2024, Scienceline Publication
World's Veterinary Journal
World Vet J, 14(2): 284-292.
ISSN 2322-4568

DOI: https://dx.doi.org/10.54203/scil.2024.wvj35
PII: S232245682400035-14

Growth Traits as Predictors of Body Weight in Sheep: A Review

Molabe Kagisho Madikadike, and Thobela Louis Tyasi*

School of Agricultural and Environmental Sciences, Department of Agricultural Economics and Animal Production, University of Limpopo, Private Bag X1106, Sovenga 0727, Limpopo, South Africa

*Corresponding author's Email: louis.tyasi@ul.ac.za

REVIEW ARTICLE
Received: March 28, 2024
Revised: April 24, 2024
Accepted: May 20, 2024
Published: June 30, 2024

ABSTRACT

The sheep production industry affects most rural areas and communal farm enterprises in the tropics and sub-tropics as a source of income. The motivation behind the present literature review was to provide detailed literature from various sources on the estimation of body weight from the growth traits of sheep. The review was conducted to highlight the importance of body weight and the significance of growth traits (heart girth, withers height, body length, sternum height, and rump height) as parameters to predict body weight. The main reason for livestock practice is to ensure food security. Therefore, it is important to assess economic traits and determine the carcass merit of sheep. Linear body measurement is a practical, fast, easy, and cheap method broadly utilized in national breeding programs to predict body weight and improve meat productivity in rural areas. The current review indicated that growth traits could be used to predict the body weight of sheep since they importantly provide necessary information about the morphological structure and potential development of the animals.

Keywords: Body length, Body weight, Growth trait, Heart girth, Rump height, Withers height

INTRODUCTION

Sheep production in South Africa is a wide-growing livestock industry in the husbandry systems (Meissner et al., 2013). Some major economic factors related to this industry include ensuring efficient economic production through management practices focusing on shortening breeding production. Cannas et al. (2019) believe that the sheep production industry affects the economic resources in most rural areas and communal farm enterprises in the tropics and sub-tropics worldwide (Gökçe and Atakışİ, 2019). According to Ayichew (2019), sheep are primarily raised for consumption (meat and milk) and their skin for clothing and belts. Additionally, these animals are used in traditional rituals or given as gifts during ceremonies such as weddings.

The livestock industry aims to ensure food security, which can be achieved by assessing important economic traits and determining their carcass merit and value (Agamy et al., 2015). Body weight is the foremost consideration in the animal industry for marketing purposes. Additionally, understanding an animal's body weight is crucial for appropriate feeding, medication, and breeding practices (Abbas et al., 2021). In the animal industry, growth traits, such as body weight and linear body measurements, are the primary concerns during breeding for the economy, especially meat production (Moradian et al., 2013).

The sheep production industry should try to maximize production since customers have a high demand for heavier sheep (Kumari et al., 2014). Due to the lack of measuring scales, such as weighing scales in rural areas, rural farmers rely only on animal physical appearance and body weight estimates, leading to poor decision-making on medical dosing, selling, feeding, and selection criteria (Abdel-Mageed and Ghanem, 2013). Compared to visual observations and breeding value, Kumar et al. (2017) state that accurate techniques are used daily to improve growth traits, and the use of linear body measurements to predict body weight is a practical, fast, easy, and cheap method widely utilized in national breeding programs to improve the productivity of meat mostly by rural area farmers.

The motivation behind the present study was to provide a detailed review of literature from various sources on the estimation of body weight regarding sheep body parameters to enrich the literature and provide a deep understanding of this concept. In this regard, the significance of body weight is explained. Then, the importance of growth traits and body parameters, such as heart girth, withers height, body length, sternum height, and rump height, in the prediction of body weight as the primary purpose of the study is clearly explained.

Significance of body weight

According to Akpa et al. (2011), growth is determined as the total sum of structural body components that could be measured by body parameters and live weight and is mainly considered in the livestock industry animal husbandry.

