SELECTION INDEXES FOR HEAVIER MARKETING BODY WEIGHT AND ADVANTAGEOUS BODY COMPOSITION IN FAYOUMI CHICKENS

By

A.R. Shemeis; A. Galal[*] and H.H. Younis[**]

Department of Animal Prod., Fac. of Agric., Ain Shams Univ., Cairo, Egypt
[*]Department of Poultry Prod., Fac. of Agric., Ain Shams Univ., Cairo, Egypt
[**]Department of Poultry Prod., Fac. of Agric., Kafer Al-Sheikh Univ., Egypt

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Abstract: *Genetic and phenotypic parameters for live performance and slaughter traits were estimated from data on 306 Fayoumi chicks progeny of 15 males and 100 hens using multiple-trait animal model including the fixed effects of hatch and rearing season and the random effects of direct genetic. The estimated parameters were used to construct seven selection indexes aiming to maximize the profit of the poultry breeder. The aggregate genotype traits were marketing body weight and dressing percentage. The full index traits were body weight (BW), shank length (SL), wattle length (WL) and comb length (CL) at marketing age (16wks). The full index had the highest correlation with the true breeding value (r_{TI} = 0.65). In predicting the true breeding value, it seems more accurate to use BW (r_{TI} = 0.56) rather than SL (r_{TI} = 0.43), WL (r_{TI} = 0.46) and CL (r_{TI} = 0.23). Accuracy of selection expected from use of the BW and WL index is almost the same as from the full index. Use of the index I_5 = 0.25 BW + 49.09 WL (r_{TI} = 0.63), should result in birds with heavier body weight at marketing (+81 gm) and lower carcass yield (-0.61 % unit).*

It is possible to prevent the genetic deterioration in carcass yield via use the restricted form of the full index ($I_{1(DP)}$ = 0.05 BW + 65.89 SL + 75.59 WL – 73.38 CL). As compared with its unrestricted form, the use of $I_{1(DP)}$ would cost 12% reduction in accuracy of selection and 25% reduction in the genetic gain in body weight at marketing.

INTRODUCTION

Dressing percentage is the most valuable trait in meat producing animals and birds. Poultry production and processing technologies have become rapidly accessible and are being implemented on a worldwide basis, which will allow continued expansion and competitiveness in this meat sector (Aho, 2001). Therefore, the success of poultry meat production has been strongly related to improvements in growth and carcass yield, mainly by increasing breast proportion and reducing abdominal fat. Intensive selection in meat-type chickens for improving growth and lasted more than 50 yr has increased growth rate but rapid growth has been accompanied by a number of negative consequences, including an increase in fat deposition (Griffin, 1996). The possibility of genetically improving carcass quality by selection depends on the genetic co-variability of BW and body composition. Body composition can be significantly improved by selection, as shown by the level of breast muscle heritability ranging from 0.53 and 0.65 in the studies of Vereijken (1992), Le Bihan-Duval et al. (1998, 1999), and Rance et al. (2002). For abdominal fat, heritability ranges between 0.50 and 0.80 (Chambers, 1990; Griffin et al., 1991; Le Bihan-Duval et al., 1998; Rance et al., 2002). Abdominal and subcutaneous fat are being regarded as the main sources of waste in the slaughterhouse. Because abdominal fat is highly correlated (0.6 to 0.9) with total carcass lipids, it is used as the main criterion reflecting excessive fat deposition in broilers (Chambers, 1990). Havenstein et al. (2003) reported that fat in broiler (at 43 d of age) accounts for as much as 10 to 15% of the total carcass weight. Therefore, there is substantial potential to improve feed efficiency and carcass quality by further reducing fatness.

Indigenous chickens are well adapted to the adverse climatic conditions of the tropical environment. They have a highly conversed genetic system, with high levels of heterozygosity, which may provide biological material for the design of genetic stocks with improved adaptability and productivity (Wimmers et al., 2000). Also, Egyptian chicken breeds were not subjected to intensive selection program and consequently, high additive and non-additive genetic variations are expected in them (Iraqi et al., 2000). However, these breeds had lower growth rate, poor feed efficiency and lower meat yield. The ultimate objective of the present study was to construct selection indexes to improve Fayoumi chickens marketing body weight and their dressed carcass percentage.

