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Analysis of muscle and bone weight variation in an Egyptian strain of Pekin ducklings

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Summary — A factor analysis with a varimax rotation was applied to ten muscle and bone traits on 144 Pekin ducklings to i) identify the main sources of shared variability, ii) deduce the factors controlling muscle and bone distribution, iii) predict the total amount of carcass muscle and bone from orthogonal muscle and bone traits. Muscle and bone weight distribution appeared to be controlled by both common and unique factors. The commonalities ranged from 0.76 (drumstick muscle) to 0.92 (neck bone) and the uniqueness (special size factors) made up the balance. The results indicated that most of the common variability (84.3%) in muscle and bone weight distribution could be accounted for by factors representing muscle, bone, neck and drumstick bone factors. The correlation coefficient between the first factor score and carcass muscle was 0.90 and that between the second factor score and total carcass bone was 0.68.

factor analysis / Pekin ducklings / multicollinearity / muscle weight variations/ bone weight variations

Résumé — Analyse de la répartition pondérale des muscles et des os chez une race égyptienne de canard Pekin. *Une analyse de facteurs utilisant une rotation varimax a été appliqué à dix caractéristiques de muscle et d'os mesurées sur 144 canards Pekin afin de : i) identifier les principales sources de variabilité commune, ii) déterminer les facteurs contrôlant la répartition des muscles et des os, iii) prédire la quantité totale de muscles et d'os dans la carcasse à partir du muscle orthogonal et des caractéristiques des os. La répartition pondérale des muscles et des os semble contrôlée à la fois par des facteurs communs et des facteurs spécifiques. Les facteurs communs ont un effet compris entre 0,76 (pour le muscle du pilon) et 0,92 (pour les os du cou). Les facteurs spécifiques (ex : facteurs de la taille) influencent l'équilibre muscle/os. Les résultats obtenus montrent que l'essentiel de la variabilité (84,3%) de la répartition pondérale des muscles et des os peut être attribuée à quatre facteurs communs : les facteurs des muscles, des os, du cou et du pilon. Le coefficient de corrélation entre le facteur numéro 1 et les muscles de la carcasse était de 0,90 et celui entre le facteur numéro 2 et les os de la carcasse de 0,68.*

analyse de facteurs / canard Pekin / répartition pondérale / muscle / os

IINTRODUCTION

Correlations between muscle and bone traits characterizing size and shape may be different if these traits are treated as bivariates rather than as multivariates. Multicollinear data analysis with multiple regression and allied techniques (on chickens, eg, Herstad and Frisch, 1972; Ricard, 1972; on cattle, eg, Williams et al, 1974; on ducks, eg, Stasko, 1965; Clayton and Draper, 1971; Clayton et al, 1974; Janiszewska et al, 1983; Ricard, 1987; on geese, eg, Wawro et al, 1985) may limit the use of such analysis for inference and forescasting (Mather, 1976; Chatterjee and Price, 1977; Stopher and Meyburg, 1979; Shahin et al, 1993).

Independent factor scores derived from a factor analysis technique (Morrison, 1967; Blackith and Reyment, 1971; Pimentel, 1979), allowing the orthogonalization of sets of traits, can be used as predictors of total carcass muscle and bone and other performance traits. Thorough factor analysis partitioning of the entire variance of each variable into common (shared with some or all variable) and unique variance (specific to a particular variable) is required for effective selection programs. Klijn (1976) used factor analysis to identify which part of the variance in a muscle's weight can be accounted for by common factors and which part by unique factors.

One objective of this study was to investigate the hypothesis of different models for the relationships between the weight of muscle and bone in various carcass parts with the corresponding weight of that tissue in a carcass by applying factor analysis to the interrelation traits rather than by simple and multiple regressions. A second objective was to identify the main sources of shared variability and deduce the factors that control muscle and bone distribution in Pekin ducklings.

