Study on Effects of Jackfruit Leaves (*Artocarpus heterophyllus*) on Morphology and Growth of Goats and Fitting the Linear Equations

A production report submitted in partial satisfaction of the requirement for the Degree of Doctor of Veterinary Medicine (DVM)

Submitted By:

Abdullah Al Noman

Roll No: 18/05

Reg No: 02062

Intern ID: 05

Session: 2017-18

Faculty of Veterinary Medicine

Chattogram Veterinary and Animal Sciences University

Khulshi, Chattogram – 4225, Bangladesh

Study on Effects of Jackfruit Leaves (*Artocarpus heterophyllus*) on Morphology and Growth of Goats and Fitting the Linear Equations

Approved by:

_____

(Dr. Md. Kabirul Islam Khan)

Professor

Department of Genetics and Animal Breeding

Contents

List of Tables

List of Figures

List of Acronyms

LWT: Live weight

ADG: Average Daily weight gain.

RMSE: Root mean square error.

SE: Standard Error

LSD: Least Significant Difference

R^2: Coefficient of regression

HG: Heat Girth

BL: Body Length

et. al: And his associate.

Abstract

Background: Farmers must adapt to alternative feeding of goats rather than traditional feeding regimes to increase growth performances and reduce costs for rearing goats. This study delves into the impact of incorporating jackfruit leaves (Artocarpus heterophyllus) into the diets of Totapari goats, focusing on growth performance. Furthermore, the study examines morphological traits such as heart girth, body length, and birth weight in male and female Totapari goats. For better decision-making and proper management, the use of mathematical models to predict values from partially or incompletely recorded data can be a great option. The study employs linear and polynomial regression models to predict body weight based on age and feeding regime.

Methods: The study involved feeding two groups of goats: one group received a traditional diet, while the other group's diet included jackfruit leaves. The growth performance of these goats was monitored over a month. The study utilized linear and polynomial regression models to predict body weight. The goodness of fit of these models was evaluated through R-squared values.

Result: The study found that goats fed with jackfruit leaves showed slightly higher growth rates, particularly among younger animals. The quadratic polynomial model was the best fit for predicting body weight, closely followed by the linear model. These models demonstrated high R^2 values, indicating a strong fit to the data.

Keywords: Fit statistics, Models, Live weight, Goats, Jackfruit leaves.

Chapter 1: Introduction

The goat population of Bangladesh is around 14.8 million (Banglapedia, 2021). The available goat breeds in Bangladesh are Black Bengal, Jamunapari, Totapari, Hariyana, and their Crosses. The Totapari goat is a distinctive breed of domestic goat originating in India. Renowned for its unique appearance and valuable attributes. The number of this breed in Bangladesh is not known. The most striking feature of Totapari goats is their remarkable appearance. They are easily identifiable by their pronounced Roman nose, which is a result of their distinctly arched nasal bone. Totapari goat breeds are mostly reared for milk and meat. The reproductive capabilities of Totapari goats are notable. Does often gives birth to twins, and occasionally even triplets. Their ability to produce offspring in multiple births contributes to their economic value in terms of meat and milk production.

Goats feed mostly grasses, bushes, and plants that have developed organically. Common grasses are the principal source of nourishment for goats among these. Most of these grasses can be found on the embankments, roadsides, fallow land, harvested land, and ridges of crop fields. These grasses are protein-deficient and incapable of supporting higher levels of ruminant output in tropical and subtropical areas. It has been demonstrated that adding tree leaves to grass diets will increase animal performance (Alam and Akbar, 1991).

In an era defined by the pressing need for sustainable agricultural practices, the exploration of alternative feed resources and innovative livestock management approaches has gained paramount significance. This study unveils a comprehensive investigation into the effects of incorporating jackfruit leaves (*Artocarpus heterophyllus*) into the diets of goats, with a particular focus on their growth performance.

Growth performance in livestock is a crucial parameter in assessing the overall health and productivity of the animals. Feed quality and composition play a significant role in

determining growth rates. This study examined the impact of feeding jackfruit leaves on the growth rates of goats in comparison to a traditional feeding regime. The decent protein content in jackfruit leaves can help make up for the lower protein levels in many distinct kinds of grasses. For goats to grow, develop their muscles, and maintain overall health, protein is essential. Grasses are a major source of energy since they are high in carbohydrates. Goats' overall energy intake can be increased by combining them with jackfruit leaves, which also have carbs. This will assist goats' daily activities and growth. Green grass and the leaves of jackfruit are both excellent sources of nutritional fiber. The villagers who raise goats have access to tree leaves, which may increase ruminant productivity.

