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Comparative Efficiency of Linear and Some non Linear Equations in Predicting Body Weight of Mule Duck at 21, 28, 35, 42, 49 and 56 Days Using Breast Angle at Corresponding Ages as a Predictor

Sandip Banerjee

Present address: Department of Animal and Range Science, Hawassa University, Ethiopia

Abstract: The study was conducted on Vigova Super M ducks reared for meat. The body weight of the birds was assessed using their breast angle. Breast angle at 21 days was used to predict the body weight at 21,28, 35,42,49 and 56 days. Similarly breast angles at 28, 35, 42, 49 and 56 days were used for prediction of body weight. The data was analyzed using linear, logarithmic, exponential, inverse, power, quadratic, logistic, compound, growth and sigmoid curve fit analysis. The results indicated that the growth of the ducks is different at different phases of life. Quadratic regression analysis has a better prediction (R^2) value than the others at most of the times.

Key words: Vigova Super M · Linear and non linear regression equations · Body weight and breast angle

INTRODUCTION

Ducks are amongst the popular avian species that are reared in eastern part of India. The ducks are reared both for their meat and eggs. West Bengal harbors the largest duck population in India [1]. The ducks are reared mostly under semi intensive management system. There is an escalation in the demand for animal sources of protein; hence duck rearing is becoming popular amongst the members of various self help groups in India. .Vigova super-M is a type of duck that has been imported to India from Vietnam, the duck is ideally suited for the humid climate of India and is reared for its good quality meat.

Muscle from the breast region (*m. pectoralis .superficialis* and *m. pectoralis profundus*)of the avian species can be used as a predictor for body weight [2-4] Breast muscle is the most important carcass part from the economic standpoint; its prediction is also of primary importance in economic modeling in order to optimize production and processing decisions [5]. The growth of the ducks differ from species to species, with the Peking exhibiting growth at an earlier stage of life with a difference in the sexes while on the other hand the Muscovy ducks grow slowly at an early age, there is also a difference in the growth of the two sexes. The mule ducks show an intermediate growth rate. The selection of appropriate strains with early maturity and high breast muscle thickness is still on the process, the reason being that the breast muscle thickness is grossly related to the presence of high diameter fast-twitch glyco- lytic (FTG) pectoral muscles which develop at a later stage of life.

Non invasive method of assessment is helpful to collect the slaughter value of the live birds, thus their own information about the

Prediction of marketable weight of ducks (56 days age) at an early stage of life taking breast angle as a predictor at 21 days and later at 28 days can assist in selection of ducklings at an early stage, therefore saving both on feed and managerial resources. Linear regression is the commonly used method to assess body weights at different ages [6,7]. However, growth of any living being is never linear and there are times when a individual grows rapidly and there are also times when the growth is more or less than expected. After a certain age the growth ceases and a plateau is reached. The present study was conducted to compare the linear regression equation with some non linear regression equations viz. logarithmic (log), inverse (Inv), quadratic (quad), compound (comp), power (pow), sigmoid (S), growth (gro), exponential (exp) and logistic (logi).

Corresponding Author: Sandip Banerjee, Department of Animal and Range Science, Hawassa University, Ethiopia B-1/87, Kalyani, Nadia, West Bengal, Pin 741235. India E-mail: sansoma2003@yahoo.co.in sansoma2003@gmail.com Tel: +251916011747 + 913325827092

MATERIALS AND METHODS

The study was conducted at Livestock Instructional Farm under Department of Animal Science, Bidhan Chandra Krishi Viswavidyalaya, Nadia,West Bengal, India. 175 ducklings of Vigova Super M were procured through a local vendor from Central Duck Breeding Farm (CDBF), Hessarghatta. The ration of the ducklings was formulated according to the recommendations of the authorities of CDBF. The ducklings were reared in a semi intensive system of management. They were allowed to forage for themselves and they were also had access to various insects, earthworms in particular.

The ducklings were weighed on a weekly basis. They were weighed prior to their feeding to ensure a empty gut. They were weighed on a pan balance weighing scale with a error margin of 10 grams. The breast angle was taken as per the method suggested by [8,9].

