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# USING EARLY LIVE BODY PERFORMANCE TRAITS OF DUCKS TO PREDICT MARKETING WEIGHT

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**ABSTRACT:**Data from five hundred and seventy four male ducks of Sudani (SUD, N= 290) and Muscovy (MUS, N= 284) breeds have been used to predict marketing weight (MW) at 12 weeks of age, employing three early live body performance traits (LBPTs) at 2, 4 and 6 weeks of age, viz keel length (KL), breast girth (BG) and body weight (BW). The results indicated that BW, KL and BG increased with advantage of age. The average daily gain of BW was found to be decreased between the two age stages (2-4 and 4-6 wks), while KL and BG increased in both breeds. BW demonstrated the highest coefficient of variation (CV%) among all LBPTs at all growth stages for the two breeds. For 2-week SUD ducklings, MW had a single linear relationship with KL (coefficient of determination, $R^2$, = 61%), BG ($R^2$ = 41%) and BW ($R^2$ = 3%). In SUD breed, $R^2$ showed increases to 74%, 68% and 79% when combining KL with BW at 2 weeks, KL with BG at 4 weeks and BW with BG at 6 weeks. MW of MUS ducklings at 2 weeks, showed to be in a simple linear relationship with KL ($R^2$ = 15%) and BW ($R^2$ = 74%). Increases in $R^2$ to 84%, 86% and 91% were noticed when combining KL with BW at 2, 4 and 6 weeks, respectively. Admittance of a third variable did not increase $R^2$ more than 9% whatever the age group or breed. However, for practical purposes, as early as 2 weeks of age, MW appeared to be predictable from early live body performance traits especially with KL in SUD duckling birds and BW in MUS duckling birds.

**Keywords**. Ducks- Marketing Weight- Early Live Body Performance- Stepwise Procedure.

## INTRODUCTION

Meat production from ducks can play relevant role in food security of economically developing countries (Pingel and Landsberg, 2011), as raising ducks, compared with that of chicken, has several advantages including lower replacement costs, reduced space requirements, lesser feeding exigencies and higher disease resistance.

In Egypt, where all duck breeds are raised for meat production, their meat yield, nationwide, has increased by 64 percent from 3.9 million tons in 2002 to 6.4 million tons in 2012 (FAOSTAT, 2016). Ducks in this country are marketed at an age of approx. 12 weeks. Prediction of the corresponding marketing weight (MW) using earlier live body performance traits (LBPTs) would be profitable as a tool for saving feeding costs, which normally account for approx. 70 percent of total production cost in poultry production (Ravindran, 2013).

This study aimed at finding formulae for estimating, as accurately as possible, the 12-week MW of Sudani and Muscovy duck breeds. Live body weights and linear measurements at 2, 4 and 6 weeks of age were used as predictors in stepwise multiple regression.

## MATERIALS AND METHODS

### EXPERIMENTAL MATERIAL

i) *Animals*. Data from El-Serw Waterfowl Research Station, Animal Production Research Institute, Ministry of Agriculture, Damietta Governorate, Egypt, were collected on five hundreds and seventy four ducks of male ducks in Sudani (N= 290) and Muscovy (N= 284) breeds.

ii) *Rearing*. The following conditions were maintained:

(a) Ducklings were wing-tagged and housed separately at hatching.

(b) During week 1, ducklings were exposed to continuous artificial light.

(c) From week 1 till week 6, ducklings were fed, *ad-libitum,* a commercial moisture started ration containing 19.2% crude protein and providing 2868 kcal/kg.

(d) From week 6 till week 12, birds were fed commercial grower ration containing 15.2% crude protein and providing 2690 Kcal/kg.

(e) From week 1 till week 12, water was available *ad-libitum,*

iii) Collection of data. Weighing and measuring were taken on fasted birds**.** Care was taken while measuring to get the bird standing squarely on its two feet in a natural position. MW (gm) was taken at 12 weeks of age and the early LBPTs were measured at 2, 4 and 6 weeks of age as follows:

(a) Keel length (KL, cm): taken along the midline of the sternum bone and extends outward, vertically, to the level of the ribs.

(b) Breast girth (BG, cm): taken through the front border of the breast bone crest under the wing and the central thoracic vertebrae

(c) Body weight (BW, gm)

The measures (a) and (b) were taken with a linen tape measure bound with a steel wire.

