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Comparative Study Between Some Curve Fit Regression Analysis in Predicting Carcass Cuts of Khaki Campbell Drakes Using Some non Invasive Body Measurements

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Abstract: The study pertains to estimating the carcass weight and weights of different carcass cuts using non invasive methods (slaughter weight and breast angle prior to slaughter). The results indicate that the accuracy of the breast angle to assess the weights of the neck, thorax, pectoral muscles and liver, are higher than the body weight itself, indicating a significant response to selection between the traits studied and the breast angle. The results for the hind region of the carcass (drumsticks and lumber were better predicted using the slaughter weight. In all the cases the quadratic curve fit equation proved to be the best estimator, except for assessing the weight of the lumber region which was better estimated using the compound, power, growth, exponential and logistic curve fit equation, however the results are only slightly better than those obtained using the quadratic regression equation.

Key words: Khaki Campbell drakes · Curve fit regression equations · Slaughter traits · Eastern India

INTRODUCTION

Ducks are reared under semi intensive management system of management. Khaki Campbell ducks are specialized egg laying breed which were developed from Indian Runner and Rouen ducks. The state of West Bengal (India) is situated in the Eastern part of the country; the state harbors the highest duck population within the country, Anon. [1]. The state is characterized by hot and humid climate the year round. Ducks are traditionally reared by almost every rural household in the Southern part of the state. Almost all the villages in the region have ponds and water bodies where the ducks fend for insects and mollusks. The ducks form an integral part of the livestock population. The duck eggs are consumed as a delicacy and fetch a higher price than the eggs from chickens, the demand for eggs (chicken and ducks) are expected to increase in the coming decades, Dastagiri [2] .This further demands for intensification of duckery as has happened for the fowl industry . However, it was also realized that the extra drakes which are hatched can be potential sources of meat especially when the demand of the meat is also rising. The present study was conducted to predict the efficiency of linear and some non linear regression methods that can be used to predict the weight of the carcass and also different carcass cuts using non invasive methods (body weight at slaughter and breast angle) of estimating the same. The estimation of carcass weight using the breast angle is based on the theory of correlated response to selection, were increase in one variable leads to increase/ decrease in another unselected variable. When two traits are genetically correlated, a change in mean genotypic value of one is accompanied by change in another.

The results as obtained from the study can be used to estimate the weight of the different carcass cuts that can be obtained from drakes which are otherwise not used for breeding.

MATERIALS AND METHODS

The study pertains to forty five Khaki Campbell drakes which were reared at a commercial farm in Eastern India. The ducklings were obtained from duck breeding farm, situated at Gobordanga, maintained by Government of West Bengal. The ducklings were reared on self

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formulated ration as containing 70% crushed maize, 5% broken rice, 15% soybean cake, 5% linseed cake, 3% sunflower cake and 2% vitamins and minerals (the same was fortified further with L Lysine and DL Methionine). The ration was provided along with rice bran at a ratio of 90:10 (mash: rice bran). The ration was mixed with water and given to the ducklings twice a day in plastic containers. They were enclosed in a netted brooding house and had access to water so that they would take a dip in the same. After the ducklings were three weeks old and could defend themselves they were allowed access to the water bodies for some time every day the duration of which was increased gradually. The ration was changed to 80: 20 (mash: rice bran) after they were a month old and later to 70:30 (mash: rice bran) after the ducks were around three months old. Both the sexes were allowed free access to water bodies (pond) from 9 AM till 15:00 hrs. During this time the ducklings had free access to mollusks and different insects and worms. They were housed in a netted enclosure during the night. During which they had free access to drinking water.

The drakes were slaughtered at 28 weeks of age. The drakes were slaughtered by severing their carotid arteries and jugular veins and allowed to bleed. The breast angle was estimated using a modified caliper as suggested by Macjowski and Zieba [3]. The body weight was estimated using a digital balance with an error margin of ±1 gram. The carcass was cut up into different parts viz. neck (region from the atlas vertebrae till just prior to the thoracic vertebrae), thoax (the region from the first thoracic vertebrae till just prior to the first lumbar vertebrae), lumber(the region from the first lumbar vertebrae till the last lumbar vertebrae or just prior to the first coccigeal vertebrae), drum sticks (the region just below the thighs and above the shanks), breast muscles (pectoral muscles).