The ducks lings were weighed and their breast angle was estimated on a weekly basis till they attained an age of 56 days.

The data was analyzed using SPSS, V12 [10] to calculate the descriptive statistics and to obtain linear and some non linear regression equations. viz. logarithmic (log), inverse (Inv), quadratic (Quad), compound (comp), power (pow), sigmoid (S), growth (gro), exponential (exp) and logistic (logi). The significance of the regression equations was also assessed.

RESULTS AND DISCUSSIONS

The results pertaining to the body weight and breast angles at different ages are presented in Table 1. It transpires from the table that the average body weight at maturity for the ducklings as obtained in the study are less than those reported by the authorities of the CDBF, it maybe ascribed to the agro climate prevalent in the study area and also due to the semi intensive method of rearing the ducklings [11].

The linear and non linear regression equations obtained for assessing the body weight at 21, 28 and 35, 42, 49 and 56 days of age using the breast angle of 21 days is presented in Table 2.

The results indicate that the coefficient of determination (R^2) values for assessing the body weight using breast angle at 21 days as predictor was highest for quad. The R^2 values for assessing body weight at 28 and 35 days of age taking breast angle of 21 days as predictor indicate that the values were highest for S non linear regression equation . The R^2 values for body weight at 42 days was similar for comp, gro, exp and logi while the values for 49 and 56 days of age indicated higher R^2 values with qua ,non linear regression equation. The present results indicate a rapid growth of the ducklings at an earlier age thus resulting in a lower value of R^2 indicating a rapid growth of the ducklings at this stage and thus the breast angle is a poor estimator to predict body weight correctly. The results pertaining to rapid growth at early stage of life in ducks are in accordance with the results obtained by [12] the period of growth can be termed as acceleration phase in the life of the ducks.

The results pertaining to assessment of body weight at 28, 35, 42, 49 and 56 days using the breast angle of 28 days as a predictor is presented in Table 3. It transpires from the tables that the R^2 values for estimating the same are fairly low in comparison to the corresponding values for estimation through breast angle at 21 days of age. This might be attributed to rapid growth of the ducklings during that particular period i.e. 28 days of age. The results from Table 3 indicate that the R^2 values show a decreasing trend from 28 days till maturity. Thus it can be inferred from the present study the estimation of body weight of the Vigova Super-M ducklings at 35, 42, 49 and 56 days using the breast angle at 28 days may not be accurate.

The results pertaining to assessment of body weight at different ages using the breast angle at 35 days as a predictor are presented in Table 4, the results indicate that the R^2 values are significant only at $P< 0.05$ for assessing the body weight at 35 days and non significant for all ages thereafter, it may be attributed to period of rapid growth and that during the phase there is more growth of the bones than that of the muscles in particular, thus the assessment of body weight using breast angle may not be accurate. The present findings are in consonance with the results obtained by [13], who reported that at four weeks of age the breast muscle make up to 4.9 percent and bones 35.6 percent of the dressed carcass while the muscle percentage was assessed to be 19.4 and 22.3 respectively at eight weeks of age respectively in Pekin drakes. The values for muscle and bones Pekin duck was 5.8 and 35.3 at four weeks of age and 19.6 and 21.6 percent of the dressed carcass at eight weeks of age respectively. Similar observations too were reported by [14], in Pekin ducks.

Table 1: Results pertaining to the range, averages and correlation between breast angle and body weight at different ages in the Vigova Super M ducks

	Breast Angle (degrees)		Body weight (grams)		
Age	Range	Mean ± SD	Range	Mean ± SD	Correlation
3 weeks	30-45	40.5± 6.43	210-400	313 ±68.96	0.873**
4 weeks	50-70	59.5 ±6.43	340-660	502 ±98.18	0.829**
5 weeks	55-80	67± 9.18	500-1000	808 ±159.5	0.882**
6 weeks	65-85	77 ±6.74	650-1200	998 ±171.96	0.899**
7 weeks	65 -90	80.5± 8.6	700-1470	1179 ±201.6	0.877**
8 weeks	70-95	83.5 ±8.51	800-1700	1460 ±266.6	0.719*