### STATISTICAL ANALYSIS

Since a preliminary study showed significant between-breeds differences in early LBPTs and since within-breed regressions of MW on early LBPTs showed significant reduction in residual variation compared with that associated with overall regression, the data of each of the two breeds were, separately, incorporated into

stepwise multiple regression analysis (SPSS, 2007) according to the following model:

$$y_i = a + b_1 X_1 + b_2 X_2 + \ldots + b_i X_i + e$$

Where:

- $y_i$ = the marketing weight of the $i^{th}$ bird,
- a = the regression intercept,
- $X_i$ = the $i^{th}$ early live performance traits,
- $b_i$ = the $i^{th}$ regression coefficient of the $y_i$ on the $i^{th}$ early live performance traits, and
- $e_i$ = the error term assumed to be NID (0 and $\sigma_e^2$).

Lack of fit and multicollinearity tests (Montgomery, 2001) were adopted and the coefficient of determination ($R^2$) for each regression equation was used as a preference criterion for prediction success. The descriptive analysis for MW and LBPTs (means, coefficient of variations and simple correlations) was carried out.

## RESULTS AND DISCUSSION

### LBPTs means and coefficients of variation

The mean values of MW and early LBPTs and their coefficients of variation are shown in Table 1 for the two breeds of birds, separately. MUS ducks reached the marketing age with 39% higher body weight than SUD ducks. Abd El-Samee *et al*. (2012) reported 17% superiority in marketing body weight for MUS over SUD breed. It is of interest to notice differences between SUD and MUS in changes in body weight and conformation occurring during growth period between two and four weeks of age. While the mean of SUD as percentage of the mean of MUS decreased in weight (from 72.6 to 66.5%), it increased in BG (from 77.5 to 80.4%) while remained almost unchanged in KL (from 77.6 to 78.0%). For the two breeds, while BW exhibited the highest coefficient of variation among all LBPTs at all growth stages, KL manifested the highest variation among the linear measurements. This is may be due to the difference of measuring unit between weight (measured in gram) and linear measurements (measured in centimeter). Similar findings indicating higher variability of body weight than linear measurements were reported on Muscovy ducks (Ogah and Kabir, 2013), Japanese quail (Ojo, 2014) and rabbits (Udeh, 2013; Shahin and Hassan, 2002). With age, coefficient of variation of BW increased in SUD and decreased in MUS, while BG increased in both breeds, and KL expanded in SUD only.

### LBPTs increase with age

Table 1 also shows that between week two and six, BW, KL and BG increased from 223.1gm to 958.9 gm, 12.4cm to 17.7cm and 4.5cm to 6.6cm, respectively in SUD ducks, and from 307.2gm to 1443.0gm, 15.9cm to 22.8cm and 5.8cm to 8.2cm, respectively, in MUS birds. Table 2 illustrates that between the two growth stages (2-4 wk and 4-6 wk), as average daily gain of BW decreased that of KL and BG increased. This is may be reflect the changes in body conformation with the age change in ducks.

### Simple correlations and simple regressions between MW and early LBPTs

The simple correlation and regression coefficients of early LBPTs with MW given in Table 3 showed that, in Sudani ducks, the correlations with MW was highest with 2-week KL, 4-week BG and 6-week BG and BW. In MUS ducks, BW had the highest correlation with MW at all the age stages. Téguia *et al*. (2008) observed that linear measurements were strongly correlated ($p<0.01$) with BW in African MUS; the highest correlations were recorded with wing length and thoracic perimeter. Ogah and Kabir (2013) reported that BG were strongly correlated with BW

in MUS ducks. Table 3 indicates that for 2-wk SUD ducklings, MW had a single linear relationship with KL ($R^2$= 61%), BG ($R^2$= 41%) and BW ($R^2$= 3%). Various regression equations have been reported keel length ($R^2$ = 74.4%) or breast girth ($R^2$ = 70.5%) to be the most appropriate and confident parameters in body weight estimation for turkey farm situation at 12 weeks of age (Amao and Ojedapo, 2016). As information, when weighing scale is not available, the $R^2$ for the regression of MW on a linear body measurements was highest when relating MW with BG at 2, 4 and 6 weeks of age in MUS ducks explained up to 73% of MW variation and at 4 and 6 weeks of age in SUD ducks explained up to 74% of MW variation.

**Lack of fit and multicollinearity**

The lack of fit test is check whether the pattern between the variables is linear. The lack of fit test resulted in to be non-significant, which achieved the assumption of linearity for multiple regression model and the analysis did not omits any important factors from the model.

Multicollinearity phenomenon occurs when two or more predictor variables are highly correlated. For detection of multicollinearity between independent variables, values of variance inflation factor (VIF) and tolerance (Tol.) of the predictors are given in Table 4. It seemed that there is no multicolinearity between the predictors in each of MUS and SUD duck breeds. This this because the safety values of VIF and Tol. in both duck breeds.

