Original article

Estimation of genetic parameters for body weight traits in squab pigeons

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Summary – Seven hundred and two squabs (young pigeons) from 144 pairs of Silver King × White King cross parents were reared by either their genetic or foster parents. Heritabilities were estimated for body weight at hatch, 3d, 1 wk, 2 wk, 3 wk and 4 wk (market age) of age and the values were 0.70, 0.23, 0.22, 0.21, 0.30 and 0.57, respectively. Genetic correlations among these body weight traits ranged from 0.26 to 0.82. Heritability estimates for weekly gains were 0.13, 0.00, 0.12 and 0.05. These estimates indicated that simultaneous genetic improvement of body weight at the different ages would be feasible. Production efficiency could be increased through selection to improve wk 3 body weight so that squabs could be marketed a week earlier than the current practice.

pigeon / heritability / genetic correlations / body weight / weight gain

Résumé – Estimation des paramètres génétiques pour des caractères de poids corporel chez le pigeonneau. *Un total de 702 pigeonneaux obtenus à partir de croisements entre 144 couples Silver King et White King ont été élevés par leurs parents génétiques ou par des parents adoptifs. Les valeurs d'héritabilité ont été estimées pour le poids corporel à différents âges: à la naissance; 3 jours; 1 semaine; 2 semaines; 3 semaines; et 4 semaines (âge à la mise sur le marché). Les estimées sont respectivement: 0,70, 0,23, 0,22, 0,21, 0,30, et 0,57. Les corrélations génétiques entre ces mesures du poids corporel varient entre 0,26 et 0,82. Les héritabilités estimées pour les gains de poids hebdomadaires sont 0,13, 0,00, 0,12 et 0,05. Ces résultats indiquent que des améliorations génétiques simultanées du poids corporel à différents âges sont possibles. Une augmentation de l'efficacité de production pourrait être obtenue par sélection afin d'améliorer le poids corporel à 3 semaines, ce qui permettrait de diminuer d'une semaine l'âge auquel les pigeonneaux peuvent être vendus sur le marché.*

pigeonneau / héritabilité / corrélation génétique / poids corporel / gain de poids

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INTRODUCTION

Pigeons are widely used as experimental models in biomedical research and have also been raised for meat production. Commercial squab (young pigeon) production has existed in North America since the early 1900s (Levi, 1974; Stanhope, 1978) and annual production is over one and half million squabs in the United States and Canada (Cheng, 1986). Unlike other poultry species, pigeons form pair bonds to breed and hatchlings must be brooded and fed by their parents until the market age of 4 wk (Levi, 1974). A pair of pigeons can raise about 15 squabs per year. Although meat from squabs is produced commercially, information regarding breeding techniques and advances is lacking. No concentrated effort in selection to improve the efficiency of production (in terms of the number of squabs produced by a breeding pair) has been made since Australia's Squab Production Tests of the early 1930s (Dark, 1973).

Cheng and Yelland (1988) provided the first heritability estimates for squab body weights at different ages using variance components and regression analysis. Their data suggested that parental and seasonal factors affected squab body weight, but they neither corrected their estimates for seasonal and other environmental factors nor estimated genetic correlations among the traits. In the present study (reported on briefly by Aggregy and Cheng, 1991), we used the same pigeon population of Cheng and Yelland (1988). In an attempt to separate the environmental effect of the parents from the additive genetic variance, a cross-fostering scheme was carried out to estimate heritabilities and correlations of body weight traits in squabs from hatch till 4 wk of age.

MATERIALS AND METHODS

The squabs used in this study were the progeny of White King by Silver King cross parents. Such a cross was made in an attempt to develop an autosexing system (Cheng, 1986). Silver and White Kings are 2 strains of the same breed, differing in only a few loci that affect plumage colour, and both have similar performances and selection policy under the standards established by The American King Club (Levi, 1974; PJ Marini, Nicholas Breeding Farms, Sonoma, CA, USA; personal communication). Our F_2 performance data can therefore be treated as providing estimates of purebred parameters.

There were 144 pairs of breeders. Each pair of breeders were housed in a 61 cm × 61 cm × 46 cm wire cage provide with 2 nests. They were fed *ad libitum* on a commercial pelleted diet containing 17% protein and added crushed oyster shells. Eggs were taken away from the parents after a complete clutch (2 eggs) was laid and replaced with wooden dummy eggs for the parents to complete incubation. Eggs were hatched artificially throughout the year and newly hatched squabs were placed either under their own parents or with foster parents at the same stage of incubation. The squabs were weighed at hatch, 3 d, 1 wk, 2 wk, 3 wk and 4 wk post-hatch.