MATERIALS AND METHODS

One hundred and forty-four (equal number of males and females) Pekin ducklings, of approximately 1 683 g in live weight and 10 weeks of age, were studied. The birds were sacrificed by severing the carotid artery and jugular veins. The head was removed at the atlantooccipital articulation. Carcasses were stored at –20 °C. Prior to cutting and dissection, carcasses were thawed for approximately 8 h at 5 °C, in their bags. The right side of each carcass was then jointed into the following commercial cuts: thigh, drumstick, wing, breast, neck and tail as described by Shahin (1990). In each, cut skin, subcutaneous fat, intermuscular fat, muscle and bone were dissected and weighed. The sum of muscle and intermuscular fat formed the lean. The sum of these parts over all cuts gave total side lean, total side bone and total side skin plus subcutaneous fat. The data from males and females were combined since the two data dispersion matrices did not differ significantly (untabulated).

STATISTICAL ANALYSIS

The data were subjected to a factor analysis procedure (SAS, 1988). The main source of shared variation among highly correlated meatiness and bone variables *(n)* was expressed in terms of a few mutually uncorrelated common factors (unknown variables or latent variables), F_1, ..., F_m (where $m < n$), then the original number of variables (Morrison, 1967; Blackith and Reyment, 1971). The first factor contained the greatest portion of original variation. Subsequent factors were mutually orthogonal to those preceding and to one another and contained less variation. To give the initial factor solution, a 'simple structure' varimax rotation (Kaiser, 1958) was performed. Varimax rotations (Pimentel, 1979) seek to maximize the variance of the loadings on each factor such that the variables having the highest loadings on a factor tend to have near-zero loadings on all others. The sum of variances of all retained factors is the total common variance.

The general model for factor analysis was:

$$X_j = (a_{j1} F_1 + a_{j2} F_2 + \dots + a_{jm} F_m) + d_j U_j$$

where X_j = variable j ($j = 1, 2, \dots, n$); F_1 = common factors affecting all variables ($i = 1, 2, \dots, m$); a_{ji} = factor loading representing the correlation of the variable with the factor; d_j = factor loading of variable j on unique factor j; U_j = factor related to each particular variable affecting a single variable.

The total variance of X is equal to unity and can be written as the sum of common variance 'commonalities, h^2', and unique variance 'uniqueness, u^2' as follows:

$$\mathrm{Var}(X_j) = 1 = h_j^2 + u_j^2$$

where $h_j^2 = \sum_{i=1}^{m} a_{ji}^2$,

representing the portion of the variable variance accounted for by all common factors; $u_j^2 = 1 - h_j^2$ 'latent variance', representing the portion of the variable variance accounted for by a unique factor (that is not shared with other variables).

A built-up stepwise multiple regression (Drapper and Smith, 1981) was used to predict total side muscle weight and total side bone weight from the orthogonal factor scores derived from the factor analysis.

RESULTS AND DISCUSSION

Table I presents the means, standard deviations, the coefficient of variability and ranges for live weight and muscle and bone traits. Body weight averaged 1 683 g and ranged from 1 000 to 2 100 g. Total side muscle weight ranged from 100 to 325 g with a mean of 236 g and total side bone weight ranged from 61 to 126 g with a mean of 99 g. The carcass muscle:bone ratio ranged from 1.63 to 3.25 with a mean of 2.39.

The breast muscle accounted for 27.8% of the total carcass muscle weight and the thigh muscle accounted for 20.1% of the total carcass muscle weight. The wing bone (scapula, humerus, radius and ulna) accounted for 21.5% of the total carcass bone weight and the thigh bone accounted for 20.6% of the total carcass bone weight. The muscle: bone ratio, 'fleshiness', for various parts of the carcass are also shown in table I.

NONINDEPENDENT MUSCLE AND BONE TRAITS, THEIR INTERRELATIONS AND RELATIONSHIPS WITH INDEPENDENT FACTOR SCORES

The coefficients of correlation among all carcass traits are presented in table II. The weight of muscle or bone in all carcass parts was highly correlated with the corresponding weight of that tissue in the carcass. Total carcass muscle had the highest correlation with breast muscle weight and total carcass bone had the highest correlation with wing bone. Muscle and bone traits were highly intercorrelated. Similar findings have been reported by Klijn (1976), Wawro et al (1984) and Shahin (1990).

In the present study, the separable muscle in the thigh was associated with 72% of the variation in total separable carcass muscle, while in beef cattle, Cole et al (1960) reported the separable muscle in the round 'thigh' was associated with 90% of the variation in separable carcass muscle.

