GENETIC PARAMETERS FOR FEATHER WEIGHTS OF BREEDING OSTRICHES

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SUMMARY

After the initial decline in value, ostrich feathers have become an integral part of the remuneration of ostrich producers. Categorised (according to the location where it was harvested) mature square-root transformed feather weights depended on gender (males having a 20% higher total feather weight than females) and genotype (South African Black ostriches having a 34% higher total feather weight than Zimbabwean Blues). Animal age interacted with gender, the difference between males and females diminishing from 10 years of age, with no significant gender difference in birds of 11+ years. Heritability estimates of categorised feather weights were low to moderate, and high at 0.30 ± 0.06 for total feather weight. The corresponding value for animal permanent environment amounted to 0.08 ± 0.04. Genetic correlations between categorised feather traits were moderate (0.54 ± 0.16) to very high (0.90 ± 0.10). The present results indicate that feather quantity can be improved by selection in ostriches.

INTRODUCTION

Ostrich farming started between 1857 and 1864 as a commercial enterprise in South Africa (Smith 1963) and has been an important contributor to the agricultural economy of South Africa for the past 150 years. Initially, ostrich feathers were the main commercial product and were highly prized by the European fashion industry. During the First World War between 1914 and 1918 the South African ostrich feather industry collapsed (Smith 1963). During the following years the ostrich industry recovered, but the skin and meat became the more dominant sources of income. Research on the improvement of the quality or quantity of ostrich feathers was thus discontinued. Swart *et al.* (1984) assessed the impact of feather quality traits on price determination in the marketplace, but no scientific selection programmes were implemented as a result. The objective of this study was thus to estimate environmental and genetic parameters influencing quantitative ostrich feather traits.

MATERIAL AND METHODS

The experimental population used for the study (2001-2006) was the commercial, pair-bred ostrich flock at the Oudtshoorn Research Farm in the Klein Karoo region of South Africa. The origin of the flock and the general management procedures implemented has been described previously (Bunter & Cloete 2004). During 2003, Zimbabwean Blue (ZB) breeders were introduced to the flock (Cloete *et al.* 2008). The flock consisted of 188 breeding pairs and the age of breeder birds in the flock ranged between 2 and 11+ years. The annual breeding season usually lasted for about eight months (from June to January of the following year) followed by a four month rest period. During the annual resting period, feathers were harvested, sorted, categorized and weighed, ensuring repeated animal-year records for the mature breeding birds in the flock at that stage. The feather categories considered were the 6 feather types harvested from the ostrich, namely, floss (one row of soft downy feathers under the wing), short hard body feathers (feathers in the centre of the dorsal surface of the wing just before long hard feathers), long hard body feathers (second and third row of shorter feathers on the outer edge of the wing), tail feathers, white plumes (first row of prominent plumes at the edge of the wing), and short body floss (feathers under the wing and on the front and behind of the thigh). Separate weights for the categories of feathers were summed to obtain a total feather weight (TFW) for each bird. All feather weights were extremely variable, with coefficients of variation ranging from 32.3 to 58.9%. The data were therefore subjected to a square root transformation to stabilise the variance.

The data were subjected to single-trait genetic analyses, using ASREML software (Gilmour *et al.* 1999). Fixed effects that were considered included the two genotypes (SAB or ZB), gender (male or female), and breeder age (2 – 11+ years). Repeated records pertaining to each animal were accommodated by fitting direct additive animal (related to the data by the numerator relationship matrix) and animal permanent environment (related to the data by an identity matrix) as random effects. Subsequently, a six-trait animal model was fitted, involving the different feather categories as traits. TFW was excluded from this analysis, as it is a function of the weight of the other categories of feathers.

RESULTS AND DISCUSSION

Table 1 shows considerable variation for each of the 7 square root transformed feather weight traits, with coefficients of variation ranging from 17.3% to 31.3%. The geometric mean for TFW amounted to 615g, with a coefficient of variation (CV) of 17.3%. No comparable estimates for feather weights of ostriches were found in the literature.