**P< 0.01*P< 0.05

Table-2: Comparison between Linear and some non linear regression equations for predicting body weight at 21, 28 and 35, 42,49 and 56 days of age with respect to breast angle at 21 days

	Body weight 21 days		Body weight 28 days		Body weight 35 days	
Type	R^2	Equation	R^2	Equation	R^2	Equation
Linear	.762[a]	$-65.906 + 9.3557(x)$	.596	$24.698+11.785(x)$	.743[a]	$-57.45+21.37(x)$
Log	.748[a]	$-965.05+(346.48\ \ln(x))$	.608	$-1138.5+(444.7\ln(x))$	.756[a]	$-2164.7 + (805.89\ \ln(x))$
Inverse	.730[b]	$632.63 - 12605/(x)$	.617	$920.43-16501/(x)$	.767[a]	$1565.86 - 29887/(x)$
Quadratic	.786[b]	$672.7-30.9(x)+0.53(x^2)$	.630	$-1211.3+79.1(x)-.9(x^2)$	.780[b]	$-2136.4+134.53(x)-1.49(x^2)$
Compound	.784[a]	$82.202+1.033^{(x)}$	.645	$175.92+1.025^{(x)}$	.762[a]	$238.4 + 1.0301^{(x)}$
Power	.769[a]	$3.6425(x)^{1.2009}$	.660	$14.15(x)^{0.9625}$	.780[a]	$12.68(x)^{1.12}$
S	.751[a]	$e^{6.8301-43.688/(x)}$	.674	$e^{7.10-35.80/(x)}$	.796[a]	$e^{7.731-41.67/(x)}$
Growth	.784[a]	$e^{4.4092+0.324x)}$	.645	$e^{5.17+.0254(x)}$	.762[a]	$e^{5.47-0.0296(x)}$
Exponential	.784[a]	$82.2021 \text{ X } 0.0324^{(X)}$	.645	$175.92 \text{ X}.0254^{(x)}$	.762[a]	$238.4 \text{ X } .0296^{(x)}$
Logistic	.784[a]	$1/405+0.0122\text{X}.9681^{(x)}$	.645	$1/670+.0057\text{X } .9758^{(x)}$	.762[a]	$1/1050 + 0.0042 \text{ X } 0.9708^{(x)}$

[a]P< 0.01 [b]P< 0.05

Table-2-contd.

	Body weight 42 days		Body weight 49 days		Body weight 56 day	
Type	R^2	Equation	R^2	Equation	R^2	Equation
Linear	.853[a]	$39.33+23.74(x)$	.537	$248.86+22.97(x)$	.481	$290.336+29.13(x)$
Log	.850[a]	$-2264.6+(885.31\ln(x))$	.551	$-2029+(869.7\ \ln(x))$	.514	$-2679.8 + (1125.0\ \ln(x))$
Inverse	.840[a]	$1823.68-32444/(x)$	.563	$1999.74-32367/(x)$	.546	$2553.16 - 42716/(x)$
Quadratic	.850[a]	$401.1-4.05(x)+0.26(x^2)$	.596	$-3082+204.3(x)+2.4(x^2)$	.771[b]	$-9617.1+568.43(x)-7.1(x^2)$
Compound	.855[a]	$348.64+1.026^{(x)}$	.529	$468.15+1.023^{(x)}$	.487	$533.17 + 1.0249^{(x)}$
Power	.854[a]	$28.59(x)^{.960}$	.545	$50.436(x)^{0.8501}$	.517	$44.011(x)^{0.9457}$
S	.849[a]	$e^{7.789-35.25/(x)}$	.559	$e^{7.86-31.7/(x)}$	.547	$e^{8.18141-35.82/(x)}$
Growth	.855[a]	$e^{5.85+0.0257(x)}$	.529	$e^{6.15+.0224(x)}$	.487	$e^{6.2788+.0245(x)}$
Exponential	.855[a]	$348.64 \text{ X } 0.0257^{(X)}$	.529	$468.14\text{X}.0224^{(x)}$	.487	$533.17 \text{ X } .0245^{(x)}$
Logistic	.855[a]	$1/1250 + 0.0029 \text{ X}.97^{(x)}$	.529	$1/1500+.0021\text{X } .98^{(x)}$	.487	$1/1750+0.0019 \text{ X } 0.9758^{(x)}$