So, it is essential to know the effects of feeding common grasses with jackfruit leaves on the growth performance of Totapari goats. Although there is a lot of variation in productivity within this breed, it is unclear if this variation is due to genetics or environment.

Body weight is a crucial factor in meat animals since it is directly related to income (Cam et al., 2010).

Body measurements are important to reflect breed norms and provide information on the morphological structure and developmental capacity of animals (Riva et al., 2002).

Estimating body weight using body measurements improves both the economic benefit of operations and the selection efficiency (Elmaz et al., 2008).

Mathematical models such as linear regression, multiple regression, logistic, and non-linear models can assist in understanding of farming system by estimating the productivity from the incomplete or partially collected data (Khan and Ahmed, 2010). It also reduces the confusion in calculating the yield by estimating its parameters. The different fit statistics such as R^2, Root Mean Square Error (RMSE), and Co-efficient of variation can be used to study the fitness of actual data. The higher the R^2 value the higher the fitness. (Khan et al., 2012).

Moreover, this study ventures into the realm of quantitative analysis, seeking to establish a meaningful relationship between dietary treatments and goat body weight through the application of linear regression modeling within semi-intensive husbandry conditions.

Therefore, this study was conducted with the objectives.

1. To study the morphological traits of Totapari goats.

2. To compare the average daily weight gain of Totapari goats after feeding jackfruit tree leaves.

3. To find the best-fitted linear models for the assessment of the live weight of Totapari goats.

Chapter 2: Materials and Methods

Study Area and Period: The study was conducted for the period of one month from June 2023 to July 2023 at Raja Hat, South Burischar, Hathazari, Chattogram. The experimental area is between the coordinates 22°24'50.9"N Latitude and 91°52'30.6"E Longitude.

Feeding Regimes and Body Weight Gain: The study was conducted on 10 goats. Where the animals were divided into two feeding regimes. Both groups contain 5 goats which are again divided according to age less than 6 months, 6 months to 1 year, and 3 years and above.

Group A (non-treatment group): This group was fed normal feeding regimes containing common grass and concentrate mix (wheat bran, maize crush, vitamin-mineral premix).

Group B (treatment group): This group was fed with green grass, concentrate mix was replaced with 100 gm of jackfruit leaves given twice daily.

Before the study, both groups were adjusted to this feeding system for 7 days.

Determination of Growth performance: The feeding trial was continued for 30 days and goats' body weight was determined every 10 days intervals. The animals were weighed in the morning before feeding by a balance.

Then the average daily gain (g/day) in the treatment and non-treatment group was observed. The following formula is used to calculate the average daily gain.

Average Daily Weight Gain (ADG) = Final body weight-Initial body weight / No of days in experiment.

Morphological Traits: Data was collected from a total of 23 Animals of different age groups for their morphological Traits such as Body weight, Heart girth measurement, Body length Measurement, Birth weight, Age at Puberty, and Service per conception. Birth weight, Age at Puberty, and Service per conception were collected from recorded data of the farm.

Animal's Heart girth, and body length was measured in their standing position using plastic measuring tape (tailor's tap) in inch.

Morphological traits and their definitions

1. Heart girth (HG)- Circumference of the chest just behind the elbow.

2. Body length (BL) - Length from point of shoulder to point of pin bone.

Actual Value of the traits: The mean and standard error of the traits (Birth weight, live body weight, live weight gain, Heart girth, Body length) were calculated using Microsoft Office Excel 2019.

Mathematical models for performances: The Following two mathematical equations were fitted in Microsoft Excel 2019 to estimate their parameters.

- Linear regression: $Y=a+bx$
- Quadratic polynomial: $Y=a+bx+cx^2$

  Here, Y is the predicted value of the traits (LW), x is the average of goat's weight during experimental periods and a, b, and c are the parameters that exhibit the shape of the curve. To obtain the model parameters, a (intercept), b (slope), and curve shape (c) and fit statistics, R^2 (Coefficient of determinant) the above models were fitted with Microsoft Excel 2019.

