). After 16 weeks of age, ducks from the first and second hatches were raised in individual cages with a dimension of ($33 \times 33 \times 33$ cm), while those from the remaining hatches were kept in floor pens (20 ducks per pen). From 4 to 16 weeks of age, ducklings were fed low protein diets (12%) in order to delay the age at first egg and thus reduce the number of small eggs. From 16 weeks of age ducks were fed a pelleted diet containing 19.2% protein and 2 765 kcal metabolizable energy per kg. Water and feed were provided *ad libitum* throughout the experimental period. Light intensity was very low in the floor house to keep the ducks from laying eggs on the playground or swimming pool. The same intensity of light was given to the cage house.

Traits measured

Fifteen traits were recorded on each individual. Growth traits were body weights at 8, 16, 20, 30 and 40 weeks of age. The length of the fourth primary feather was measured at 8 and 16 weeks of age. Egg numbers were recorded from the age at first egg up to 245, 280, and 360 days of age. Egg shell thickness and strength were measured for at least 3 eggs at 30 weeks of age, using FHK (Fujihira Industrial Co., Ltd) shell thickness and strength meters. Five eggs, laid over consecutive days, were weighed at 30 and 40 weeks of age recording the average weight.

Statistical computations

Statistical parameters

The following parameters were calculated for each trait: mean, variance, standard deviation, coefficient of variation. The data were tested for normality.

Estimates of genetic parameters for female duck traits

The following model was used
$$Y_{ijklm} = \mu + h_i + f_j + s_{jk} + d_{jkl} + e_{ijklm}$$
where Y_{ijklm} observation
  μ mean
  h_i ($i = 1$ to 5) hatch effect, fixed
  f_j ($j = 1$ to 4) sire origin effect, fixed
  s_{jk} sire within origin effect, random ($0, \sigma_s^2$)
  d_{jkl} dam within sire, random ($0, \sigma_d^2$)
  e_{ijklm} residual, random ($0, \sigma_e^2$).

Variance components due to sires and dams within sires were estimated by Restricted Maximum Likelihood Estimation (REML) using the SAS procedure for univariate analysis (SAS Institute Inc., 1985). The asymptotic covariance matrix of estimates was obtained.

The heritabilities were calculated from paternal half sib (h_s^2), dam half sib (h_d^2) and from maternal full sib. (h_{s+d}^2) correlations (Falconer, 1960).

The standard errors of these heritability estimates were calculated according to Kendall & Stuart (1969). The variance of the ratio of random variable X_1 and X_2 is given by

$$\text{Var}(X_1/X_2) = \left(\frac{\text{E}(X_1)}{\text{E}(X_2)}\right)^2 \left(\frac{\text{Var}X_1}{\text{E}^2(X_1)} + \frac{\text{Var}X_2}{\text{E}^2(X_2)} + \frac{2\text{Cov}(X_1, X_2)}{\text{E}(X_1)\text{E}(X_2)}\right)$$

for example,

$$\text{Var}\, h_s^2 = 16\, \text{Var} \frac{\sigma_s^2}{\sigma_s^2 + \sigma_d^2 + \sigma_e^2}$$

RESULTS

Table I gives the statistical parameters for the 15 traits measured. Feather length stopped growing at 16 weeks of age, but body weights increased after the age at first egg (126 days), until 30 weeks of age. Means and standard deviations for egg number up to 245, 280 and 360 days of age were 107 ± 13, 139 ± 15, 207 ± 26. Corresponding values were 3.8 ± 0.5 kg/cm^2 for egg shell strength and 0.37 ± 0.02 mm for egg shell thickness at 30 weeks of age. For egg weight at 30 and 40 weeks of age values were 64.2 ± 4.3 g and 67.8 ± 4.3 g, respectively. As measured by coefficient of variation, feather length was highly variable at 8 but not 16 weeks of age. Variability of 8 weeks body wieght was higher than that for body weights at the older ages, and variation of egg number an egg shell strength was similar.

Variation of age at first egg was moderately low as was that of egg shell thickness and egg weight. According to the calculated values of the skewness and kurtosis coefficients (data not shown), most of the traits were normally distributed. Only feather length at 16 weeks showed a highly positive kurtosis and the egg number at 360 days was skewly distributed.

Heritability estimates with standard errors are summarized in Table II. Values for body weights were generally greater than those for egg numbers. Comparisons between paternal and maternal half sib estimates showed the former to be generally larger for body weight and smaller for egg numbers than the latter.