**Early LBPTs as predictors of MW in a multiple regression**

The within age-group within breed stepwise multiple regressions of MW on early LBPTs are shown in Table 5. The results illustrated that to estimate MW, duck raisers need primarily to measure KL in SUD and BW in MUS for 2-wk ducks, BG in SUD and BW in MUS for 4-weeks birds, BW in SUD and MUS for 6-weeks birds. In SUD, increases in $R^2$ to 74%, 68% and 79% are observable when combining KL with BW at 2 weeks, KL with BG at 4 weeks and BG with BW at 6 weeks. In MUS, increases in $R^2$ to 84%, 86% and 91% are noticeable when combining KL with BW at 2, 4 and 6 weeks, respectively. Whatever the age-group or breed, admittance of a third variate in the multiple regression estimating MW does not increase more than 9% in accuracy. The regression equation of BW on body length, BG and chest width ($R^2$ = 85%) has been suggested to be used in Muscovy duck farms (Raji *et al*., 2009). Ojo *et al*. (2014), on quail birds, indicated that incorporating more linear body measurements in the estimation equation of BW has improved prediction accuracy. Udeh *et al*. (2013) reported that body length serves as a reliable index ($R^2$=71%) of body weight in rabbits.

## CONCLUSION

This study depicts that marketing body weight in Sudani and Muscovy ducks is predictable from early live body performance traits, especially with KL and BW as early as 2 weeks of rearing. On the grounds of that, a breeding program could perform to achieve maximum economic returns at marketing in Sudani and Muscovy ducks by using easily linear measurements like Keel length and Breast girth in combination with body weight.

**Table (1):** Means values (M) of early live weights (gm) and body measurements (cm) and their coefficients of variation (V) of Sudani and Muscovy ducks

| Variable | Sudani | | Muscovy | | $\frac{\text{M of Sudani}}{\text{M of Muscovy}} x\ 100$ |
|---|---|---|---|---|---|
| | M | V | M | V | |
| **MW** | 2238.5 | 23.1 | 3116.8 | 20.3 | 71.8 |
| **Week-2 LBPTs** | | | | | |
| Body weight | 223.1 | 10.7 | 307.2 | 21.9 | 72.6 |
| Keel length | 12.4 | 4.4 | 15.9 | 7.9 | 78.0 |
| Breast girth | 4.5 | 6.2 | 5.8 | 4.9 | 77.5 |
| **Week-4 LBPTs** | | | | | |
| Body weight | 629.5 | 17.2 | 968.2 | 20.2 | 65.0 |
| Keel length | 14.7 | 5.8 | 19.0 | 6.7 | 77.4 |
| Breast girth | 5.4 | 6.3 | 6.7 | 6.1 | 80.6 |
| **Week-6 LBPTs** | | | | | |
| Body weight | 958.9 | 17.4 | 1443.0 | 17.6 | 66.5 |
| Keel length | 17.7 | 6.7 | 22.8 | 8.0 | 77.6 |
| Breast girth | 6.6 | 8.7 | 8.2 | 7.9 | 80.4 |

MW: marketing weight at 12 weeks of age; LBPTs: live body performance traits;
N per breed: Sudani, 290; Muscovy, 284.

**Table (2):** Average daily gain of early LLBPTs of Sudani and Muscovy ducks during the growth periods from 2-4 and 4-6 weeks for Sudani and Muscovy breeds

| LBPTs | Breed | Average daily gain at | |
|---|---|---|---|
| | | 2-4 wks | 4-6 wks |
| Body weight (gm/day) | Sudani | 29.0 | 23.5 |
| | Muscovy | 47.2 | 33.9 |
| Keel length (cm/day) | Sudani | 0.16 | 0.21 |
| | Muscovy | 0.22 | 0.27 |
| Breast girth (cm/day) | Sudani | 0.06 | 0.08 |
| | Muscovy | 0.06 | 0.10 |