  The R^2 was obtained by fitting each predicted value from linear regression, and quadratic polynomial regression. The predicted values of live weight from the addressed two models were obtained by including their parameter values in Proc GLM of SAS (SAS, 2008). The following statistical models were used to obtain the least square means with standard error of all parameters.

The model is given as:

$$Y_{ij} = \mu + B_i + S_j + e_{ij}$$

Where Y_{ij} is the value of the traits, μ is the overall mean, B_i is the effect of Age and S_j is the sex effect, e_{ij} is the random error.

The mean differences were compared using least significant difference that (Isd) (Steel et al., 1997) at a 5% level of significance.

Chapter 3: Results and Discussion

Morphological Traits:

Birth weight: The birth weight of Totapari male and female goat kids is shown in Table1. Average birth weights are slightly higher for male animals compared to female animals within the same age group. This is a common phenomenon in many mammal species, where male offspring tend to be slightly heavier at birth due to differences in fetal development. Male fetuses often grow faster during gestation, leading to higher birth weights.

Kid's weight at birth has been influenced by sex, type of birth, season of birth, maternal age, and weight. (Bharathidhasan et al., 2009).

The average birth weight of Jamunapari goat and Black Bengal goat male kids was higher in other studies also. (Khan et al., 2013). In this study the birth weight of kids was higher than (Khan et al., 2013) It was due to the breed differences.

Heart Girth (HG) and Body Length (BL): Across all age groups, male animals tend to have larger heart girth and body length measurements compared to female animals. This is in line with typical sexual dimorphism in many animal species, where males are often larger in size. The differences in HG and BL could be attributed to genetic differences, with males having genetically determined larger body structures for enhanced physical competition and reproductive success. The female kid's heart girth was similar to that of De Villiers et al., (2009) but the male kids less than 1 year of age Heart girth measurement was lower than De Villiers et al,. (2009).

Table 1: Morphological traits of male and female Totapari goats.

Age of animal	Heart Girth (inch)		Body Length(inch)		Birth Weight (Kg)	
	Male	**Female**	**Male**	**Female**	**Male**	**Female**
less than 6 months	19.95 ± 0.803	18.75 ±0.75	19.33^{b} ±0.789	17.9^{a} ±0.90	2.24±0.182	2.20+0.100
6-1 year	24.17 ±0.615	23.0 ±0.578	23.12 ±0.562	22.1 ±0.45	2.26+0.090	2.06+0.088
3year and above	31.0 ±0.764	30.83 ±0.167	30.33^{b} ±0.67	28.6^{a} ±0.72	2.43+0.120	2.25+0.062

Notes: Means with different superscript values between sex within traits indicated significant differences at 5% level of significance.

Growth performance of Trial Animals:

The mean ± standard error values of growth performance of both Non-Treatment and Treatment groups are shown in Table 2.

Live Weight Gain: Table 2 indicates the live weight gain(g/day) in T_0 (Non-treatment group) after 30 days feeding trial live weight gain was 61.0±0.404g/day in less than 6-month kids, 66.0±0.431g/day in 6-month to 1 year old goats, 37.0±0.238g/day in greater than 3year old goats.

Table 2 Indicates the live weight gain (g/day) in T_1(Treatment group). After 30 days feeding trial live weight gain was respectively 66.80±0.431g/day in less than 6-month kids, 69.0±0.453g/day in 6-month to 1 year old goats, 45.0±0.294g/day in 3 years and above goats.

Animals fed with jackfruit leaves tend to exhibit slightly higher average daily gains compared to the normal feeding group across different age groups. These findings suggest that jackfruit leaves might have a positive impact on growth rates, particularly in the earlier stages of life. It can be attributed to the leaves' rich nutritional composition,

including proteins, bioactive compounds, and fiber. These factors are likely to enhance nutrient absorption, promote better digestion, and support muscle development, resulting in increased live weight gain (g/day). Additionally, the palatability and balanced nutrient profile of jackfruit leaves may have contributed to the improved growth rates.

Table 2: Estimated mean ± standard error values of the treatment group and non-treatment group of Totapari goats.