[a]P< 0.01 [b]P< 0.05

Table-3: Comparison between Linear and some non linear regression equations for predicting body weight at 42, 49 and 35 days of age with respect to breast angle at 28 days

	Body weight 28 days		Body weight 35 days		Body weight 42 day	
Type	R^2	Equation	R^2	Equation	R^2	Equation
Linear	.686[b]	$39.33+23.74(x)$	.501	$-236.64+17.56(x)$	.498	$-77.98+18.13(x)$
Log	.683[b]	$-2269.2+(752.6\ \ln(x))$	.511	$-3505+(1056.9\ \ln(x))$	.498	$-3413.4 + (1081.7\ \ln(x))$
Inverse	.678[b]	$1255.2-44353/(x)$	.518	$1877.77-62989/(x)$	.495	$2085.6 - 63864/(x)$
Quadratic	.687	$82.47-1.45(x)+0.09(x^2)$	.526	$-2871.2+106.1(x)-.7(x^2)$	.498	$-340.98+26.98(x)-0.0736(x^2)$
Compound	.647[b]	$108.21+1.026^{(x)}$	.459	$201.41+1.023^{(x)}$	.457	$322.66 + 1.019^{(x)}$
Power	.648[b]	$.992(x)^{1.52}$	.469	$2.76(x)^{1.3867}$	.458	$10.14(x)^{1.122}$
S	.646[b]	$e^{7.7276-89.92/(x)}$	.476	$e^{8.0795-82.72/(x)}$	.456	$e^{8.020-66.266/(x)}$
Growth	.647[b]	$e^{4.68+0.0255(x)}$	.459	$e^{5.305+.0230(x)}$	.457	$e^{5.7766+.0188(x)}$
Exponential	.647[b]	$108.21 \text{ X } 0.0255^{(X)}$	.459	$201.41\text{X}.0230^{(x)}$	.457	$322.66 \text{ X } .0188^{(x)}$
Logistic	.647[b]	$1/670+0.0092\text{X}.9748^{(x)}$	.459	$1/1050 + .005 \text{ X } .9773^{(x)}$	.457	$1/1250 + 0.0031 \text{ X } 0.9814^{(x)}$

[a]P< 0.01 [b]P< 0.05

Table-3-contd.

	Body weight 49 days		Body weight 56 days	
Type	R^2	Equation	R^2	Equation
Linear	.380	29.73+19.31(x)	.140	535.57+15.70(x)
Log	.366	-3439.9+(1131.88 In(x))	.144	-2407.9+(950.299 ln (x))
Inverse	.352	2293.18-65604/ (x)	.148	2437.68-56978/(x)
Quadratic	.433	$4942.77-145.9(x)+1.37(x^2)$	.154	$-2839.1+129.21(x)-.945(x^2)$
Compound	.307	$420.28+1.017^{(x)}$	.135	$667.55+1.0133^{(x)}$
Power	.297	$19.54 (x)^{1.0007}$	.138	$59.98(x)^{0.779}$
S	.285	$e^{8.0416 -58.007 / (x)}$	.140	$e^{8.0622- 46.47/(x)}$
Growth	.307	$e^{6.041 +0.0171(x)}$	.135	$e^{6.50+.0.0129(x)}$
Exponential	0.31	$420.28 X 0.0171^{(X)}$	.135	$667.55X.0129^{(x)}$
Logistic	.307	$1/1500+0.0024X .9831^{(x)}$	.135	$1/1750 +.0015 X .9872^{(x)}$

[a]P< 0.01 [b]P< 0.05

Table 4: Estimation of body weight at different age using breast angle at 35 days of age and predicting body weight at 35, 42, 49 and 56 days.