MATERIALS AND METHODS

Genetic groups and management

One hundred Fayoumi hens were artificially inseminated with fresh semen collected from 15 cocks of the same breed. Fertile eggs from individual sire-dam families were collected over consecutive three 7-d periods. A total number of 306 males were used in this study. All chicks were pedigree wing-banded at hatch and brooded in electrical brooding batteries. At 3 weeks of age, the birds were housed on floor pens until the end of the experiment. All chicks were reared under similar environmental, managerial and hygienic conditions. Feed and water were provided *ad libitum*. They were fed a diet containing 20% CP and 2850 kcal ME/kg diet from 0 to 8 weeks of age, then they fed diet added 18% CP and 3000 kcal ME/kg diet. After brooding period (3 wks), the average maximum and minimum ambient temperatures recorded during the experimental period in side the house were 31.6 and 28.7C, respectively.

Measurements and observations

At 16 weeks of age, body weights, shank length and head appendages (comb and wattle) were individually recorded for all chicks. The length of shank was measured from the top of hock joint to the foot bad using a digital caliper and head appendages were measured using a measuring tape as a distance between the upper and the lower point of the organs. A total number of 306 males were randomly assigned to carcass evaluation. They were sacrificed by severing jugular vein and carotid arteries and blood weight was calculated as the difference in body weight before and after bleeding, feather was manually removed after scalding at a 60C for approximately 2 min. The carcasses were then reweighed to calculated feather weight by difference. Thereafter, they were processed by removing the head, shank and feet and eviscerated by removing the viscera without disturbing the fat pad along the abdominal fat wall. Carcasses, non-visceral (blood, head, feathers shanks and feet) and visceral (alimentary tract) offal components and giblets were weighed and expressed as a percentage of live body weight before slaughtering.

Traits considered

Live performance traits considered in the study were body weight (MBW) and lengths of shank (SL), wattle (WL) and comb (CL) at marketing (16 weeks of age). At slaughtering, the weight non-visceral offals (feathers, head, feet and blood), giblets (liver, heart and gizzard), abdominal fat and dressed carcass were recorded for each bird.

Estimation of genetic and phenotypic parameters

The genetic and phenotypic parameters of live performance and slaughter traits were estimated from the additive direct components of variance and covariance using the following multi-trait animal model using the DF-REML Computer Program of Meyer (1998):

$$\mathbf{y = Xb + Za + e} \ ,$$

where:

y	=	the vector of observations of all traits:
b	=	the vector of fixed effects (hatch= 3 periods);
a	=	the vector of random additive direct genetic effects;
X and Z	=	known incidence matrices relating observations to the respective the fixed and random effects; and
e	=	the vector of random residual effect.

Aggregate genotype. This was defined as:

$$\mathbf{T = a_1 g_{MBW} + a_2 g_{DP}} \ ,$$

where:

g_{MBW}	=	the additive genetic value for marketing body weight, recorded before the morning feeding and expressed in g;
g_{DP}	=	the additive genetic value for dressed carcass percentage estimated as 100*hot carcass weight/marketing body weight; and
a_1 and a_2	=	the relative economic weights for the marketing body weight and dressed carcass percentage.

The economic weights for marketing body weight and dressed percentage were estimated as the changes in net income with 100 gram increase in marketing body weight at constant dressed carcass percentage and with 0.01 unit increase in dressed carcass percentage at constant marketing body weight. The estimation of changes in net income was based on a current local marketing price per kg dressed carcass of L.E. 12 and a current carcass yield of 60 percent. The other traits were included in the aggregate genotype with zero economic value to calculate their response to selection.

Selection index

Sources of information (MBW, SL, WL and CL) were used in different combinations to construct ten selection indexes (Cunningham et al., 1970).