Age of Animal	**Birth weight(kg)**		**Live weight(kg)**		**Live weight gain (g/day)**	
	T_0	**T_1**	**T_0**	**T_1**	**T_0**	**T_1**
less Than 6 Months	2.13±0.240	2.40±0.220	11.28±1.801	13.51±1.452	61.0^{a}±0.404	66.80^{b}±0.431
6 months to 1 year	2.17±0.113	2.30±0.142	18.86^{a}±0.923	24.63^{b}±0.843	66.0^{a}±0.431	69.0^{b}±0.453
3 years and above	2.30±0.058	2.10±0.046	40.50±1.194	40.22±1.176	37.0^{a}±0.238	45.0^{b}±0.294

Note: T_0- Non-treatment group. T_1-Treatment Group. Means with different superscript values between sex within traits indicated significant differences at 5% level of significance.

Model fittings: After fitting the regression equation, with the data on live weight of different age goats under two feeding regimes the regression parameters and the value of R^2 are presented in Table 3.

Model Parameters: Table 3 is divided into age groups (Less than 6 months, 6 months to 1 year, and 3 years and above) and values of live weight of goats under two feeding regimes. There are two sorts of models for each age range and live weight combination: linear and polynomial. The shape and fit of the models are determined by regression coefficients. The fit statistics include R-squared (R^2) values, which indicate how well the models fit the data. R^2 values closer to one indicate a better fit. The higher R^2 values are considered superior (Khan et al., 2012).

In animals less than 6 months old, Intercept and slope of the non-treatment group were lower than treatment groups in both linear and polynomial regression.

Table 3: Estimated model co-efficient, fit statistics, and predicted values of live weight in between age Groups.

Age	Traits			
	Models	Fit statistics	LWT (T_0)	LWT(T_1)
Less Than 6 Months	Linear	a	8.05	10.84
		b	0.625	0.66
		R^2	0.9983	1
		Actual	9.61	12.51
		Predicted	14.06	19.20
	Polynomial	a	8.09	10.82
		b	0.58	0.68
		c	0.0075	0.0038
		R^2	0.9984	1
		Actual	9.61	12.51
		Predicted	20.66	20.01
6 months to 1 Year	Linear	a	17.89	19.81
		b	0.66	0.701
		R^2	0.9987	0.9998
		Actual	19.56	21.56
		Predicted	30.95	34.92
	Polynomial	a	17.89	19.77
		b	0.66	0.73
		c	-	0.0075
		R^2	0.9987	0.9999
		Actual	19.56	21.56
		Predicted	30.95	39.21
3 Years and Above	Linear	a	39.62	38.40
		b	0.36	0.45
		R^2	0.9996	0.9996
		Actual	40.54	39.54
		Predicted	54.58	56.40
	Polynomial	a	39.66	38.38
		b	0.33	0.47
		c	0.0075	0.0043
		R^2	0.9999	0.9997
		Actual	40.54	39.54
		Predicted	65.43	63.95

Note: a=Intercept, b=Slope, c= Curve shape, LWT (T_0) = Live weight in Non-Treatment Group, LWT(T_1) =Live Weight in Treatment Group, R^2= Coefficient of regression.

In 6 months to 1 year old animals, intercept and slope of non-treatment group were lower than treatment group in both linear and polynomial regression.

In 3 years and above old animals, intercept was higher in non-treatment group. However, the slope was lower in the non-treatment group.

The curve shape (c) was lower in treatment groups.

In less than 6 months old animals, the co-efficient of determination (R^2) of non-treatment group was respectively 0.9983 and 0.9984 in linear and polynomial regression. R^2 values were exactly 1 for the treatment group in both models.

In 6 months to 1year old animals, the R^2 values were 0.9987 in non-treatment group.

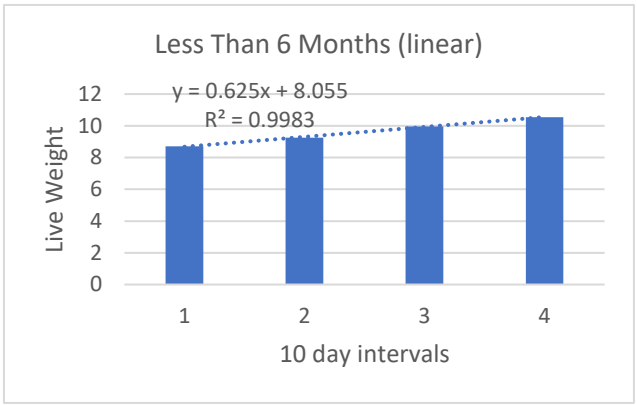
Whereas R^2 values were respectively 0.9998 and 0.9999 in linear and polynomial models for treatment group. The R^2 values were comparatively higher in treatment groups.