The curve fit equations those were estimated were (logarithmic, inverse, quadratic, compound, sigmoid, growth, exponential and logistic). The efficacy of each regression equation was estimated using the coefficient of determination values (R^2) . The data was analyzed using SPSS V12 for Windows.

RESULTS AND DISCUSSION

The results pertaining to the carcass quality of Khaki Campbell drakes are presented in Table 1. The study indicates that the average body weight of the Khaki Campbell drakes fall within the range as reported by Ksążkiewicz [4]. The average values for the dressing percentage as obtained is less than those obtained by Książkiewicz [4] and Omojola [5]. This might be attributed to the method of dressing of the carcass. Conventionally the dressing percentage of fowls is calculated with the skin on the carcass and that the feathers are only plucked out. However, in the present study the carcass was skinned resulting into low dressing out percentage. Moreover, the low dressing percentage may also be attributed to high temperature and humidity conditions prevailing in the region. Pingel [6] was in opinion that there was a significant genotype by environmental interaction in ducks, there is depress in growth of duck when they are exposed to high temperature.

The weight of the intestine increased in ducks reared under the present study (176.5±28.95) which amounts to; 12.12 % of the live weight. It was observed by Huisman *et al.* [6] and also by Van der Klis *et al*. [7] that the gastrointestinal tract has different possibilities to adapt or to react morphologically to changing conditions such as diet is altered, while Koninkx *et al.* [8] observed that intestinal morphology can change due alteration in the composition of the of intestinal

Table 1: Descriptive statistics indicating the weight before slaughter, breast angle before slaughter, carcass cuts and carcass weight.

	Minimum (grams)	Maximum (grams)	Mean ± SD
WBS	1220	1624.0	1456. ±172.65
BABS (DEGREES)	70	90	80.62±8.75
WNk	76	99	85±9.89(5.83)
WTo	170	210	190±.18.26(13.04)
WDs	220	261	237±.17.34(16.27)
WBr	178	202	192. ±10.87(13.18)
WLu	68	86	77.25±7.63(5.3)
WTe	.05	14	6.90±3.65(.47)
WLi	28	62	47.5±15.3(3.26)
WC	741	850	796.5±51.82(54.7)

Table 2: Curve fit equations predicting weight of the carcass, with Weight at slaughter and Breast angle at slaughter as predictors.

	Weight of the carcass			
	Weight at slaughter		Breast angle at slaughter	
Type	R^2	Equation	R^2	Equation
Linear	.232	454.49 - .4893(x)	.194	21.43+.0743(x)
Log	.227	2632.1-384.4 In(x)	.204	-324.52+(60.66In (x))
Inverse	.221	-314.62-301208/(x)	.215	142.85-49403/(x)
Quadratic	.375	$-10912+28.17(x)-.018\ (x^2)$	.991	$-4432+11.3(x)-.0071(x^2)$
Compound	.263	$44026.8-.9915^{(x)}$	.205	$37.31+1.001^{(x)}$
Power	.261	$1.9e^{21}\ (x)^{-6.75}$	.216	$.4259\ (x)^{0.7844}$
S	.260	$e^{-2.81+5341.26\ /\ (x)}$	.227	$e^{5.189-638.3/(x)}$
Growth	.263	$e^{10.69-.0085\ (x)}$	.205	$e^{3.619+.001(x)}$
Exponential	.263	$44026.8X-..0085^{(X)}$	.205	$37.31\ X.0010^{(x)}$
Lgistic	.263	$1/796.5+e.^{0.000023+1.0086\ (x)}$	.205	$1/796.5+e.^{-0.268+\ .999(x)}$

Table 3: Curve fit equations predicting weight of the neck region,with Weight at slaughter and Breast angle at slaughter as predictors.