Correlations among the interdependent carcass traits with nonrotated orthogonal factor scores showed that the first factor score, representing general size 'muscling', was highly correlated ($P < 0.01$) with each trait (table III). The highest correlation (0.84) was with the thigh muscle, indicating that

Table I. Means, standard deviations (SD), coefficient of variability (CV%) and minimum and maximum values for live and carcass traits.

	Mean	*SD*	*CV%*	*Range*
Live weight (g)	1 682.6	209.6	12.5	1 000–2 100
Dissected side weight (g)	469.3	76.1	16.2	257.4–618.2
Total side muscle (g)	235.5	40.1	17.0	100.3–324.5
Total side bone (g)	98.6	10.2	10.3	60.9–125.9
Total side fat (g)	135.3	43.7	32.3	47.3–258.2
Total side subcutaneous fat (g)	121.7	40.0	32.9	44.3–235.4
Total side intermuscular fat (g)	13.6	5.4	39.7	3.0–28.7
% of Live weight				
Total muscle	27.9	2.8	9.9	19.9–34.2
Total bone	11.8	1.0	8.7	9.0–14.9
Total fat	15.9	4.2	26.6	6.7–25.2
Total subcutaneous fat	14.3	3.9	27.4	6.2–23.5
Total intermuscular fat	1.6	0.5	33.5	0.5–2.8
% of Total muscle				
Drumstick muscle	13.9	1.5	11.1	10.5–18.5
Thigh muscle	20.1	2.1	10.4	15.9–30.1
Breast muscle	27.8	5.5	19.9	11.9–40.5
Wing muscle	14.1	1.4	10.0	9.0–17.8
Neck muscle	10.2	1.6	15.4	7.3–14.6
% of Total bone				
Drumstick bone	11.8	1.2	10.0	8.5–17.4
Thigh bone	20.6	1.6	7.8	16.3–28.0
Breast bone	15.7	1.6	10.1	9.7–19.4
Wing bone	21.5	2.1	9.6	12.8–27.9
Neck bone	15.7	2.3	14.3	12.2–25.5
Muscle:bone ratio in:				
Drumstick	2.8	0.4	14.6	1.7–5.2
Thigh	2.3	0.2	10.4	1.7–3.0
Breast	4.3	1.2	28.0	1.8–7.7
Wing	1.6	0.3	17.2	0.9–2.4
Neck	1.6	0.2	13.6	1.1–2.1
Whole carcass	2.4	0.3	13.8	1.6–3.3

70.7% of the total phenotypic variance in the thigh muscle was explained by a general size factor (factor 1). The initial solution (table III) identified the principal patterns of variation in the original variables. As it was difficult to interpret them meaningfully (distinctive clusters of variables were not obvious), a further step (varimax rotation) was required.

Breast muscle weight alone accounted for 89% of the variability in the total side muscle weight. Multiple correlations (table IV) showed that R^2 increased from 0.96, 0.98, 0.99 and residual standard deviation of the estimate decreased from 8.4 to 6.4 to 4.7 to 3.8 g with the stepwise addition of the thigh muscle, neck muscle, wing muscle and drumstick muscle, respectively. These

Table II. Coefficient of correlation between variables.

	LW	*TSM*	*TSB*	*DM*	*TM*	*BM*	*WM*	*NM*	*DB*	*TB*	*BB*	*WB*	*NB*
Live weight (LW)													
Total side muscle (TSM)	0.840												
Total side bone (TSB)	0.736	0.624											
Drumstick muscle (DM)	0.787	0.800	0.619										
Thigh muscle (TM)	0.717	0.846	0.573	0.707									
Breast muscle (BM)	0.720	0.944	0.495	0.668	0.704								
Wing muscle (WM)	0.740	0.893	0.519	0.710	0.751	0.802							
Neck muscle (NM)	0.680	0.583	0.605	0.575	0.566	0.385	0.493						
Drumstick bone (DB)	0.351	0.292	0.589	0.326	0.367	0.175	0.248	0.338					
Thigh bone (TB)	0.609	0.569	0.763	0.562	0.600	0.466	0.500	0.452	0.520				
Breast bone (BB)	0.712	0.698	0.796	0.599	0.529	0.636	0.617	0.481	0.288	0.561			
Wing bone (WB)	0.618	0.617	0.808	0.547	0.557	0.530	0.552	0.498	0.356	0.650	0.702		
Neck bone (NB)	0.389	0.070	0.532	0.231	0.112	–0.107	0.001	0.579	0.240	0.268	0.331	0.264	

Table III. Explained variation associated with unrotated factor analysis. Correlations between factor score coefficients and original variables.