To cite this paper: Madikadike MK, and Tyasi TL (2024). Growth Traits as Predictors of Body Weight in Sheep: A Review. *World Vet. J.,* 14(2): 284-292. DOI: https://dx.doi.org/10.54203/scil.2024.wvj35

Body weight is an important parameter for selecting animals for various purposes, such as breeding and marketing (Lakew et al., 2017).

Animal breeding practices aimed to improve the economy. Body weight is an economically important trait in the quantitative selection of animals for breeding and maximizing production (Kumar et al. 2017). Dekhili and Aggoun (2013) indicated that body weight is the most significant trait in meat industries, where breeders select Ettawa sheep of high body carcass weight to breed for the next generation. According to Shirzeyli et al. (2013), body weight could be used to monitor animal growth and make good decisions for choosing male and female replacements by determining the value of animals and the rearing efficiency. Moreover, knowledge of animal body weight assists breeders in knowing breeding regarding carcass production per animal (Iqbal et al., 2013; Yilmaz et al., 2013).

Kumar et al. (2017) reported body weight as the most important feature of economic growth. Some rural farmers are still disadvantaged when selling their sheep due to a lack of weighing scales. Tsegaye et al. (2013) found that knowledge of animal weight helps the estimation of the market price to avoid selling the animals or their product at a price they do not deserve. Chitra et al. (2012) also agree and mention that sheep body weight helps in determining the correct drug dosage, while Asefa et al. (2017) indicate that knowledge about the body weight of small ruminants plays a role in ensuring proper management of feeding and avoiding obesity and anorexia. Recent studies showed that body parameters serve either to supplement body weight as an estimate of production or as a predictor of some less visible traits (Dekhili and Aggoun, 2013). According to Babale et al. (2018), the most reliable traits to estimate live body weight are wither height, body length, heart girth, rump height, and width. Moreover, they can also be used as indicators of breed origin and relationships within species.

As reported by Prasad (2010), knowledge about the body weight of goats, sheep, and pigs is important for the computation of balanced ratio, evaluation of growth, and health management. Birteebi and Ozoje (2012) documented that precise body weight could guarantee that farmers or producers were well repaid for their hard work and investments when raising the West African long-legged and West African dwarf sheep. Animal breeding practices aim to improve traits of economic importance, such as body weight, for better selection and production improvement (Shirzeyli et al., 2013).

Significance of growth traits as parameters to predict body weight

Prediction of body weight from linear body measurements is the simple, cheap, and best method, especially in communal areas where they lack resources, such as weighing scales, to determine the body weight of their animals (Sandeep et al., 2017). According to Younas et al. (2013), the livestock and meat industry aims to have an accurate and objective measurement method for improving traits and predicting the weight, values, and merit of the carcass of the live animal at a low cost. Moreover, Asefa et al. (2017) added that linear body measurements could be used indirectly to determine body weight as they are easy and simple to measure. Body linear measurements are the quantitative traits of carcass or meat and assist in developing selection criteria based on farmers' objectives (Kumar et al., 2017).

The primary aim of the animal industry is to have a technique that can accurately measure, access traits of economic importance, and establish animal merit and value of the carcass when the animal is alive (Agamy et al., 2015). One of the most popular methods for determining the relationship between two traits is a correlation between traits (Shirzeyli et al., 2013). Knowledge about the relationship between live body weight and body parameters helps the selection of superior animals in body weight in the Balochi male sheep for breeding purposes (Jahan et al., 2013).

Based on reports by Shirzeyli et al. (2013), linear body measurements differ in terms of breed, gender, and age. Many studies have been performed where body parameters are used to predict the body weight of different livestock (Babale et al. 2018). Kumar et al. (2017) concluded that body measurements serve as valuable growth indicators for sheep, particularly in rural areas where scales are scarce, aiding in the estimation of body weight and carcass characteristics. Birteeb et al. (2012) added that they have been used by other authors to predict body weight in exotic sheep breeds. As stated by Kumar et al. (2017), linear body measurement in livestock is a tool for farmers to recognize the morphological genetic strengths and weaknesses of sheep. Furthermore, body measurements can indirectly give an accurate estimate of body weight, especially when measured in the morning before the time sheep are released to graze or given feeds. According to Lakew et al. (2017), body measurements are key data sources for reflecting the breed standards and can also be used as qualitative growth indicators that reflect animal body changes during the animal's lifetime.