	Body weight 35 days		Body weight 42 days	
Type	R^2	Equation	R^2	Equation
Linear	.779[a]	-218.16 +15.316(x)	.686[b]	2.171+14.91(x)
Log	.795[a]	-3483.5+(1022.73 In(x))	.700[b]	-3175.6+(995.36ln (x))
Inverse	.809[b]	1832.65 -67470/ (x)	.712[b]	1997.67-65628/(x)
Quadratic	.817[b]	$-2610.5+88.25(x)-0.55 (x^2)$	.722	$-2400.5+88.1(x)-.55(x^2)$
Compound	.734[a]	$202.42+1.021^{(x)}$	.666[b]	$340.6+1.016^{(x)}$
Power	.756[a]	$2.5686 (x)^{1.3658}$	.683[b]	$11.389 (x)^{1.0635}$
S	.777[a]	$e^{8.04911-90.512 / (x)}$	.698[b]	$e^{7.9628-70.301 /(x)}$
Growth	.734[b]	$e^{5.3103 +0.0204(x)}$	.666[b]	$e^{5.83+.0.0159(x)}$
Exponential	.734[b]	202.42 X 0.0204(X)	.666[b]	340.6X.0159(x)
Logistic	.734[b]	1/670+0.0049X.9798 (x)	.666[b]	1/1050+.0029X .984(x)

[a]P< 0.01 [b]P< 0.05

Table 4: contd

	Body weight 49 days		Body weight 56 days	
Type	R^2	Equation	R^2	Equation
Linear	.441	203.09+14.566(x)	.298	394.47+16.05(x)
Log	.469	-2990.4 + (993.63 In(x))	.325	-3178.6+(1107.86 In(x))
Inverse	.497	2193.85 -66825/(x)	.353	2617.02 -75528/ (x)
Quadratic	.665	$-7136.9+238.3(x)-1.67 (x^2)$	.542	$-9862.2+328.737(x)-2.3424 (x^2)$
Compound	.416	$456.74 +1.014^{(x)}$	.304	$580.20+1.0137^{(x)}$
Power	.445	$21.52 (x)^{0.9503}$	.330	$28.3921 (x)^{0.9358}$
S	.472	$e^{8.0283- 63.99/(x)}$	.358	$e^{8.2406-63.717 / (x)}$
Growth	.416	e 6.124+.0.0139 (x)	.304	$e^{6.3634 +0.0136(x)}$
Exponential	.416	456.74 X .0139 (x)	.304	580.204 X 0.0136(X)
Logistic	.416	1/1250+0.0022X 0.9862 (x)	.304	1/670+0.0017X.9865 (x)

Table 5: Estimation of body weight using breast angle of 42 days of age as a predictor and estimating body weight 42, 49 and 56.

	Body weight 42 days		Body weight 49 days		Body weight 56 days	
Type	R^2	Equation	R^2	Equation	R^2	Equation
Linear	.808[a]	-694.88 +22.02(x)	.780[a]	-853.05+26.39(x)	.402	-483.17+25.366(x)
Log	.821[a]	-6230.3+(1666.12In(x))	.796[a]	-7498.4+(1999.29ln (x))	.428	-7059+ (1965.12 In(x))
Inverse	.833[a]	2637.75 -125116/ (x)	.810[a]	3146.93-150432/(x)	.455	3446.72 -151104/(x)
Quadratic	.852[a]	$-5787.8+158.1(x)-0.9 (x^2)$	.832[b]	$-7604.5+206.78(x)-1.12(x^2)$	.694	$-22028+601.05(x)-3.81 (x^2)$
Compound	.814[a]	$156.61+1.0242^{(x)}$	.736[a]	$166.8+1.0255^{(x)}$	.431	$264.554 +1.0223^{(x)}$
Power	.831[a]	$.3773 (x)^{1.8133}$	.757[a]	$0.2825 (x)^{1.9171}$	.445	$0.8989 (x)^{1.7055}$
S	.847[a]	$e^{8.6806-136.48 / (x)}$	.778[a]	$e^{8.9520 -144.1 /(x)}$	.472	$e^{89887- 131.15(x)}$
Growth	.814[a]	$e^{5.0538 +0.0239(x)}$	.736[a]	$e^{5.1167+.0.0252(x)}$	.416	$e^{5.578+.0.0220 (x)}$
Exponential	.814[a]	156.613 X 0.0239(X)	.736[a]	166.8X.0252(x)	.416	264.55X .022 (x)
Logistic	.814[a]	1/670+0.0064X.9764 (x)	.736[a]	1/1050 +.0060 X .9751(x)	.416	1/1250 +0.0038 X 0.978 (x)