	Common factors			
	1	*2*	*3*	*4*
Drumstick muscle	0.838	–0.094	–0.114	0.199
Thigh muscle	0.841	–0.193	0.036	0.278
Breast muscle	0.778	–0.501	–0.091	–0.005
Wing muscle	0.826	–0.400	–0.097	0.126
Neck muscle	0.713	0.403	–0.306	0.308
Drumstick bone	0.489	0.364	0.703	0.195
Thigh bone	0.767	0.157	0.357	–0.168
Breast bone	0.801	0.027	–0.151	–0.424
Wing bone	0.789	0.083	0.054	–0.440
Neck bone	0.321	0.843	–0.327	–0.004
% of variance	54.0	14.8	8.8	6.7

results indicated that total muscle weight can be predicted with a high degree of accuracy from breast and thigh muscles: as much as 96% of the variation in total muscle weight was accounted for by these two traits.

The wing bone *(ossa alae)* alone accounted for 65% of the variability in the total side bone weight. Multiple correlations (table V) showed that R^2 increased to 0.76, 0.84, 0.88 and 0.92 and residual standard deviation of the estimate decreased to 4.99, 4.2, 3.5 and 3.0 g with stepwise addition of the neck bone, thigh bone, breast bone and drumstick bone, respectively.

In chickens, the tibia, femur, coracoid, humerus and sternum (breast bone) were

Table IV. Stepwise multiple regression of total side muscle weight (g) on original muscle traits.

Step	*Independent variables (predictors)*	*Intercept*	*Regression coefficient b*	*SE*	R^2	*Residual standard deviation*
1	Breast muscle	120.64	1.71	0.05	0.891	13.28
2	Breast muscle	35.19	1.25	0.04	0.957	8.40
	Thigh muscle		2.50	0.17		
3	Breast muscle	19.56	1.25	0.03	0.975	6.36
	Thigh muscle		1.83	0.14		
	Neck muscle		1.96	0.19		
4	Breast muscle	18.77	1.06	0.03	0.987	4.67
	Thigh muscle		1.40	0.11		
	Neck muscle		1.70	0.14		
	Wing muscle		1.21	0.11		
5	Breast muscle	7.82	1.02	0.02	0.991	3.84
	Thigh muscle		1.22	0.10		
	Neck muscle		1.40	0.12		
	Wing muscle		1.06	0.09		
	Drumstick muscle		1.06	0.12		

Table V. Stepwise multiple regression of total side bone weight (g) on original bone traits.

Step	*Independent variables (predictors)*	*Intercept*	*Regression coefficient b*	*SE*	R^2	*Residual standard deviation*
1	Wing bone	42.59	2.63	0.16	0.653	6.00
2	Wing bone	27.12	2.34	0.14	0.762	4.99
	Neck bone		1.40	0.17		
3	Wing bone	12.78	1.60	0.15	0.836	4.16
	Neck bone		1.25	0.15		
	Thigh bone		1.59	0.20		
4	Wing bone	11.89	1.03	0.15	0.881	3.54
	Neck bone		1.07	0.13		
	Thigh bone		1.38	0.17		
	Breast bone		1.30	0.18		
5	Wing bone	0.77	1.00	0.12	0.918	2.97
	Neck bone		0.97	0.11		
	Thigh bone		0.89	0.16		
	Breast bone		1.36	0.15		
	Drumstick bone		1.94	0.25		

the most common predictors of total carcass bone used by many investigators (Martin and Patrick, 1962; Morris et al, 1966; Cox and Ballonn, 1971). It is worth mentioning that, the humerus bone in ducks is the longest bone in the skeleton, while in chickens and turkeys, the tibia is the longest and largest bone in the skeleton.