DISCUSSION

Chinese farmers have raised Tsaiya ducks for centuries. These ducks exhibited considerable variation in plumage color ranging from solid black to pure white. Due to the farmers' preference, ducks with light brown plumage were selected and kept as the major variety of Tsaiya. Thus "Brown Tsaiya" became a common name for the local Tsaiya duck (Tai, 1985b). The body weight of Brown Tsaiya at 30 weeks of age (1 397 g) which could be taken as an adult body weight, was similar to those of White Tsaiya (Huang *et al.*, 1983). This weight, however, was less than that of native laying duck in Indonesia (Hetzel, 1984). Tsaiya appears to be the lightest

Table I. Statistical parameters for body weights, feather lenghts, and laying traits.

Trait	Unit	Sample size N	Mean — X	Standard deviation S	Coefficient of variation c.v. (%)
FL 8 W	cm	488	6.9	3.5	49.9
FL 16 W	cm	389	14.9	0.8	5.5
BW 8 W	g	537	997	167	16.7
BW 16 W	g	537	1270	136	10.7
BW 20 W	g	537	1403	133	9.4
BW 30 W	g	537	1397	120	8.6
BW 40 W	g	537	1407	133	9.4
A 1st egg	day	537	126	11	8.7
N eggs 245 D	egg	537	107	13	12.6
N eggs 280 D	egg	537	139	15	10.9
N eggs 360 D	egg	537	207	26	12.4
ES 30	kg/cm^2	536	3.8	0.5	13.5
ET 30	mm	537	0.37	0.02	5.7
EW 30	g	537	64.2	4.3	6.7
EW 40	g	509	67.8	4.3	6.4

FL 8w, 16w: Feather lengths at 8, 16 weeks of age.
BW 8w, 16w, 20w, 30w, 40w: Body weights at 8, 16, 20, 30 and 40 weeks of age.
A 1st egg: Age at first egg: N eggs 245 D, 280 D, 360 D: Number of egg laid up to 245, 280, 360 days of age.
ES 30: Egg shell strength at 30 weeks of age, ET 30: Egg shell thickness at 30 weeks of age. EW 30, EW 40: Egg weight at 30, 40 weeks of age. $ $P < 0.05$ (by sign test; Siegel, 1956)

in body weight and the highest in egg production of small ducks under intensive feeding. Although the records analysed were stopped at 360 days of age in order to study part records and to shorten the generation interval, these ducks can lay on average 240 and 300 eggs per caged bird up to 58 and 69 weeks of age respectively (Rouvier unpublished data). These values are similar to those reported for Alabio, Bali, Tegal and Khaki Campbell ducks under intensive management (Hetzel, 1985). Compared to the Pekin and Muscovy breeds, Tsaiya ducks mature at a young age (average 126 days) and have high egg production to 360 days of age (average 207 eggs). It should be remembered that the Pekin and Muscovy are meat breeds, while the Brown Tsaiya in an egg laying breed.

According to the coefficients of variation there was homogeneity of the traits except for body weight and feather length at 8 weeks of age, which were measured during the growing period. The very high coefficient of kurtosis value for feather length at 16 weeks indicates that most of the values of this trait are the same. The negative skewness and positive kurtosis values for egg number indicated the high average egg laying rate (88% up to 360 days of age) and the limitation of

Table II. Heritability estimates from paternal half sib (h_s^2), dam half sib (h_d^2) and from maternal full sib (h_{s+d}^2) correlations.

Trait sd	$h_s^2 SE$	$h_d^2 SE$	$h_{s+d}^2 SE$
FL 8 W	0.22 ± 0.16	0.40 ± 0.21	0.31 ± 0.10
FL 16 W	0	0.17 ± 0.30	0.09 ± 0.15
BW 8 W	0.46 ± 0.18	0.46 ± 0.17	0.46 ± 0.09
BW 16 W	0.61 ± 0.19	0.34 ± 0.15	0.47 ± 0.09
BW 20 W	0.36 ± 0.15	0.30 ± 0.16	0.33 ± 0.09
BW 30 W	0.51 ± 0.18	0.38 ± 0.16	0.44 ± 0.11
BW 40 W	0.39 ± 0.17	0.55 ± 0.18	0.47 ± 0.09
Age 1st egg	0.18 ± 0.13	0.24 ± 0.17	0.21 ± 0.09
N eggs 245 D	0.02 ± 0.11	0.32 ± 0.18	0.17 ± 0.08
N eggs 280 D	0.12 ± 0.12	0.17 ± 0.16	0.15 ± 0.08
N eggs 360 D	0.14 ± 0.12	0.25 ± 0.17	0.20 ± 0.09
ES 30	0.11 ± 0.12	0.15 ± 0.18	0.13 ± 0.08
ET 30	0.23 ± 0.15	0.27 ± 0.18	0.25 ± 0.09
EW 30	0.32 ± 0.15	0.21 ± 0.17	0.27 ± 0.10
EW 40	0.24 ± 0.13	0.19 ± 0.18	0.21 ± 0.09

Symbols for the traits are the same as in Table I.

the period of observation on egg production. The duck eggs are mainly consumed in processed form such as salted eggs and thousand-years eggs and payment is by number in Taiwan, thus eggs of medium size (66-67 g) are most welcomed by egg dealers, and farmers have selected for this trait for many years. This might explain the low coefficient of variation in egg weight.