LBPTs: live body performance traits

**Table (3):** Relationship between marketing weight (MW, gm) an early live body performance traits (LBPTs) at 2, 4 and 6 weeks of age of Sudani and Muscovy ducks

| | Prediction equation | ϕR²% | Correlation coefficient† |
|---|---|---|---|
| **Sudani** | | | |
| **Week-2 LBPTs** | | | |
| Body weight (gm) | MW = 1286.1 + 4.3 BW | 3 | 0.19 |
| Keel length (cm) | MW = -6830.6 + 730.2 KL | 61 | 0.78 |
| Breast girth (cm) | MW = -3250.3 + 1199.8 BG | 41 | 0.64 |
| **Week-4 LBPTs** | | | |
| Body weight (gm) | MW = -2657.1 +7.8 BW | 47 | 0.69 |
| Keel length (cm) | MW = -1340.6 + 242.3 KL | 16 | 0.40 |
| Breast girth (cm) | MW = - 4321.0 + 1199.1 BG | 64 | 0.80 |
| **Week-6 LBPTs** | | | |
| Body weight (gm) | MW = -3764.7 + 6.2 BW | 75 | 0.86 |
| Keel length (cm) | MW = -796.8 + 170.9 KL | 15 | 0.40 |
| Breast girth (cm) | MW = -2887.3 + 767.3 BG | 74 | 0.86 |
| **Muscovy** | | | |
| **Week-2 LBPTs** | | | |
| Body weight (gm) | MW = 618.4 + 8.1 BW | 74 | 0.88 |
| Keel length (cm) | MW = -40.4 + 197.4 KL | 15 | 0.39 |
| Breast girth (cm) | MW = -6566.7 + 1662.6 BG | 56 | 0.75 |
| **Week-4 LBPTs** | | | |
| Body weight (gm) | MW = 200.9 + 3.0 BW | 86 | 0.93 |
| Keel length (cm) | MW = -398.8 + 184.9 KL | 13 | 0.37 |
| Breast girth (cm) | MW = -4519.4 + 1123.0 BG | 54 | 0.74 |
| **Week-6 LBPTs** | | | |
| Body weight (gm) | MW = -294.4 + 2.3 BW | 90 | 0.95 |
| Keel length (cm) | MW = 362.6 + 120.7 KL | 12 | 0.35 |
| Breast girth (cm) | MW = -3747.6 + 829.4 BG | 73 | 0.85 |

ϕ: $R^{2=}$ Coefficient of determination; †: all correlation coefficients are significant ($P< 0.05$);
N per breed: Sudani, 290; Muscovy, 284.

**Table (4):** Diagnoses of multicollinearity among the predictors within age-group in Sudani and Muscovy duck breeds

| Predictor | Multicollinearity indicators | |
|---|---|---|
| | **Tol.** | **VIF** |
| **Sudani** | | |
| **At week-2** | | |
| Body weight (gm) | 0.22 | 4.59 |
| Keel length (cm) | 0.12 | 8.20 |
| Breast girth (cm) | 0.11 | 9.10 |
| **At week-4** | | |
| Body weight (gm) | 0.41 | 2.39 |
| Keel length (cm) | 0.50 | 1.97 |
| Breast girth (cm) | 0.34 | 2.96 |
| **At week-6** | | |
| Body weight (gm) | 0.25 | 4.00 |
| Keel length (cm) | 0.48 | 2.06 |
| Breast girth (cm) | 0.19 | 5.33 |
| **Muscovy** | | |
| **At week-2** | | |
| Body weight (gm) | 0.23 | 4.31 |
| Keel length (cm) | 0.48 | 2.06 |
| Breast girth (cm) | 0.29 | 3.44 |
| **At week-4** | | |
| Body weight (gm) | 0.38 | 2.59 |
| Keel length (cm) | 0.64 | 1.55 |
| Breast girth (cm) | 0.31 | 3.15 |
| **At week-6** | | |
| Body weight (gm) | 0.19 | 5.09 |
| Keel length (cm) | 0.78 | 1.26 |
| Breast girth (cm) | 0.18 | 5.35 |

Tol.: Tolerance value (Tolerance value less than 0.10 indicates collinearity);
VIF: Variance inflation value (VIF value greater than 10 indicates collinearity)

**Table (5):** Within age-group within breed stepwise multiple regression (SMR) of MW (gm) on early LBPTs of Sudani and Muscovy ducks