	Weight of the neck			
	Weight at slaughter		Breast angle at slaughter	
Type	R^2	Equation	R^2	Equation
Linear	.13	228.1 -1.922(x)	.818	12.68+.7993(x)
Log	.112	759.3-(156.5 In(x))	.843	-235.55+(71.25ln (x))
Inverse	.095	-84.06+12528.9/(x)	.867	155.46-6301.3/(x)
Quadratic	.661	$-4729.6+111.6(x)-.642(x^2)$	.978	$-440.09+11.16(x)-.0587(x^2)$
Compound	.411	$5700.7+.946^{(x)}$	.796	$34.53+1.01^{(x)}$
Power	.381	$6.1e^{10}\ (x)^{-4.71}$	.823	$1.576\ (x)^{0.8857}$
S	.351	$e^{-.777+394.63\ /\ (x)}$	.849	$e^{5.317-78.44/(x)}$
Growth	.411	$e^{8.65-.0557\ (x)}$	.796	$e^{3.542+.0099(x)}$
Exponential	.411	$5700.7X-.0557^{(X)}$	.796	$34.533\ X.0099^{(x)}$
Logistic	.411	$1/85+e.^{-0.0002+.1.057\ (x)}$	.796	$1/85+e.^{.029+\ .9901(x)}$

Table 4: Curve fit equations predicting weight of the thorax region,with Weight at slaughter and Breast angle at slaughter as predictors.

	Weight of the thorax			
	Weight at slaughter		Breast angle at slaughter	
Type	R^2	Equation	R^2	Equation
Linear	.182	298.45 -1.23(x)	.174	42.62+.0200(x)
Log	.175	1261.19-(228.17 In(x))	.193	-128.66+(39.91ln (x))
Inverse	.166	-157.98-.42024.8/(x)	.213	122.54-7908.8/(x)
Quadratic	.273	$-2987.8+33.6(x)-.0917\ (x^2)$	.997	$-1600.5+17.61(x)-.0458(x^2)$
Compound	.200	$2739.8+.979^{(x)}$	.187	$48.90+1.002^{(x)}$
Power	.199	$6e^{10}\ (x)^{-3.988}$	.207	$5.273\ (x)^{0.519}$
S	.198	$e^{-.063+749.55\ /\ (x)}$	.228	$e^{4.929-102.71/(x)}$
Growth	.200	$e^{7.915-.0211\ (x)}$	.187	$e^{3.8899+.0026(x)}$
Exponential	.200	$2739.8X-.0211^{(X)}$	.187	$48.91\ X.0026^{(x)}$
Logistic	.200	$1/190+e.^{.0004+.1.02\ (x)}$	.187	$1/190+e.^{-0204+\ .9974(x)}$

Table 5: Curve fit equations predicting weight of the breast muscles,with Weight at slaughter and Breast angle at slaughter as predictors.

	Weight of the breast muscle			
	Weight at slaughter		Breast angle at slaughter	
Type	R^2	Equation	R^2	Equation
Linear	.854	924.95 -4.48(x)	.022	57.57+.1201(x)
Log	.862	4553.01-853.89 In(x))	.018	-26.36+(20.35ln (x))
Inverse	.869	-783.49+162463/(x)	.014	98.36-3397.1/(x)
Quadratic	.921	$8169.52-80.9(x)+.2012\ (x^2)$	.952	$4535.8-47.14(x)+.1244(x^2)$
Compound	.801	$4.1e^7+.9315^{(x)}$	.020	$60.95+1.0014^{(x)}$
Power	.801	$2.6e^{32}\ (x)^{-13.46}$	.016	$22.59\ (x)^{.2412}$
S	.799	$e^{-9.39-2547.4\ /\ (x)}$	.012	$e^{4.59-.39.87/(x)}$
Growth	.801	$e^{17.53-.071\ (x)}$	.020	$e^{4.11+.0014(x)}$
Exponential	.801	$4.1\ e^{7}X-.071^{(X)}$	.020	$60.95\ X.0014^{(x)}$
Logistic	.801	$1/192+e.^{2.4e(-8)+.1.0735\ (x))}$	.020	$1/192+e.^{-(0164+\ .9986(x)}$

Table 6: Curve fit equations predicting weight of the drum sticks, with Weight at slaughter and Breast angle at slaughter as predictors.