Estimates of heritabilities for body weight were moderate to high. Values of h_s^2 ranged from 0.36 ± 0.15 to 0.61 ± 0.19 and of h_d^2 ranged from 0.30 ± 0.16 to 0.55 ± 0.18. This indicated the existence of considerable additive genetic variation for these traits and the absence of maternal effects. Values of h_s^2 were slightly higher than h_d^2, which could be due to some additive genetic variation for sex linked genes. Body weight at 30 weeks of age which could be regarded as adult body weight had a high heritability $(h_{s+d}^2 = 0.44 \pm 0.11)$. These results were not consistent with those of Sochocka & Wezyk (1971) who found higher h_d^2 values than h_s^2 values for growth traits in Pekin females. On the whole, additive genetic variation for egg weights was low, except for weight at 30 weeks of age with heritability estimates of $h_s^2 = 0.32 \pm 0.15$ and $h_{s+d}^2 = 0.27 \pm 0.10$. This implies that body weight and egg weight traits could be improved easily by predicting breeding values and selecting on a within line basis. It is interesting to note that there was no noticeable genetic variation for egg shell strength and feather length at 16 weeks of age. For feather length at 8 weeks of age, that is during feather growth, h_{s+d}^2 was 0.31 ± 0.10.

For laying traits (egg number), dam variance components (σ_d^2) were higher than sire variance components (σ_s^2). While h_s^2 estimates were low, h_{s+d}^2 values were

significant, being respectively for egg numbers up to 245, 280 and 360 days of age, $h^2_{s+d} = 0.17 \pm 0.08; 0.15 \pm 0.08$ and 0.20 ± 0.09. Two explanations could be given. If we suppose no maternal genetic effects and no effects of sex linked genes, $\sigma^2_d - \sigma^2_s$ can be written (Falconer, 1960) as

$$\sigma^2_d - \sigma^2_s = \frac{1}{8}V_{A \times A} + \frac{3}{32}V_{A \times A \times A} + \dots$$
$$+ \frac{1}{4}V_D + \frac{1}{8}V_{A \times D} + \frac{1}{16}V_{D \times D} + \dots$$
$$+ V_{Ec}$$

Here $V_{A \times A}$, $V_{A \times A \times A}$, $V_{A \times D}$, $V_{D \times D}$, are epistatic genetic variances due to the gene interactions among additive × additive, additive × additive × additive, additive × dominance, and dominance × dominance effects,
V_D is the dominance genetic variance, and
V_{Ec} is the variance of common environment. This could be reduced to a minimum according to the experimental design. But a small maternal effect linked to the egg weight could exist.

The presence of non-additive genetic variation for egg laying traits observed in this study suggests that these traits are significantly associated with fitness for this breed. This could be also due to the long term mass selection of this breed by Chinese farmers. According to this interpretation, non-additive genetic variation (dominance and epistasis) exists. Therefore crossbreeding of lines should be applied to improve the laying ability of Tsaiya.

If maternal genetic effects do exist, in the case of additive and dominance genetic

$$\sigma^2_d - \sigma^2_s = \frac{1}{4}V_D + CovAoAm + V_{Am} + V_{Dm} + V_{Ec}$$

variation, for example,
where V_{Am} is additive genetic variance for maternal effects, V_{Dm} is dominance genetic variance, $CovA_oA_m$ is covariance between direct and maternal additive genetic effects. Although $CovA_oA_m$ could be negative, if V_{Am} exists that could make σ^2_d higher than σ^2_s. In that case, within line selection could produce further genetic improvement for the laying traits.

CONCLUSION

Considerable additive gene action existed for growth rate up to maturity and egg weight in the laying duck Brown Tsaiya. Thus these traits might be easily controlled by selection. Body weight at sexual maturity and in adults could be indicated by the body weight at 30 weeks of age where heritability is larger than at 20 weeks of age. Egg weight could be measured at 30 weeks of age according to its genetic variation at that age. There were considerable non-additive genetic variations and maternal genetic variation for egg production traits. Additivity was not evident for egg number up to 245 days of age and appears only after 280 days of age, as in the results from Tai (1985b) with White Tsaiya. The lack of additive genetic

variation may be due to the history of this breed which was selected for increasing egg production for centuries by Chinese farmers. The rate of egg production was high when compared to other duck breeds. Further improvements could be got by within line selection and/or crossbreeding between lines of the Brown Tsaiya breed. It would be useful to study egg number up to 280 days or 360 days of laying.

ACKNOWLEDGEMENT

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