Data on progenies from different clutches of the same parents were used and corrected for various fixed effects.

Statistical analysis

The data were analyzed according to the following model:

$$Y_{ijklm} = \mu + \alpha_i + F_j + B_k + S_1 + (\alpha F)_{ij} + E_{ijklm}$$

where Y_{ijklm} is the weight or weight gain (g) of the mth progeny in the $ijklh$ class; μ is the overall mean; α_i is the random effect of the ith mating pair; F_j is the fixed effect of the jth foster parent; B_k is the fixed effect of the kth clutch; S_1 is the fixed effect of the lth season in which the squab was hatched; E_{ijklm} is the random error. Variance components were estimated using the variance component procedure (PROC VARCOMP) of the SAS Institute (1985) computer package. Heritabilities (h^2) were estimated by:

$$h^2 = \frac{2\sigma_\alpha^2}{\sigma_p^2}$$

where σ_α^2 is the between matings variance component and σ_p^2 is the phenotypic variance component. Progeny from mating pairs are full sibs. The between mating pair component (σ_α^2) includes the variance due to genetic differences in body weight or weight gain among full sibs 50% of the additive genetic variance and 25% of the dominance genetic variance) (Cockerham, 1954). In addition, this component includes the variance resulting from the influence of preoviposition environment provided to the fertilized egg by the dam. Much of such influence can be classified as genetic with regard to the dam, but is classified as environmental from the standpoint of the young squab.

Standard errors (SE) of the h^2 were estimated by:

$$SE(h^2) = 2\sqrt{\frac{2(n-1)(1-t)^2(1+(k-1)t)^2}{k^2(n-s)(s-1)}}$$

as indicated by Becker (1984), where n is the total number of individuals; t is the intraclass correlation; k is the coefficient of the between matings variance component and s is the number of matings.

Correlations (r_{xy}) were estimated by:

$$r_{xy} = \frac{\text{Cov}(x,y)}{\sqrt{\text{var}(x)\text{var}(y)}}$$

where r_{xy} is the estimate of genetic or phenotypic correlation; $\text{Cov}(x,y)$ is the genetic or phenotypic covariance between traits x and y, and $\text{var}(x)$ and $\text{var}(y)$ are the estimated genetic or phenotypic variances of traits x and y, respectively.

Standard errors for genetic correlations (r_g) were calculated by an approximation formula given by Robertson (1959).

Thus:

$$SE(r_g) = \frac{1 - r_g^2}{\sqrt{2}} \sqrt{\left[\frac{SE(h_x^2)SE(h_y^2)}{h_x^2 h_y^2} \right]}$$

where r_g is the genetic correlation between traits x and y.

RESULTS

Morphological techniques for sexing squabs are not reliable so the body weights and weight gains reported are not differentiated by sex. Overall means, phenotypic standard deviations (σ_p) and heritability estimates of body weight and weight gain at different ages are presented in table I. Variability in body weight is $\approx$ 12% on day of hatch and increases to 32% at 3 d of age, it then declines gradually to $\approx$ 11% at 4 wk of age. Variability in weight gain during the lst wk is $\approx$ 28%, declines to $\approx$ 19% at wk 2, and then increases to $\approx$ 40% at wk 3. The weight gain from 3–4 wk is not significantly different from 0. The heritability estimates for body weights were generally higher than estimates for weight gains. The genetic and phenotypic correlations estimated from the full sib components of variance for body weights and weight gains are presented in tables II and III respectively.

Table I. Means, phenotypic standard deviations (σ_p) and heritability estimates of body weight and weight gain at different ages.

Squab age	Body wt (g)	σ_p	$h^2 \pm SE$
Hatch	16.34	1.93	0.70 ± 0.09
3 d	56.02	17.75	0.23 ± 0.07
1 wk	169.88	43.44	0.22 ± 0.08
2 wk	394.46	64.50	0.21 ± 0.08
3 wk	516.27	63.04	0.30 ± 0.08
4 wk	544.92	59.57	0.57 ± 0.09
Age period	Weight gain (g)		
0–1 wk	150.29	42.53	0.13 ± 0.06
1–2 wk	222.18	42.09	0.00 ± 0.12
2–3 wk	118.41	47.76	0.12 ± 0.06
3–4 wk	27.17	44.20	0.05 ± 0.10

Genetic correlations among the body weight traits range from 0.26 to 0.80. Phenotypic correlations between hatch weight and later body weight were all low and r_p among body weight traits from 3 d of age till 4 wk ranged from 0.38 to 0.89. Both phenotypic and genetic correlations among the different weight gains were either zero or negative ranging from −0.23 to −0.49.