	Weight of the drum sticks			
	Weight at slaughter		Breast angle at slaughter	
Type	R^2	Equation	R^2	Equation
Linear	.109	302.538 -1.0033(x)	.55	-8.05+.374(x)
Log	.098	1315.61-(228.84 In(x))	.543	-409.71+(89.70ln (x))
Inverse	.086	-154.57+ 51778.9/(x)	.536	171.35-21419/(x)
Quadratic	.608	$-10126+85.6(x)-.179\ (x^2)$	.575	$381.52-2.86(x)-.0067(x^2)$
Compound	.373	$66356+.9701^{(x)}$	.515	$27.28+1.0046^{(x)}$
Power	.353	$4e^{18}\ (x)^{-7.12}$	.508	$.2062\ (x)^{1.09}$
S	.333	$e^{-3.1331+1662.67\ /\ (x)}$	.500	$e^{5.4883-260.41/(x)}$
Growth	.373	$e^{11.102-.0304\ (x)}$	.515	$e^{3.306+.0046(x)}$
Exponential	.373	$66356X-.0304^{(X)}$	.515	$27.28\ X.0046^{(x)}$
Logistic	.373	$1/237+e.^{-.000015+1.0308\ (x)}$	.515	$1/237+e.^{.0367+\ .9955(x)}$

Table 7: Curve fit equations predicting weight of the lumber region, with Weight at slaughter and Breast angle at slaughter as predictors.

	Weight of the lumber region			
	Weight at slaughter		Breast angle at slaughter	
Type	R^2	Equation	R^2	Equation
Linear	.822	-418.53 + 6.25(x)	.027	95.26-.189(x)
Log	.800	-1987.3+(472.46 In(x))	.040	156.57-(17.48ln (x))
Inverse	.777	526.98-35442/(x)	.054	60.32+1556.42/(x)
Quadratic	.927	$1909.94-54.73(x)+.396\ (x^2)$	.872	$1192.55-28.93(x)+.1868(x^2)$
Compound	.928	$.0112+1.1148^{(x)}$	.019	$93.52+.998^{(x)}$
Power	.928	$1e^{-14}\ (x)^{8.32}$	.029	$182.28\ (x)^{-.1888}$
S	.926	$e^{12.16-632.62\ /\ (x)}$	.042	$e^{4.161+17.21/(x)}$
Growth	.928	$e^{-4.48+.1087\ (x)}$	.019	$e^{4.54-.002(x)}$
Exponential	.928	$.0112X0.1087^{(X)}$	.019	$93.523\ X-.002^{(x)}$
Logistic	.928	$1/77.25+e.^{89.0+897\ (x))}$	.019	$1/77.25+e.^{.011+\ 1.002(x)}$

Table 8: Curve fit equations predicting weight of the liver, with Weight at slaughter and Breast angle at slaughter as predictors.

	Weight of the liver			
	Weight at slaughter		Breast angle at slaughter	
Type	R^2	Equation	R^2	Equation
Linear	.09	113.77 -1.032(x)	.332	64.95+.3299(x)
Log	.049	189.41-(32.7 In(x))	.414	20.6577+(15.71ln (x))
Inverse	.02	45.39+835.87/(x)	.489	96.51-685.89/(x)
Quadratic	.548	$-365.74+22.42(x)-.26(x^2)$	.847	$-19.49+4.46(x)-.046(x^2)$
Compound	.144	$137.65+.98^{(x)}$	.351	$65.54+1.0043^{(x)}$
Power	.108	$1019.67\ (x)^{-.791}$	.436	$37.025\ (x)^{0.2028}$
S	.074	$e^{3.3+26.26/(x)}$	.513	$e^{4.59-8.841/(x)}$
Growth	.144	$e^{4.92-.0214(x)}$	.351	$e^{4.18+.0043(x)}$
Exponential	.144	$137.65X-.0214^{(X)}$	.351	$65.544\ X.0043^{(x)}$
Logistic	.144	$1/47.5+e.^{.0073+1.02(x)}$	.351	$1/47.5+e.^{-(0153+.9957(x)}$

microflora. While Ferraris *et al*. [8] opined that the intestine possesses an inherent ability to create and maintain regional differences with regards to mucosal structure, the intestine can change its surface by growing in length and/or by increasing or decreasing the height of its villi. While Van Djik *et al* [9] observed that shortening and fusion of villi will result in loss of surface for digestion and absorption of food The weights of the different carcass cuts as obtained in the study could not be compared due to difference in carcass cuts as have been carried out by different authors. The foraging behavior of drakes under the present system often resulted in increase in the gut weight and therefore leading to decrease of dressing percentage as observed in the present study.