INDEPENDENT FACTORS AND THEIR INTERPRETATION

In order to improve the factor interpretability and to simplify the structure of the factors, the varimax final solutions were applied and are presented in table VI and figure 1. This involved rotating the factor axes until distinct clusters of variables were more readily identifiable (ie, each factor is defined by a few high loadings). The factor analysis technique reduced (condensed or amalgamated) the entire set of correlations of the ten meatiness and bone traits into four linearly independent functions of the original variables. Four common factors were identified, contributing to 84% of the variability of the original ten variables, leaving 16% to ten 'special' factors.

The first factor was characterized by high positive loadings (factor-variate correlations) on all meatiness traits; the variables associated with the wing muscle and breast muscle had the highest loadings, followed by the thigh muscle and drumstick muscle. This factor, accounting for 54% of the variation in the original variables, can be interpreted as a general size factor or an index of general 'meatiness' (bone independent), analogous to comparable interpretations by Ricard and Rouvier (1966) and Rouvier and Ricard (1967). Klijn (1976) found that muscle weight variability depends on body size (factor 1) for 66% of the total variance in the wing and 57% in the leg.

The subsequent factors were mutually orthogonal (essentially uncorrelated) to the first, present patterns of variation and were independent of general size (multicollinearity was no longer present). The intercorre-

Table VI. Explained variation associated with rotated factor analysis. Correlations between factor score coefficients and original variables.

	Common factors			
	1	*2*	*3*	*4*
Drumstick muscle	0.765	0.266	0.267	0.189
Thigh muscle	0.821	0.198	0.135	0.302
Breast muscle	0.833	0.396	–0.128	0.007
Wing muscle	0.865	0.312	0.013	0.087
Neck muscle	0.509	0.127	0.745	0.174
Drumstick bone	0.122	0.109	0.138	0.927
Thigh bone	0.340	0.554	0.143	0.571
Breast bone	0.419	0.781	0.238	0.047
Wing bone	0.335	0.792	0.177	0.233
Neck bone	–0.126	0.204	0.923	0.106
Description	Muscle factor	Bone factor	Neck factor	Drumstick bone factor

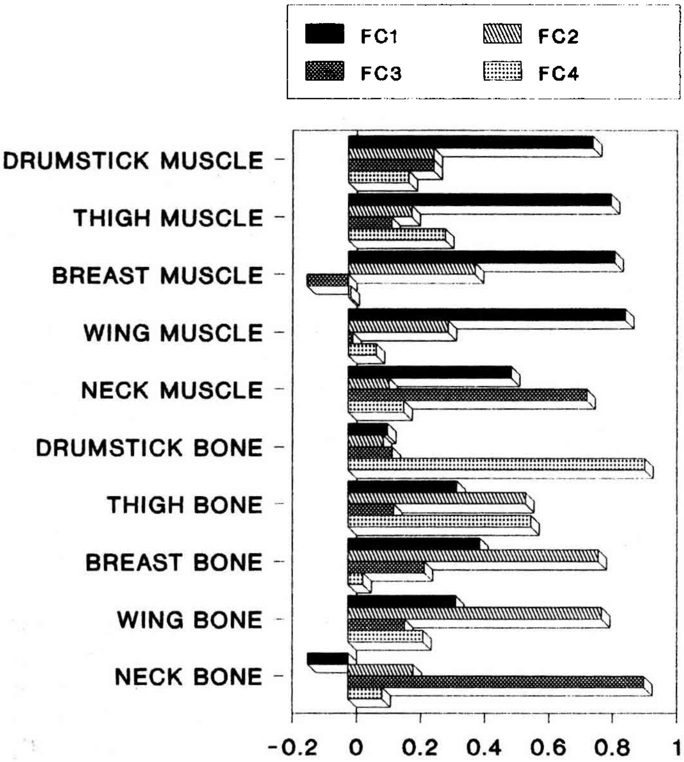

Fig 1. Correlations between factor score coefficients and original variables.

lations between factors were zero. The second factor gave relatively little weight to the drumstick bone and accounted for an additional 14.8% of the total variation. Variables associated with the wing bone had the highest loadings on it, followed by those associated with the breast bone and thigh bone. This factor could be called *bone factor.*

The third factor accounted for 8.8% of the total variation and had high loadings on the neck muscle and bone and could be called *neck factor.* The neck in ducks is thick, long and very flexible and its skeleton is composed of 15 cervical vertebrea. The neck structures and functions enable the bird to maintain its balance and to shift its center of gravity for running and flying. Ducks are known for their capacity to fly long distances.