Table II. Genetic correlation with *SE* (above diagonal) and phenotypic correlations of body weight at different ages.

	Hatch	*3 d*	*1 wk*	*2 wk*	*3 wk*	*4 wk*
Hatch		0.47 ± 0.11	0.35 ± 0.13	0.28 ± 0.14	0.34 ± 0.12	0.26 ± 0.09
3 d	0.32		0.66 ± 0.14	0.56 ± 0.17	0.47 ± 0.16	0.33 ± 0.14
1 wk	0.21	0.68		0.82 ± 0.09	0.64 ± 0.13	0.46 ± 0.13
2 wk	0.14	0.56	0.73		0.77 ± 0.09	0.60 ± 0.11
3 wk	0.15	0.41	0.89	0.71		0.80 ± 0.05
4 wk	0.12	0.26	0.38	0.57	0.72	

Table III. Genetic correlation with *SE* (above diagonal) and phenotypic correlations of weight gain at different ages.

	0–1 wk	*1–2 wk*	*2–3 wk*	*3–4 wk*
0–1 wk		0.00 ± 0.00	−0.24 ± 0.32	−0.23 ± 0.91
1–2 wk	0.00		0.00 ± 0.00	0.00 ± 0.00
2–3 wk	−0.36	0.00		−0.49 ± 0.54
3–4 wk	−0.25	0.00	−0.28	

DISCUSSION

The hatching weight of squabs was relatively constant with a high heritability probably due to the common preovipositional maternal variance (egg size). The heritability estimate for body weight at 3 wk was similar to the estimate reported by Cheng and Yelland (1988). However heritability estimates for body weight at 3 d, 1 wk, and 2 wk of age were higher (0.23, 0.22 and 0.21 compared to 0.14, 0.04 and 0.16), and estimates for body weight at hatch and 4 wk were lower (0.70 and 0.57 compared to 0.74 and 0.65) than those calculated by Cheng and Yelland (1988) using full sib variance components. Cheng and Yelland (1988) reported that heritabilities estimated by regression (progeny on mid-parent) for squab weights to 1 wk were zero but after 1 wk of age their values estimated from regression and from full sib components were similar.

Heritabilities estimated from covariance of full sibs are biased by one quarter of the dominance variance and the common environmental variance. Hatchlings from precocial species such as chickens can be reared independently of the parents, but the young of pigeons (altricial) are dependent on their parents, causing resemblance of full sibs. The cross fostering experiment was designed to minimize the bias of the full sib covariance caused by common nest environment and post-hatch parental effects. Pigeons form pair bonds, so that designing a mating system to provide substantial numbers of half sibs to estimate heritability from the sire component of variance is difficult. It is not possible under the present model to divide the σ_α^2 into additive genetic variance, dominance genetic variance and variance due to preoviposition environment. On the other hand, in broiler chicks, Pinchasov (1991) reported that the high initial correlation between egg weight and chick

weight decreased markedly after hatch and was not significant by 5 d after hatching. Similarly, as the age of the squab increases, the preovipositional maternal effect on body weight may become insignificant compared to the effect of the genotype.

Additive genetic variances associated with body weight from 3 d of age to 2 wk were low, indicating that the r_p between body weight traits until 2 wk resulted primarily from environmental causes. The parental ability to raise squabs for the first 2 wk is vital. Breeding pigeons are more sensitive to environmental changes than chickens (Cheng, personal observation), so disturbances during the first 2 wk of brooding should be kept to a minimum. Selection to improve parenting traits, if these traits are heritable, should be important and their genetic correlations with squab growth should be examined. After 2 wk of age, additive genetic variance was associated with body weight increases, indicating that after this age the body weight of squabs is influenced by their own genotype.

Genetic correlations are important for determining the genetic relationship between body weights at different ages. Estimates of r_g between weight at hatch and weight at ages 2–4 wk were low and suggest that squab hatch weight is a poor indicator of later body weight. As pointed out by Abdellatif (1989), hatch weight must therefore be considered a separate trait. The relatively high heritability for 4 wk body weight, low heritabilities for weight at other ages, and the low or negative genetic correlations among weight gains for different periods could indicate that squabs are opportunistic growers having the genetic potential to make compensatory gains whenever conditions are favourable.

The relatively higher heritabilities of body weights late in this trial indicate that genetic gains could be made through selection allowing squabs to reach market weight earlier than 4 wk, which would shorten the recycling time for parents.

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