RESULTS AND DISCUSSION

Heritabilities: Heritability estimates (h^2) for live performance and body composition are given in Table 1. Generally, body composition traits of the Fayoumi chicks at 16 weeks of age were more heritable than live performance traits (h^2 = 0.22 to 0.83 vs. 0.20 to 0.48). In agreement with the results obtained on 16-week old naked neck chickens by Galal (2000), the present study showed that body weight and length of shank seem to be more heritable (h^2 = 0.36 and 0.48, respectively) than lengths of comb (0.25 and 0.20, respectively) and wattle (h^2 = 0.18 and 0.21, respectively). Fathi et al. (2003) gave much higher heritability estimates for 16-week body weight of naked neck (0.60) and normally feathered (0.53) cocks. It appeared that the heritability estimate of dressing percentage of Fayoumi (h^2 = 0.58, Table 1) and naked neck golden Montazah (0.53, Fathi et al., 2003) chickens were comparable to those of abdominal fat content (0.65, Table 1; 0.62, Fathi et al, 2003). These values were much higher than those obtained for giblets content (0.22 Table 1; 0.21, Fathi et al., 2003).

Correlations: Genetic and phenotypic correlations between live performance and slaughtering traits are presented in Table 2. The live performance traits were positively intercorrelated genetically (r_G = 0.49 to 0.90) and phenotypically (r_P = 0.22 to 0.73). Genetically, they were negatively correlated with dressing percentage (-0.18 to -0.83) and giblet percentage (-0.04 to -0.77) and positively correlated with external offal's percentage (0.13 to 0.77) and abdominal fat percentage (0.42 to 0.98). These results indicate that selection for heavier BW or longer length of shank, wattle and comb at 16 weeks of age is expected to result in developing birds with unfavorable body composition in terms of less dressing percentage, higher content of external offal's and abdominal fat content. The sign and magnitudes of the genetic correlations obtained in the present study between body weight and its contents in terms of carcass and giblets (r_G = -0.44 and -0.64, respectively) were in disagreement with those obtained by Fathi et al.(2003) on naked neck (r_G = 0.50 and 0.37, respectively) and normally feathered (r_G = 0.63 and 0.28, respectively) Golden Montazah chickens. However, both studies are in agreement regarding the relationship between

body weight and its abdominal fat content (r_G = 0.83, Table 1; 0.73, Fathi et al., 2003).

Indexes: Table 3 gives for each index the b-value, the standard deviation and accuracy of selection together with the relative efficiency in relation to the full index. The maximum accuracy of selection (r_{TI} = 0.65) was obtained using the full index (I_1) including the four sources of information. Dropping marketing body weight from the full index to formulate I_2 was associated with greater reduction in accuracy of selection than dropping the head appendages (lengths of wattle and comb) to formulate I_4 (r_{TI} = 0.59 vs. 0.63). Examining the single trait indexes (alternative iii) indicating that marketing body weight (I_6) seems to be more accurate than lengths of shank (I_7), wattle (I_8) and comb (I_9) in predicting the true breeding value (r_{TI} = 0.56 vs. 0.23 to 0.46). This is due to its presence in the aggregate genotype. Due to its strong genetic relationship with marketing body weight (r_G = 0.90) and its low genetic antagonism with dressing percentage (r_G = -0.18), selection based on length of shank alone appears to be more accurate (r_{TI} = 0.46) than that based on lengths of wattle (r_{TI} = 0.43) and comb (r_{TI} = 0.23). In improving the accuracy of prediction, combining body weight and shank length into one index (I_4) is expected to be more efficient than combining marketing body weight and wattle length (I_5) (r_{TI} = 0.63 vs. 0.57).