The results pertaining to assessing the weight of the carcass using the two non invasive estimators are presented in Table 2. The results pertaining to the estimation of carcass weight based on the weight at slaughter and breast angle at slaughter indicates that the quadratic regression equation provided a better estimator than all the curve fit equations studied. However, the results indicated that the coefficient of determination (R^2) values as obtained with the breast angle as an estimator was significantly higher than the values obtained from taking the slaughter weight as estimator. The significance of breast angle as a predictor for body weight in avian species was also reported by Rouvier, [10]; Bordas *et al*. [11] and Komender and Grashorn, [12], Siegel [13] and Heath and Owens [14].

The results pertaining to assessing the weight of the neck using the two non invasive estimators are presented in Table 3. The weight of the neck as obtained in the study can also be best predicated by the quadratic regression equation and the breast angle again is a better predictor when compared to the body weight at slaughter. The R^2 values as obtained indicates that the breast angle is a better predictor for the trait in comparison to the slaughter weight, however the accuracy is lower than the results as obtained for the whole carcass weight.

The results pertaining to assessing the weight of the thorax using the two non invasive estimators are presented in Table 4. The results also indicate that the accuracy for estimating the weight of the thorax is higher for the quadratic curve fit equation and the R^2 values being the highest amongst all those calculated. It may be ascribed because the breast angle and the weight of the thorax are correlated traits. The larger is the angle means more surface area of the region thereby increases in weight for the same. The R^2 value with respect to slaughter weight too is high but lesser in comparison to the values as obtained for the breast angle.

The results pertaining to assessing the weight of the breast muscles using the two non invasive estimators are presented in Table 5. The results pertaining to weight of the pectoral (breast muscles) and both the traits indicate that the R^2 values are higher for the quadratic curve fit equations however the difference between the slaughter weight values and those obtained using the breast angle is quite narrow, indicating that slaughter weight can be effectively used as a predictor of reasonable accuracy in this case.

The results pertaining to assessing the weight of the drumsticks using the two non invasive estimators are presented in Table 6. The R^2 values pertaining to estimating weight of the drumsticks indicate that the accuracy for the region is higher for quadratic regression analysis however lower than the values obtained ahead for the other carcass cuts. The results further indicate that the slaughter weight is a better predictor in comparison to the breast angle. This indicates that the influence of the breast angle as a predictor decreases at the hind region of the carcass.

The results pertaining to assessing the weight of the lumber region using the two non invasive estimators are presented in Table 7. The R^2 values for weight of the lumber region of Khaki Campbell drakes indicate that the compound, power, growth, exponential and logistic curve fit equations have similar accuracy for the trait and are slightly better than the quadratic regression analysis as obtained using the slaughter weight as a predictor. The results for the breast angle as a predictor indicate that the R^2 value for quadratic curve fit equation was higher than the other curve fit equations. However, the R^2 values as obtained using the breast angle were lower than those obtained taking the body weight as a predictor.

The results pertaining to assessing the weight of the liver using the two non invasive estimators are presented in Table 8. The R^2 values for determining the weight of the liver taking the slaughter weight and breast angle indicates that the later is a better predictor than the former for the trait. It may be attributed to the earlier observations where the breast angle proved to be a better predictor for the thorax region.

Summary: The results indicate that breast angle can be effectively used as a predictor for economically important carcass trait like breast muscle however the weight of the drum sticks are better predicted using the slaughter weight . The study shows that amongst all the curve fit regression equations the better predictor is the quadratic equation, where as slightly better results were obtained using the slaughter weight and compound, power, growth, exponential and logistic curve fit equations the accuracy being the same for all the cases.

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