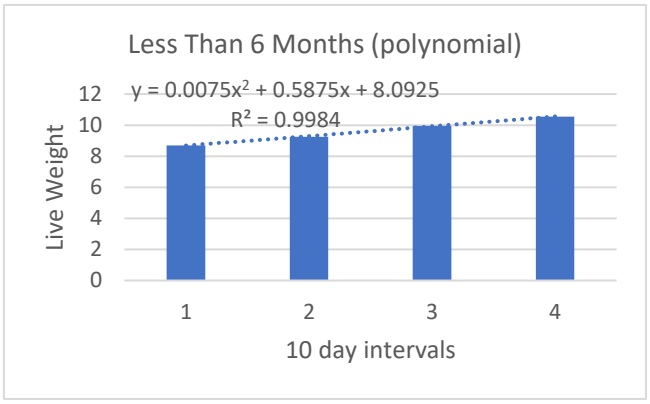
3 years above old animal's R^2 values were almost similar in both treatment and non-treatment group.

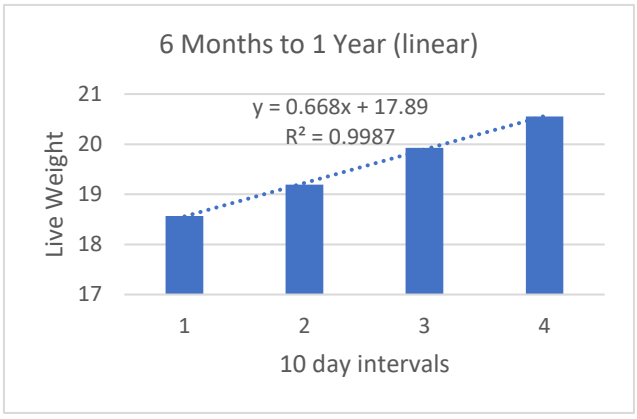
The goodness of fit: Both Linear and Polynomial models have high R-squared (R^2) values, indicating a strong fit to the data. The values of fit statistics were higher in polynomial equations where less than 6 months of age had a maximum R^2 value for LWT. The values of R^2 for all age groups was over 90%, polynomial showed an overall good fit to the data. If a model achieves R^2 above 90% indicates close agreement with predicted value (Khan et al., 2012).

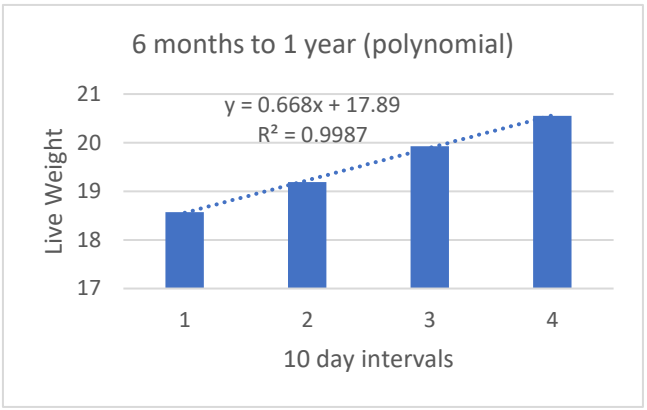
Actual and predicted value of weight in different models: The actual weight values were not like the predicted values in all age groups and treatments. Predicted values were much higher in polynomial models. Though the R^2 values were much satisfied in both models, which indicated the close agreement between the predicted and actual values.

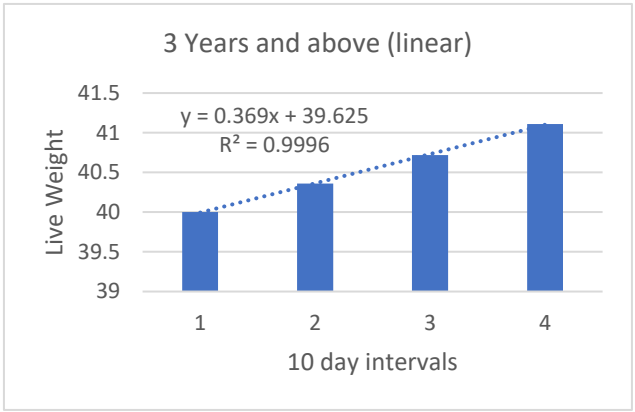
Figure1: Graphs of linear and polynomial regression of non-treatment group of goats.