[a]P< 0.01 [b]P< 0.05

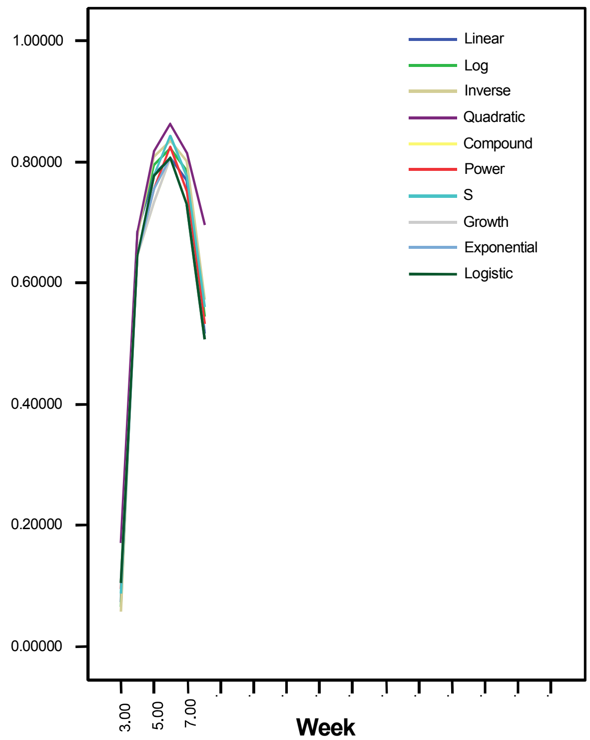

Fig. 1: Regression prediction curve for estimating body weight at different ages taking breast angle as a predictor, Y axis indicates the R2 values at different ages (X axis) with respect to different regression curves

The R^2 values for assessing the body weight of the ducks taking the breast angle at 42 days as a predictor are presented in Table 5, the results indicate that the estimation using qua regression equation is better than all other types of estimators. The prediction value however decreases with age and the value is significant at 42 and 49 days only, indicating that the muscle development, however the growth is not as rapid as that of the earlier weeks, ie. 4^{th} and 5^{th} week of age .

Figure 1. Regression prediction curve for estimating body weight at different ages taking breast angle as a predictor, the values at X axis indicate the age in weeks while the R2 values are presented in Y axis The results pertaining to R^2 values taking the breast angle at 49 days as the predictor for body weight at 49 and 56 days are presented in Table 6. The results indicate that the qua regression equation provides the best estimator for the body weight at both 49 and 56 days respectively, at $P<0.01$.

The results pertaining to R^2 values for predicting the body weight at 56 days keeping the breast angle of 56 days as a predictor is also presented in Table 6, the results also suggest that the qua regression equation has a higher R^2 value than all other predictors. This may be also attributed to growth of different muscles at different stages of life; the results are in consonance with the observation of [15].

The results from the present study indicates that the pattern of growth is sigmoid with times when the growth of the ducklings are more rapid than that of other times, the present findings are similar to that obtained by [16] and [17]. The present findings of rapid growth of ducks early in their life is in agreement with the results obtained by [18-20].

The rapid growth of the ducks can be attributed to their evolutionary character. The ancestors of the birds being migratory in nature usually flew long distances for food and they were semi aquatic in nature needed the young ducklings to grow fast and deposit high amount of body reserves to take cope up with the demand for strong muscles and long bones to fly long distances, the observations are in consonance with those of [21].

Table-6: Estimation of body weight at 49 and 56 days taking breast angle at 49 days as predictor and breast angle at 56 days as predictor and body weight at 56 days*