Knowledge of the correlation between body weight and linear body parameters is vital for better improvement and management in terms of adequate medicine administration and feed supply (Mohammad et al., 2012). Body traits are important when selecting superior indigenous Mengali sheep to gain more genetic progress in reproductive yield (Tariq et al., 2012).

According to Verma et al. (2016), linear body measurements detail the skeletal structure, growth, and development

capability of the Harnali sheep. Body parameters have been used to predict body weight in many sheep breeds (Younas et al., 2013). A study by Shirzeyli et al. (2013) indicated that linear body parameters provide information about the morphological structure and potential for development in Iranian sheep. Additionally, linear body parameters, such as rump height, withers height, body length, and heart girth, could be considered to predict body weight (Olawumi and Farinnako, 2017).

The capacity and skill of producers and purchasers to understand linear body measurements to growth traits are important in increasing production (Babale et al., 2018). As reported by Kumar et al. (2017), body measurements in sheep are used to evaluate the quantitative traits of meat. Eghahi et al. (2011) added that body measurements had been used in predicting body weight and helping in setting appropriate meat prices. Berhe (2017) highlighted that linear body measurements, mostly in smallholder farmers, could sustain the improvement of indigenous sheep. Common traits used for breed improvement are body length, heart girth, and withers height. As confirmed by Weldeyesus and Yayneshet (2016), the aforementioned body measurements are critical traits used for selecting and improving commercial goats. Many researchers have studied these traits as predictors of body weight in small livestock, including sheep and goats (Eyduran et al., 2017).

Heart girth

Heart girth is measured as the body circumference around the chest just behind the front legs and withers (Kumar et al., 2017). Most studies have revealed that heart girth could be used to predict body weight in different livestock and give reasonably accurate results. Body weight was predicted from linear body measurements in Awassi Crossbred sheep in a study conducted by Lakew et al. (2017). The findings indicated a highly significant relationship between body weight and heart girth, implying that heart girth impacts body weight and that improving heart girth might result in improved body weight. Kumar et al. (2017) reports agree with the above results. Their results showed that body weight could be predicted by heart girth. Therefore, heart girth could be used as the independent trait to estimate body weight in rural areas, where they lack weighing scales, and can also be used as a trait for the development and improvement of Harnali sheep.

In West African Dwarf goats, the correlation between body weight and linear body measurements was evaluated, and heart girth was revealed to have a strong relationship with body weight despite gender and location (Olawumi and Farinnako, 2017). A study by Younas et al. (2013) on Hissardale sheep showed that when body length, height at withers, and heart girth increase in the early stages of an animal's life, body weight increases, as well. Body weight in three Egyptian Fat-tailed sheep was estimated using linear body measurements, and a significant relationship between heart girth and body weight was found in Barki sheep Agamy et al. (2015). Furthermore, Abd-Alla (2014) considers heart girth a reliable predictor of body weight.

In their study on Jamuna basin sheep of Bangladesh across various age groups, Sun et al. (2020) found that heart girth was statistically significant in the 1-9 months group and 1-2 years group, correlating strongly with body weight. This positive relationship suggests that heart girth can be used effectively to estimate and potentially enhance body weight. Similar findings were reported in studies involving animals aged 2-6 years (Yilmaz et al., 2013), indicating the reliability of heart girth in estimating body weight across different age ranges. Moreover, a study focusing on sheep aged 13-24 months identified heart girth as the most effective trait for estimating body weight. This correlation implies that Nigerian sheep breeds with larger heart girth tend to have higher body weights (Mahmud et al., 2014).