The fourth factor accounted for 6.7% of the total variation, with the drumstick bone having the highest loadings. It could be called the *drumstick bone factor* or *tibia factor* or *weight support factor.* The tibia in ducks is about twice as long as the femur, while in the chicken and turkey it is about one and one-half as long as the femur. Generally, the drumstick region (distal hind leg) is essential for locomotion (walking and perching), and is responsible, in part, for supporting the weight of the bird. Wright (1932, 1954) used factor analysis to identify factors that control the bone dimensions in White Leghorn fowls and found that the proportions of the variability determined by the three common factors are 73.8, 6.3 and 1.8%, respectively, leaving 18.1% to the six unique factors. He found that leg and wing measurements depend on a common factor, which is not operative on the head.

In summary, most of the common variabilities in meatiness and bone traits could be accounted for by factors representing muscles, bone, neck and drumstick bone.

INDEPENDENT FACTOR SCORES AND THEIR RELATIONSHIP WITH TOTAL SIDE MUSCLE AND TOTAL SIDE BONE WEIGHTS

Correlations between varimax rotated factor scores and total muscle weight ranged from 0.08 to 0.899 and between factor scores and total side bone ranged from 0.311 to 0.682. The correlation between FC1 and total side muscle weight was 0.899 and that between FC2 and total side bone weight was 0.682. Ricard and Rouvier (1966), working with chickens, found that the genetic correlations of the first (size) and second (compactness) factors with muscle/bone deviation were 0.223 and 0.336, respectively. Ricard (1980) suggested that the correlation between general size and meatiness in Muscovy ducks seems to be high and positive.

Meatiness factor score alone accounted for 81% of the variation in the total side muscle weight. Results of a stepwise multiple regression of total size muscle weight on the four varimax factor scores (table VII) showed that R^2 increased from 0.94 to 0.96 and the RSD of the estimate decreased from 17.6 to 7.7 g as FC2, FC4 and FC3 orthogonal factor scores were added stepwise. The final multiple regression equation for estimating total side muscle weight from independent factor scores was:

Total side muscle (kg) = 235.52 + 36.02 FC1 + 14.72 FC2 + 4.68 FC4 + 3.22 FC3

Bone factor score (FC2) alone accounted for 47% of the variation in total side bone weight. The results of a stepwise multiple regression of total side bone weight on the four varimax factor scores (table VIII) showed that R^2 increased from 0.65 to 0.91 and the RSD of the estimate decreased from

Table VII. Stepwise multiple regression of total side muscle weight (g) on orthogonal factor scores.

Step	*Independent variables (predictors)*	*Intercept*	*Regression coefficient b*	*SE*	R^2	*Residual standard deviation*
1	FC1	235.52	36.02	1.47	0.809	17.58
2	FC1	235.52	36.02	0.79	0.944	9.55
	FC2		14.72	0.79		
3	FC1	235.52	36.02	0.70	0.958	8.34
	FC2		14.72	0.70		
	FC4		4.68	0.70		
4	FC1	235.52	36.02	0.64	0.964	7.71
	FC2		14.72	0.64		
	FC4		4.68	0.64		
	FC3		3.22	0.64		

Table VIII. Stepwise multiple regression of total side bone weight (g) on orthogonal factor scores.

Step	*Independent variables (predictors)*	*Intercept*	*Regression coefficient b*	*SE*	R^2	*Residual standard deviation*
1	FC2	98.55	6.92	0.62	0.465	7.45
2	FC2	98.55	6.92	0.50	0.653	6.02
	FC4		4.40	0.50		
3	FC2	98.55	6.92	0.25	0.817	4.40
	FC4		4.40	0.25		
	FC3		4.10	0.25		
4	FC2	98.55	6.92	0.25	0.913	3.03
	FC4		4.40	0.25		
	FC3		4.10	0.25		
	FC1		3.16	0.25		

6.02 to 3.03 g as FC4, FC3 and FC1 orthogonal factor scores were added in stepwise. The final multiple regression equation for estimating total side bone weight from independent factor scores was:

Total side bone (kg) = 98.55 + 6.92 FC2 + 4.40 FC4 + 4.10 FC3 + 3.16 FC1

Tables VII and VIII show that the regression coefficients in a stepwise multiple regression of total side muscle and total side bone against the four orthogonal varimax factors were stable and did not change with the addition of variables in the equation (order of entry did not affect the results). Corresponding regression coefficients obtained from regressing total side muscle and total side bone on original intercorrelated variables (nonorthogonal) (tables IV and V) were unstable and sensitive to the addition of variables in the equations. This instability rendered it impossible to estimate the unique effects of individual variables in the regression equation and thus, could lead to false inferences.

VARIABILITY OF NONINDEPENDENT MUSCLE AND BONE TRAITS

The overall variability of bone traits was lower than that of flesh traits (table I).

Table IX lists the commonalities h^2 and uniqueness u^2 (1 minus commonality) for

Table IX. Common and unique factors for each variable.

	Common factor h^2	*Unique factor* u^2
Drumstick muscle	0.763	0.237
Thigh muscle	0.824	0.176
Breast muscle	0.864	0.136
Wing muscle	0.852	0.148
Neck muscle	0.861	0.139
Drumstick bone	0.905	0.095
Thigh bone	0.768	0.232
Breast bone	0.845	0.155
Wing bone	0.826	0.174
Neck bone	0.920	0.080

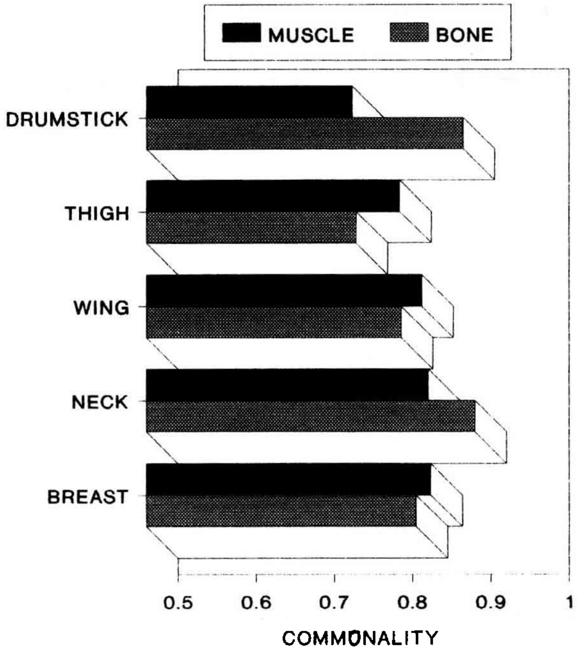

Fig 2. Commonality for each variable.

several variables. The variance of a variable was partitioned into a common portion, shared with some or all the other variable 'commonalities', and a portion unique to that particular variable, which was not shared with any other variable 'uniqueness'. The results indicated that about 76 to 92% of the variation in meatiness and bone traits were brought about by the common factors, whereas 8 to 24% of their variations were contributed by unique factors, specific for each trait.

The commonalities for muscle traits ranged from 0.763 for the drumstick muscle to 0.864 for the breast muscle and those for bone traits ranged from 0.768 for the thigh bone to 0.920 for the neck bone (fig 2). The drumstick muscle and the thigh bone had the lowest commonality with the greatest uniqueness of their own. Approximately 76–77% of the variation in the drumstick muscle and thigh bone was brought about by common factors, whereas 23–24% of their variations were contributed by the unique factor specific for each of the drumstick muscles or thigh bones.

CONCLUSION

With the ever-growing demand for lean meat, there is an urgent need for rapid, accurate and efficient methods for assessing the total amount of carcass muscle. Studies have shown that total dissection is one of the best methods for estimating the total composition of a bird. However, as this technique is either time-consuming, expensive or both, simplified methods for assessing total muscle and bone in the carcass would be of value to workers in the meat industry and in meat research.

Clear-cut advantages of the factor analysis technique appeared when the information in the ten meatiness and bone traits was consolidated into four advantageously interpretable factors which then clarified the relationship between the weights of muscle and bone in various cuts with the corresponding weight of that tissue in the carcass.

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