	Body weight 49 days		Body weight 56 days		Body weight 56 days*	
Type	R^2	Equation	R^2	Equation	R^2	Equation
Linear	.769[a]	-467.5 +20.45(x)	.466	-247.73+21.33(x)	.514	-430.34+22.758(x)
Log	.786[a]	-5850.9+(1603.97In(x))	.504	-6076.7+(1721.89ln (x))	.544	-6896.5+ (1892.9 In(x))
Inverse	.801[a]	2743.93-124578/ (x)	.543	3196.8-137463/(x)	.573	3353.8 -155741/(x)
Quadratic	.816[a]	$-5069.1+139.6(x)-0.76 (x^2)$	.832 [a]	$-18121+484.15(x)-.2.96(x^2)$	.722	$-13177+339(x)-1.941 (x^2)$
Compound	.730[a]	$239.9+1.0198^{(x)}$	.486	$331.5+1.018^{(x)}$	.504	$297.94 +1.0191^{(x)}$
Power	.753[a]	$1.3379 (x)^{1.5436}$	.525	$2.27 (x)^{1.4724}$	.533	$1.399 (x)^{1.569}$
S	.776[a]	$e^{8.5705-120.53 / (x)}$	.565	$e^{8.7492 -117.51 /(x)}$	.560	$e^{8.834- 129.07(x)}$
Growth	.730 [a]	$e^{5.4803+0.0196(x)}$	.486	$e^{5.8036+.0.0183(x)}$	.504	$e^{5.6969+.0.0189 (x)}$
Exponential	.730 [a]	239.91 X 0.0196(X)	.486	331.5X.0183(x)	.416	297.94 X .0189 (x)
Logistic	.730 [a]	1/670+0.0042X.9806 (x)	.486	1/1050 +.0030 X .9819(x)	.416	1/1250 +0.0034 X 0.981 (x)

[a]$P< 0.01$ [b]$P< 0.05$

They reported that in Pekin ducks there are two types of pectoral muscles fast-twitch oxidative glycolytic (FTO) and IIB or fast-twitch glyco- lytic (FTG) differ in their aerobic capability. The numbers of FTG are higher in ducks that have a short bursting flight have been reported by [22-25]. It was observed by [15] that the average fiber diameter of the FTO muscles are lesser than FTG muscle fibers at all ages, they also reported that the FTG fibers do not develop till 20 days of age in Pekin ducks and thereafter there is fluctuation in the numbers of FTG muscles. They also observed that both the muscle fibers showed a sigmoid growth pattern.

The result from the present study is helpful to selecting the boy weight at maturity for ducklings of Vigova Super-M strain at different stages of their growth using a non invasive method of assessing breast angle. Non invasive methods, linear and non linear mathematical or statistical functions can provide estimates for target variables using one or more easily measurable non invasive body traits. It was observed by [26] that regression models can be used to predict carcass, breast and leg weights utilizing data on body conformation traits and weight at different age.

[27], was in opinion that the late intensive growth of the breast muscle is related to the growth of the wings which are necessary for the flight of the ducks. There are also studies which indicate that the percentage of breast muscle increase is more than the percentage of decrease in leg muscle as the duck matures in age.

However, there is possibility of improving the breast muscle proportion in ducks through selection programmes. Initiation of such projects can assist in obtaining higher breast muscle thickness and maturity at an earlier age.

CONCLUSION

The present study indicates that the quadratic non linear regression equation serves as a better predictor than linear and most of the non linear regression equation studied if breast angle is taken as a predictor. The growth of the Vigova Super M duck shows a sigmoid pattern and the growth is fast at early stage of life.