| Equation | $R^2$%* | SE of estimate |
|---|---|---|
| **Sudani's SMRs** | | |
| **At week 2** | | |
| MW = -6830.6 + 730.2 KL | 61 | 322.6 |
| MW = -7778.7 + 993.3 KL – 10.4 BW | 74 | 261.8 |
| MW = -6327.8 + 403.5 KL – 18.4 BW + 1676.5 BG | 79 | 238.9 |
| **At week 4** | | |
| MW = -4321.0 + 1199.0 BG | 63 | 311.7 |
| MW = -3359.8 + 1507.7 BG – 179.4 KL | 68 | 292.0 |
| MW = -3469.2 + 1256.0 BG – 202.0 KL + 2.8 BW | 71 | 279.5 |
| **At week 6** | | |
| MW = -3764.6 + 6.26 BW | 0.75 | 259.3 |
| MW = -3742.67 + 3.46 BW + 398.05 BG | 0.79 | 232.3 |
| MW = -2233.41 + 3.12 BW + 703.22 BG – 181.48 KL | 0.88 | 175.3 |
| **Muscovy's SMRs** | | |
| **At week 2** | | |
| MW = 618.3 + 8.1 BW | 74 | 320.6 |
| MW = 3341.6+ 11.2 BW – 230.2 KL | 84 | 247.6 |
| MW = 2086.9 + 10.31 BW- 233.0 KL + 272.8 BG | 85 | 244.4 |
| **At week 4** | | |
| MW = 200.9 + 3.0 BW | 86 | 235.4 |
| MW = 821.1 + 3.1 BW – 38.5 KL | 86 | 231.7 |
| MW = 366.46 +2.95 – 50.61 KL+ 124.98 BG | 87 | 230.3 |
| **At week 6** | | |
| MW = -294.4 + 2.3 BW | 90 | 197.6 |
| MW = 45.6 + 2.4 BW – 18.3 KL | 91 | 195.6 |

*: $R^2$**%**= Coefficient of determination percentage
MW: marketing weight;
LBPTs: early live body performance traits;
BW= body weight (gm), KL: keel length (cm), BG: breast girth (cm);
N per breed: Sudani, 290; Muscovy, 284.

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## الملخص العربي

## استخدام صفات أداء الجسم الحي المبكرة في البط للتنبؤ بالوزن التسويقي لها

جودة فتحى جودة ، وائل على حسن ، خالد عبد المعبود أحمد

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قسم أبحاث تربية الأرانب والرومى والطيور المائية ، معهد بحوث الإنتاج الحيواني، وزارة الزراعة ، الدقى ، الجيزة ، مصر

استخدمت بيانات 574 ذكر بط تمثل عدد 290 طائر من سلالة السوداني و284 طائر من سلالة المسكوفي في تقدير الوزن التسويقي عند عمر 12 أسبوع معتمدا على صفات الأداء الحي عند عمر مبكر والتي تشمل طول العارضة، محيط الصدر ووزن الجسم. قسم البط داخل كل سلالة إلى أربعة مجاميع عمرية هى 2، 4، 6 (تمثل الأعمار المبكرة)، 12 أسبوع (تمثل العمر التسويقي). أظهرت النتائج أن وزن الجسم وطول العارضة ومحيط الصدر تزيد بزيادة العمر. وتلاحظ أن متوسط معدل النمو اليومي لوزن الجسم في المرحلة العمرية من 2-4 أسبوع ، 4-6 أسبوع قد انخفض بالرغم من أن طول العارضة ومحيط الصدر قد زاد في كلا السلالتين. وقد وجد أن معامل الاختلاف لوزن الجسم كان عالياً في كل المرحل العمرية لكل صفات الأداء الحى في كلا السلالتين. بالنسبة لصغار البط على عمر 2 أسبوع ، فإن العلاقة الخطية البسيطة مع الوزن التسويقي قد قدرت مع كل من طول العارضة ($R^2$ = 61%) ، محيط الصدر ( $R^2$= 41%) ووزن الجسم ($R^2$=3%). أظهرت قيمة $R^2$ زيادة وصلت إلى 74% ، 68% ، 79% عند إضافة طول العارضة مع وزن الجسم عند عمر 2 أسبوع ، وإضافة طول العارضة مع محيط الصدر عند عمر 4 أسبوع ووزن الجسم مع محيط الصدر عند 6 أسبوع. الوزن التسويقي لصغار سلالة المسكوفي عند عمر 2 أسبوع يرتبط بعلاقة خطية بسيطة مع طول العارضة ($R^2$=15%) ووزن الجسم ($R^2$=74%). الزيادة فى قيمة $R^2$ إلى 84%، 86، 91% لوحظت عند إضافة طول العارضة مع وزن الجسم عند عمر 2، 4، 6 أسبوع، على التوالي. بينما إضافة متغير ثالث للمعادلة لم يحسن من قيمة $R^2$ بأكثر من 9% سواء على مستوى العمر أو السلالة. على أية حال ، من الناحية العملية ، فإن الوزن التسويقي يمكن التنبؤ به عند عمر أسبوعان اعتمادا على صفات أداء الجسم الحى وخاصة باستخدام طول العارضة في سلالة البط السوداني ووزن الجسم في سلالة البط المسكوفي.