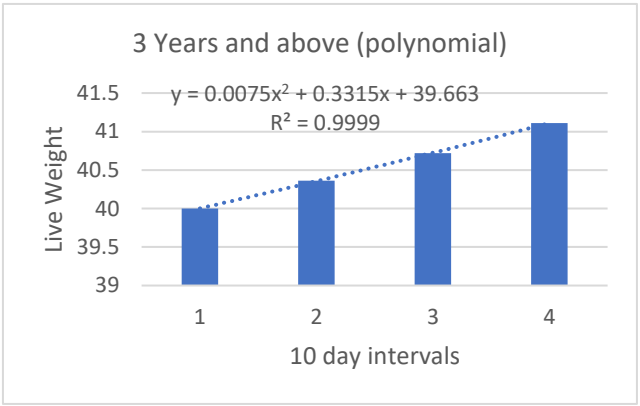






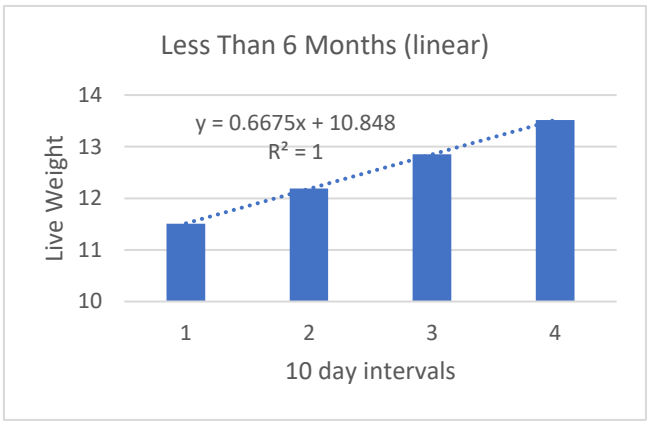


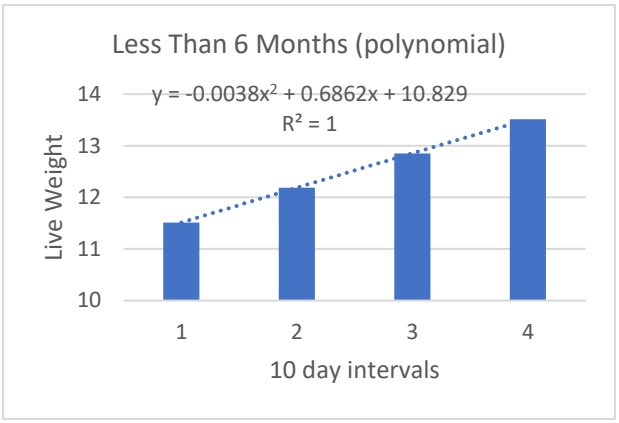


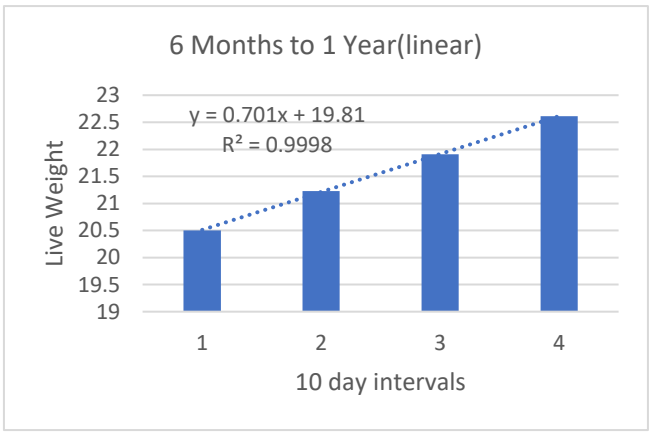


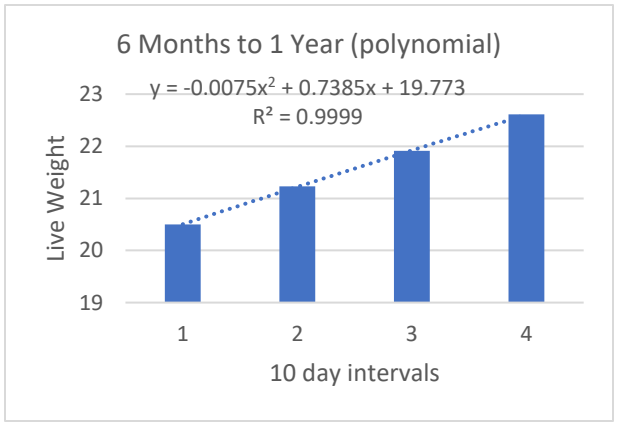
Figures: Linear regression Graph (Left side) and Polynomial regression Graph (Right side).