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REFERENCES

1. Muthukumar, S.P and A.K. Dev Roy, 2009. Alternate poultry production in India. All India Poultry Business Directory. 3rd Edn. Sadana Pub www. dairyyearbook. com/ poultry News1. aspx , assessed on 10th August 2010)
2. Siegel, P.B., 1962. A Double selection experiment for body weight and breast angle at eight weeks of age in chickens Gen., 47: 1313-19
3. Ricard, F.H. and R. Rouvier, 1970. Study of anatomical composition of chicken. Ann. Génét. Sél. Anim., 1: 151-165.
4. Komender, P. and M. Grashorn, 1990. Ultrasonic measurement of breast meat. In: Poult. Int., 29: 36- 40.
5. Zuidhof, M.J., 2005. Mathematical Characterization of Broiler Carcass Yeild Dynamics Poult. Sci., 84:1108- 22.
6. Wolf, J. and H. Knižetová, 1994 Crossbreeding effects for body weight and carcase traits in Pekin duck . British Poultry Sci., 35(1): 33-45.
7. Raji, A.O., J.U. Igwebuike and M.T. Usman, 2009 Zoometrical body measurements and their relation with live weight in matured local Muscovy ducks in Borno state Nigeria. ARPN Journal of Agricultural and Biological Sci., 4(3): 58-62.
8. Macjowski, J. and J. Zieba, 1982. Genetics and Animal Breeding Part-A. Biological and genetic foundations of animal breeding. Elisever scientific Pub. Co. PWN.Polish Scientific publishers. Warszawa. pp: 30-37.
9. Nyeland, J., A.D. Fox, J. Kahlert and O.R. Therkildsen, 2003: Field methods to assess pectoral muscle mass in moulting geese. - Wildl. Biol., 9: 155-159.
10. SPSS version 12 software (SPSS, Inc. Chicago, IL, USA.
11. Central Poultry Development Organization. 2009. Duck Management Guide. http: // www. cpdosrbng. kar. nic. in/ DUCK% 20 FARMING%20GUIDE. pdf assessed on 10th August 2010.
12. Gille; F. and V. Salomon, 1998. Muscle growth in wild and domestic ducks British Poultry Sci., 39(4): 500 - 5.

13. Pingel, H., 1986. Recent research on the breeding of waterfowl. Proc. of 7th Europ. Poultry Conf. Paris, pp: 70-81.
14. Bochno, R., W. Brzozowski and D. Murawska, 2005. Age-related changes in the distribution of lean, fat with skin and bones in duck carcases. British Poultry Sci., 46(2): 199-203.
15. Gille, U. Franz- Victor Solomon and Sylvia Kattein. 1998. Post hatching myofiber development in the M pectoralis of white Pekin ducks. The Anatomical Record. 250: 154-58.
16. Brody, S., 1945. Bioenergetics and growth. Reinhold Pub. Corp. New York.
17. Knížetová, H., J. Hyánek, L. Hyánková and P. Bìlíèek, 1995. Comparative studies of growth curves in poultry. Genet. Sel. Evol., 27: 365-75.
18. Nixey, C., 1986. A comparison of growth and fat deposition of commercial avian species. 7th European Poultry Conference, Paris.Aug, 24-28. World Poultry Science Association, pp: 671-80.
19. Salomon, F.V., G. Sager, M. Al Hallak and H. Pingel, 1988. Wachstumsspezifische Approximationen 11 K6rperdimensionen bei Gefliigel. 5. Mitteilung: Vergleichende Betrachtung des Wachstums von Huhnern, Enten and Gansen. Arch Gefiügelk 52: 176-180.
20. Shalev, A. and H. Pasternak, 1989. Meat production efficiencies of turkey, chicken and duck broilers. World Poult. Sci., 45: 109-114.
21. Bjornhag, G., 1979. Growth in newly hatched birds. Swed. J. Agic. Res., 9: 121-25-125.
22. Ashmore, C.R. and L. Doerr, 1971 Postnatal development of fiber types in normal and dystrophic skeletal muscle of the chick. Exp. Neurol., 30: 431-436.
23. Salomon, F.V., T.H. Anger, H. Krug, U. Gille and H. Pingel, 1990 Zum Wachstum von Skelett, Ko¨rpermasse und Muskelfaserdurchmesser der Pute (Meleagris gallopavo) vom Schlupf bis zum 224. Lebenstag. Anat. Histol. Embryol., 19: 314-325.
24. Ono, Y., H. Iwamoto and H. Takahara, 1993. The relationship between muscle growth and the growth of different fiber types in the chicken. Poultry. Sci., 72: 568-576.
25. Smith, D.P., D.L. Fletcher, R.J. Buhr and R.S. Beyer 1993. Pekin duckling and broiler chicken pectoralis muscle structure and composition. Poultry Sci., 72: 202-208.
26. Khosravinia, H. N.H.N. Murphy. and M.G. Govindaiah, 2006. Imposing restriction in selection for disproportionate cut-up carcass yield in an experimental flock of broiler chicken. J. Poultry. Sci., 43: 109-119.
27. Pingel, H., 1999. Influence of breeding and management on the efficiency of duck production. Lohmann Information, 22: 7-13.