Expected Response: The expected responses in marketing body weight and its components when the selection based on the most accurate indexes was applied are given in Table 4. Selection based on all indexes is expected to develop birds having heavier marketing body weight (70 to 81 gm), longer shanks (0.11 to 0.12 cm), wattle (0.21 to 0.33 cm) and comb (0.14 to 0.17 cm) and disadvantageous body composition in terms of less carcass yield (-0.47 to -0.61 unit), less giblet content (-0.04 to -0.08 % unit) and higher abdominal fat content (0.19 to 0.20 % unit). It is possible to prevent this deterioration in body composition by restricting the full index to zero genetic change in dressing percentage ($I_{1(DP)}$). As compared to its unrestricted form (Full index), selection based on ($I_{1(DP)}$) is expected to develop birds having relatively lighter body weight at marketing (-25%) and better body composition in terms of low proportions of external offal's (-

0.44 vs. -0.10 %) and abdominal fat (0.14 vs. 0.19%) and higher proportion of giblets (-0.01 vs. -0.04%). This will cost 12% reduction in accuracy of selection.

It could be concluded that the use of body weight (BW) and shank length (SL) taken at marketing as sources of information in the selection index:

$$I_1 = 0.25\ BW + 49.09\ WL \qquad (r_{TI} = 0.63),$$

would be recommended to optimize selection for the given aggregate genotype provided some reduction in dressing percentage (-0.61 unit) is to be accepted. Otherwise, it is possible to prevent this deterioration by restricting the full index to zero genetic change in dressing percentage in the index:

$$I_{1(DP)} = 0.05\ BW + 65.89\ SL + 75.59\ WL - 73.38\ CL \qquad (r_{TI} = 0.53),$$

provided accepted limited sacrifices in accuracy of selection (-12%) and genetic gain in body weight at marketing (-20 gm).

Table (1): Means, Phenotypic Coefficients of Variation (CV_P) and Heritabilities (h^2) for the live performance and body composition traits

Trait	Symbol	Mean	CV_P (%)	h^2
Live performance traits:				
Body weight, g	BW	1462.5	13.5	0.36
Shank length, cm	SL	10.6	4.3	0.48
Wattle length, cm	WL	3.4	19.1	0.21
Comb length, cm	CL	3.9	19.2	0.20
Slaughter traits:				
Dressing, %	DRP	64.77	3.46	0.58
Non-visceral offal's, %	NOP	20.24	7.5	0.68
Giblets, %	GP	4.63	9.51	0.22
Abdominal fat, %	AFP	0.68	65.99	0.83

Table (2): Genetic (above diagonal) and Phenotypic (below diagonal) correlations between live performance and slaughtering traits

Traits	Live performance traits				Slaughtering traits			
	BW	SL	WL	CL	DRP	EOP	GP	AFP
Live performance traits:								
Body weight, BW	…..	0.90	0.76	0.74	-0.44	0.26	-0.64	0.83
Shank length, SL	0.69	….	0.50	0.66	-0.18	0.27	-0.77	0.98
Wattle length, WL	0.34	0.26	….	0.49	-0.45	0.13	-0.04	0.42
Comb length, CL	0.24	0.22	0.73	….	-0.83	0.77	-0.76	0.52
Slaughtering traits:								
Dressing, %, DRP	0.16	0.20	-0.05	-0.17	….	-0.73	0.41	-0.01
External-offal's, %, EOP	-0.15	-0.02	0.02	0.30	-0.44	…..	-0.78	0.16
Giblets, %, GP	-0.56	-0.38	-0.15	-0.19	-0.04	0.01	….	-0.70
Abdominal fat, %, AFP	0.33	0.15	0.08	0.09	-0.20	0.05	-0.20	….

* Symbols defined in Table (1).

Table (3): Weighing Factor, Standard Deviation, Accuracy of Selection and Relative Efficiency for Various Alternative Indexes.

Alternative	Index	b-value for body weights*:				σ_I	r_{TI}	R.E.
		BW	SL	WL	CL			
i. Full index	I_1	0.21	21.01	75.85	-32.30	69.31	0.65	100
ii. Reduced indexes	I_2	….	79.61	89.99	-35.93	62.83	0.59	
	I_3	….	77.80	60.40	…..	60.01	0.57	
	I_4	0.27	19.78	….	…..	59.96	0.63	
	I_5	0.25	…..	49.09	….	67.03	0.57	
iii single trait indexes	I_6	0.30	….	…..	…..	59.59	0.56	
	I_7	….	100.05	…..	…..	45.74	0.46	
	I_8	….	…..	73.95	…..	49.16	0.43	
	I_9	….	….	….	31.91	24.20	0.23	
IV. Restricted full index	$I_{10(DP)}$	0.05	65.89	75.59	-73.38	55.98	0.53	

* Symbols defined in Table (1).