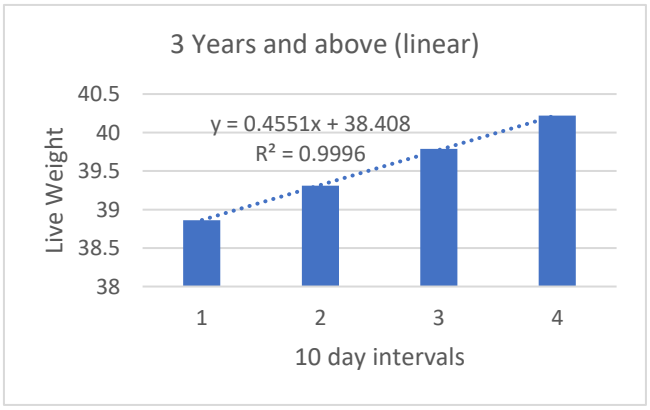
Figure 2: Graphs of linear and polynomial regression of treatment group of goats.

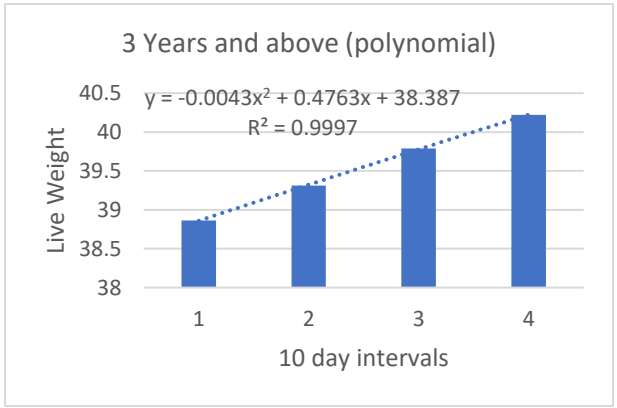












Figures: Linear regression Graph (Left side) and Polynomial regression Graph (Right side).

Chapter 4: Conclusion

The results collectively suggest that supplementing animal diets with jackfruit leaves can contribute to enhanced growth rates, particularly in the early life stages. The comprehensive analysis of growth performance, morphological traits, and model fittings underscores the multifaceted nature of growth and development in Totapari goats. This study also showed the application of different mathematical models, those can be implemented to predict the body weight of goats among two used models, quadratic polynomial model showed best fit, and linear model gives a closer predicted value to actual live weight. Higher birth weight was observed in Totapari goats. Which was higher than the birth weight of other commonly found breeds in Bangladesh like Black Bengal and Jamuapari goats. These findings open avenues for further research into optimizing feed formulations for improved growth performance in diverse age groups of Totapari goats. However, some constraints in this study were a small population size, and short experimental period.

However, more study with larger population size and larger experimental period is recommended. These findings open avenues for further research into optimizing feed formulations for improved growth performance in diverse age groups of trial animals. The study contributes to our understanding of the intricate interplay between nutrition, age, and growth in animal development.

Reference

Akbar, M. A., and Alam, M. N. (1991). Effects of feeding mango (*Mangifera indica*) and shaora (*Streblus asper*) tree leaves to Black Bengal goats of Bangladesh. Small Ruminant Research, 6(1-2), 25-30.

Bharathidhasan, A., Narayanan, R., Gopu P., Subramanian, A., Prabakaran, R., Rajendran, R. (2009). Effect of nongenetic factors on birth weight, weaning weight and preweaning gain of Barbari goat. Tamil Nadu Journal Veterinary and Animal Sciences, 5(3): 99-103.

Cam, M.A, Olfaz. M., and Soydan E, (2010). Possibilities of using morphometric characteristics as a tool for body weight prediction in Turkish hair goats (Kilkeci). Asian Journal of Animal and Veterinary Advances, 5, 52-59.