Table 1. Descriptive statistics for square root transformed feather traits of breeding ostriches for the 2001 – 2006 production years

Traits	Number of records	Raw mean ± SD	CV (%)	Kurtosis	Skewness
Floss (g)	1429	4.31 ± 1.35	31.3	-0.36	0.08
Short hard bodies (g)	1673	11.5 ± 2.5	21.7	0.09	-0.12
Long hard body (g)	1734	9.39 ± 2.39	25.5	-0.05	0.01
Tail (g)	1676	9.08 ± 2.23	24.6	0.00	-0.08
White plumes (g)	1729	13.9 ± 2.4	17.3	0.46	-0.57
Short body floss (g)	1632	11.1 ± 2.4	21.6	0.30	-0.20
Total (g)	1782	24.8 ± 4.3	17.3	1.18	-0.41

SD, standard deviation; CV%, coefficient of variation

With the exception of floss and tail feathers, the weights of all feather types were ($P<0.05$) heavier for males than for females (Table 2). This resulted in a 20% higher TFW for males relative to females (respective geometric means being 600 vs. 501g respectively). The weights for all the different feather traits were higher ($P<0.05$) for SAB breeders compared to ZB breeders, long hard body plumes being the only exception. Overall, TFW of SAB breeders exceeded that of ZB breeders by 34%. Geometric means for TFW in the two genotypes amounted to 635g for the SAB genotype, compared to 475g in the ZB genotype. Gender and animal age were found to interact ($P<0.05$) for the respective categories of feather weights. Males produced a greater quantity of feathers up to an age of 10 years, where after the gender difference was reduced to a tendency ($P<0.10$).

The results of single-trait analyses for the categorised feather weights are provided in Table 3. The heritability estimate (h^2) for long hard body feathers were moderate at 0.20 ± 0.05, while the h^2 of the rest of the feather weights were low to moderate, ranging between 0.11 ± 0.05 and 0.16 ± 0.05. All these h^2 estimates were significant (at least double the corresponding SE). The h^2 estimate of TFW was fairly high at 0.30 ± 0.06.

Table 2. Least-squares means (± SE), depicting the effects of gender and genotype on the weight of different categories of square root transformed feather traits of breeding ostriches for the 2001 – 2006 production years ([a,b] depict differences between gender groups or genotypes; P<0.05)

Traits	Gender		Genotype	
	Males	Females	SAB	ZB
Floss (g)	4.19 ± 0.26	3.90 ± 0.15	4.40 ± 0.9[a]	3.80 ± 0.14 [b]
Short hard bodies (g)	11.8 ± 0.41[a]	10.4 ± 0.2[b]	11.8 ± 0.1[a]	10.7 ± 0.2[b]
Long hard body (g)	9.70 ± 0.43[a]	8.69 ± 0.25[b]	9.37 ± 0.17	9.10 ± 0.21
Tail (g)	8.69 ± 0.43	8.31 ± 0.26	9.26 ± 0.16[a]	7.78 ± 0.22[b]
White plumes (g)	13.6 ± 0.5[a]	12.6 ± 0.3[b]	14.1 ± 0.2[a]	12.0 ± 0.2[b]
Short body floss (g)	11.2 ± 0.4[a]	10.1 ± 0.2[b]	11.4 ± 0.2[a]	9,8 ± 0.2[b]
Total (g)	24.5 ± 0.7[a]	22.4 ± 0.5[b]	25.2 ± 0.3[a]	21.8 ± 0.4[b]

These results indicate that genetic improvement can be achieved in ostrich feather weights. The only previous indication that feather quantity may respond to selection come from Louw and Swart (1982). The latter authors reported that the number of wing quills had a heritability of 0.24. Animal permanent environment (pe^2) accounted for a proportion of between 0.08 and 0.22 of the phenotypic variation associated with the respective categories of feather weights.

Genetic parameters from the six-trait analysis are presented in Table 4. Estimates of h^2 for the weight of all categories of feathers were generally somewhat higher compared to those estimated from single-trait analyses, at the expense of animal permanent environment. It is reasonable to expect that the other categorised feather weights in a multi-trait analysis would contribute to a better partitioning of h^2 and pe^2 effects. Genetic correlations (r_g) among all categorised feather weights were moderate to very high and ranged from 0.54 ± 0.16 to 0.90 ± 0.10. Permanent environmental correlations were mostly lower than genetic correlations, while environmental correlations resembled genetic correlations in sign, but were considerably lower in magnitude.