Table (4): Expected genetic changes in live performance and slaughter traits when using the most accurate indexes.

Alternative	Index	Source of Information	Expected Genetic Changes (kg) in Body Weights*							
			BW	SL	WL	CL	DP	EOP	GP	AFP
i. Full index	I_1	BW, SL, WL, CL	80	0.11	0.33	0.14	-0.47	-0.10	-0.04	0.19
ii. Reduced indexes	I_5	BW, WL	81	0.12	0.31	0.17	-0.61	0.09	-0.06	0.20
iii. Single trait indexes	I_6	BW	70	0.11	0.21	0.15	-0.47	0.21	-0.08	0.20
IV. Restricted full index	$I_{1(DP)}$	BW, SL, WL, CL	60	0.08	0.28	0.04	0.00	-0.44	0.01	0.14

* Symbols defined in Table (1).

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الملخص العربي

ادلة انتخابية لوزن جسم تسويقى اثقل وتركيب جسم افضل فى دجاج الفيومى

احمد راغب شميس – احمد جلال السيد* – حسن حسن يونس**

قسم الانتاج الحيوانى – كلية الزراعة – جامعة عين شمس – القاهرة – مصر

[2]قسم انتاج الدواجن – كلية الزراعة – جامعة عين شمس – القاهرة – مصر

[3]قسم انتاج الدواجن – كلية الزراعة – جامعة كفر الشيخ – مصر

تم تقدير المعايير الوراثية والمظهرية للاداء الحى ومقاييس الذبيحة على 306 طائر من سلالة الفيومى نتجت من التزاوج بين 15 ديك فيومى مع 100 انثى باستخدام الموديل الاحصائى الصفات المتعددة للحيوان multiple-trait animal والذى اشتمل على التاثيرات الثابتة مثل الفقس والموسم والثاير العشوائى للوراثة المباشرة. استخدمت المعايير المقدرة لعمل 7 ادلة انتخابية للمساعدة فى تعظيم المنفعة لمربى الدواجن. وكانت الصفات الوراثية هى وزن الجسم عند التسويق ونسبة التصافى. يحتوى الدليل الكامل على وزن الجسم (BW)، طول عظمة الساق (SL)، طوا الداليات (WL)، طوا العرف (CL) عند التسويق (16 اسبوع). وجد ارتباط عالى بين الدليل الكامل والقيمة التربوية الحقيقية (r_{TI} = 0.65). عند التوقع بالقيمة التربوية الحقيقية، شوهد ان وزن الجسم (r_{TI} = 0.56) اكثر دقة من طول عظمة الساق (r_{TI} = 0.43)، طوا الداليات (r_{TI} = 0.43)، طول العرف (r_{TI} = 0.23). دقة الانتخاب المتوقع من استخدام الدليل المحتوى على وزن الجسم وطوال الداليات متشابهة فى الغالب مع الدليل الكامل. استخدام الدليل I_5 = 0.25 BW + 49.09 WL (r_{TI} = 0.63) يؤدى الى انتاج طيور ذات وزن جسم اثقل (81 جرام) عند التسويق وانخفاض نسبة التصافى بمقدار (0.61% وحدة). من الممكن منع التدهور الوراثى فى نسبة التصافى عن طريق استخدام دليل الانتخاب المقيد ($I_{1(DP)}$ = 0.05 BW + 65.89 SL + 75.59 WL – 73.38 CL). ومقارنة بالدليل الانتخابى الكامل فان الدليل المقيد يؤدى الى تقليل دقة الانتخاب بمقدار 12% وتقليل العائد الوراثى فى وزن الجسم عند التسويق بمقدار 25%.