Choudhury, M. P., Sarker, S. C., Islam, F., Ali, A., Bhuiyan, A. K. F. H., Ibrahim, M. N. M., and Okeyo, A. M. (2012). Morphometry and performance of Black Bengal goats at the rural community level in Bangladesh. Bangladesh Journal of Animal Science, 41(2), 83-89.

De Villiers, J. F., Gcumisa, S. T., Gumede, S. A., Thusi, S. P., Dugmore, T. J., Cole, M., ... and Stevens, C. (2009). Estimation of live body weight from the heart girth measurement in KwaZulu-Natal goats. Applied Animal Husbandry and Rural Development, 1(2), 1-8.

Elmaz, O., Dikmen. S., Cirit. U., and Demir, H. (2008). Prediction of post pubertal reproductive potential according to prepubertal body weight, testicular size, and testosterone concentration using multiple regression analysis in Kıvırcık Ram Lambs. Turkish Journal of Veterinary and Animal Sciences, 32, 335- 343.

Islam, M., Chowdhury, S. A., and Alam, M. R. (1997). The effect of supplementation of jackfruit leaves (Artocarpus heterophyllus) and mashkalai (Vigna mungo) bran to common grass on the performance of goats. Asian-Australasian Journal of Animal Sciences, 10(2), 206-209.

Khan, K. I., and Khatun, J. (2013). Different traits of Black Bengal goats under two feeding regime and fitting the Gompertz curve for prediction of weaning weight in the semi-scavenging system. Indian Journal of Animal Research, 47(6), 498-503.

Khan, M. K. I., Blair, H. T., and Lopez-Villalobos, N. (2012). Lactation curves of different cattle breeds under cooperative dairying conditions in Bangladesh. Journal of Applied Animal Research, 40(3), 179-185.

Khan, M. K., and Naznin, M. (2013). Study the live weight and live weight gain of Black Bengal and Jamunapari goat breeds by fitting the linear regression under semi-intensive conditions. Pakistan Journal of Biological Sciences: PJBS, 16(19), 998-1003.

Khan, M.K.I. and Ahmed,S. (2010). Performance of Hubbard classic broiler parents and fit the regression models for their prediction. Bangladesh Journal of Animal Sciences, 39: 156-162.

Riva, J., Rizzi, R., Marelli, S. and Cavalchini, G. (2002). Body Measurements in Bergamasca Sheep. Small Ruminant Research, 221-227.

Steel, R.G.D., J.H Torrie and Dickey, D.A. (1997). Principles and Procedure of Statistics-A Biomedical Approach. Mc Grow-Hill Book Companies Inc., New York and London, pp: 139-177.

Thanh, L. P., Kha, P. T. T., Tinh, P. V. T., and Hang, T. T. T. (2021). Effect of jackfruit leaves on feed utilization and ruminal fermentation of growing goats. Livestock Research for Rural Development, 33, 104.

Acknowledgements

The author expresses heartfelt humility and gratitude to the ALMIGHTY for unending grace and benefits. Without it he would not have been able to do the task successfully.

The author extends his heartfelt appreciation to his esteemed internship supervisor, Professor Dr. Md. Kabirul Islam Khan, of the Department of Genetics and Animal Breeding, Faculty of Veterinary Medicine, Chattogram Veterinary and Animal Sciences University, for his intellectual guidance, unwavering support, and constant encouragement have been instrumental in shaping the trajectory of this work.

The honorable Vice Chancellor of Chattogram Veterinary and Animal Sciences University, Professor Dr. A.S.M Lutful Ahasan, has also received the author's profound gratitude and thanks. The author expresses his admiration for Professor Dr. A.K.M. Saifuddin, Director of External Affairs, and Professor Dr. Mohammad Lutfur Rahman, Dean of the Faculty of Veterinary Medicine for facilitating unique internship programs and research exposure.

The author expresses gratitude to his family, friends, well-wishers, and supporting staff members who have been a constant source of inspiration during this work.

Biography

I am Abdullah Al Noman passed my DAKHIL exam in 2015 from Madrasa board and HSC exam in 2017 with GPA-5 from Chittagong board. I am currently enrolled in Chattogram Veterinary and Animal Sciences University as an intern student. As a person, I am full of enthusiasm, encouragement, and determination.

I am engaged with various extracurricular activities in and outside my university.

As a vet student, I devote my life to my patients with the hopes of becoming a successful veterinarian. I am enthusiastic about working with pet animals and being a successful pet practitioner.