Table 3. Estimated variance components and ratios (± SE) of the different square root transformed feather weight traits as derived from single-trait analyses of mature breeding ostriches for the 2001 – 2006 production years

Traits	σ^2_a	σ^2_{pe}	σ^2_e	h^2	pe^2
Floss (g)	0.166	0.331	1.029	0.11 ± 0.05	0.22 ± 0.05
Short hard bodies (g)	0.581	0.475	3.049	0.14 ± 0.05	0.12 ± 0.04
Long hard body (g)	0.858	0.503	3.042	0.20 ± 0.05	0.11 ± 0.04
Tail (g)	0.669	0.841	2.845	0.15 ± 0.05	0.19 ± 0.05
White plumes (g)	0.726	0.847	3.007	0.16 ± 0.06	0.19 ± 0.05
Short body floss (g)	0.686	0.691	2.877	0.16 ± 0.05	0.16 ± 0.05
Total (g)	4.012	1.081	8.181	0.30 ± 0.06	0.08 ± 0.04

σ^2_a, direct additive variance component; σ^2_{pe}, female permanent environmental variance component; σ^2_e, environmental (residual) variance component; h^2, direct heritability; pe^2, animal permanent environment

CONCLUSION

Results from this study confirm that feather quantity in ostriches is heritable, and would respond to directed selection if desired. Moderate to high genetic correlations indicate that selection for specific categories of feathers are likely to result in correlated responses in other categories. However, below unity genetic correlations suggest that feather weights on different body parts may not always be the same genetic trait. Further investigations are needed to assess the genetics of ostrich feather quality traits.

Table 4. Estimates (± SE) of heritability (*h^2*), animal permanent environment (*pe^2*) (in bold letters) as well as genetic, permanent environmental and environmental correlations (in normal print) among square root transformed feather weight traits, as derived from a six-trait analysis

Traits	Traits	r_g	r_{pe}	r_e
Floss (g)	Floss (g)	**0.16 ± 0.05**	**0.12 ± 0.05**	
	Short hard bodies (g)	0.73 ± 0.14	0.19 ± 0.26	0.35 ± 0.03
	Long hard body (g)	0.54 ± 0.16	-0.04 ± 0.54	0.28 ± 0.03
	Tail (g)	0.73 ± 0.14	0.03 ± 0.25	0.18 ± 0.03
	White plumes (g)	0.74 ± 0.14	-0.15 ± 0.40	0.24 ± 0.03
	Short body floss (g)	0.54 ± 0.18	0.40 ± 0.23	0.24 ± 0.03
Short hard bodies (g)	Short hard bodies (g)	**0.16 ± 0.04**	**0.10 ± 0.04**	
	Long hard body (g)	0.73 ± 0.12	0.74 ± 0.50	0.13 ± 0.03
	Tail (g)	0.74 ± 0.13	0.12 ± 0.25	0.21 ± 0.03
	White plumes (g)	0.73 ± 0.12	0.11 ± 0.37	0.24 ± 0.03
	Short body floss (g)	0.87 ± 0.10	0.67 ± 0.18	0.31 ± 0.03
Long hard body (g)	Long body floss (g)	**0.21 ± 0.05**	**0.03 ± 0.04**	
	Tail (g)	0.82 ± 0.10	0.08 ± 0.46	0.20 ± 0.03
	White plumes (g)	0.66 ± 0.12	0.99 ± 0.62	0.20 ± 0.03
	Short body floss (g)	0.81 ± 0.11	0.23 ± 0.43	0.25 ± 0.03
Tail (g)	Tail (g)	**0.20 ± 0.05**	**0.14 ± 0.06**	
	White plumes (g)	0.90 ± 0.10	-0.30 ± 0.41	0.07 ± 0.03
	Short hard bodies (g)	0.74 ± 0.14	0.27 ± 0.21	0.16 ± 0.03
White plumes (g)	White plumes (g)	**0.22 ± 0.05**	**0.07 ± 0.04**	
	Short body floss (g)	0.65 ± 0.14	0.35 ± 0.29	0.14 ± 0.03
Short body floss (g)	Short body floss (g)	**0.18 ± 0.05**	**0.13 ± 0.05**	

r_g, genetic correlation; r_{pe}, permanent environmental correlation, r_e, residual correlation

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