Linear body parameters have been used to estimate body weight by some workers in exotic sheep breeds (Birteeb et al., 2012). Research by Kumar et al. (2017) described heart girth as the most important trait, and it was observed to be the trait that can be used to estimate body weight, especially in rural areas where weighing scales are absent. Similar suggestions were reported by Petrovic et al. (2012) and Jafari and Hashemi (2014) using different sheep breeds. According to Kumar et al. (2017), farmers who lack a weighing scale can use heart girth as a predictor of body weight. Prasad (2010) conducted a study and stated that body parameters, such as heart girth, are commonly used in estimating body weight in small ruminants, such as goats, sheep, and pigs.

Body length

According to Babale et al. (2018), body length is measured from the occipital protuberance to the base of the tail. Body parameters, such as body length, can be used to evaluate quantitative traits of meat, and it is easy to measure. It can be used as an indirect way to predict live weight and carcass traits (Agamy et al., 2015). Shirzeyli et al. (2013) conducted a study involving four sheep breeds and found that certain linear body measurements, such as body length, could predict body weight specifically in the Shaal breed. The relationship between animal body measurements and body weight varies depending on factors like breed, sex, and age, offering insights into their growth and development (Tariq et al., 2012). In another study focusing on sheep, Shirzeyli et al. (2013) highlighted a strong correlation between

body length and body weight. Similarly, Kumar et al. (2017) reported a positive statistical relationship between body weight and body length from a study conducted on Harnali sheep.

In indigenous sheep populations of Southern Ethiopia study by Melesse et al. (2013), the body length of Sidama-Gedeo, Wolaita, KmabataTembaro-Hadiya, and Gamogofa ewe had a high positive statistical correlation with body weight. A study on highland sheep in Tigray in Ethiopia by Berhe (2017) showed that body length in areas with no weighing scales could predict body weight due to a high positive correlation with body weight.

Wither height

As stated by Agamy et al. (2015), the wither height of an animal is the distance from the bottom of the front foot (phalanges) to the highest point of withers between the shoulders and is measured when the animal is standing. A study on indigenous sheep breeds showed a positive relationship between wither height and body weight (Mohammad et al., 2012).

Jahan et al. (2013) documented that withers height is a statistically significant trait related to body weight, suggesting that an increase in withers height could lead to an increase in body weight. Shirzeyli et al. (2013) studied four different breeds, namely Mehrabani, Macoei, Zandi, and Shaal. The results showed that withers height could be used to predict body weight in the Shaal breed; however, it was not significant in other breeds. In Ossimi and Rahmani ram-lambs, Agamy et al. (2015) outlined that withers height was correlated to body weight. The results are in line with Shehata (2013), who stated that body weight and withers height had a highly significant relationship.

Linear body measurements of Kashmir Merino Sheep were used as predictors of body weight by Rather et al. (2021), and a positive phenotypic correlation was observed between body weight and all the traits in the study. Wither height was the best predictor of body weight in that study. Genetic and phenotypic relationships between various body measurements were found by Petrovic et al. (2012) in Merino lands chaf sheep, Jafari and Hashemi (2014) in the Makuie sheep breed, and Kumar et al. (2017) in Harnali sheep. Additionally, wither height correlated to body weight in a study conducted by Mahmud et al. (2014) in 37 months and in different sheep age groups.

Different linear body measurements and prediction equations for the live weight of indigenous sheep populations in southern Ethiopia were studied, and withers height had a positive statistical relationship with body weight in Wolaita and Sidama-Gedeo ewes aged 1-2 years (Melesse et al., 2013). In rams, a significant relationship was also found between body weight and body length

Sternum height

Tyasi et al. (2020) reported sternum height as the vertical distance from the lower tip of the sternum to the ground in standing animals in the Nguni cattle breed. Prediction of body weight from body parameters was reported by Sun et al. (2020). The study revealed a correlation coefficient between body weight and sternum height among sheep aged 1-9 months, indicating that these sheep tended to have higher body weights compared to other breeds like Dorper. Furthermore, Temoso et al. (2017) conducted a study in Botswana on both sheep and goats, disregarding sex. Sternum height was also found to have the highest correlation with body weight, and the results are consistent with those of Norris et al. (2015) on indigenous goats.

Correlation and path analysis of body weight and biometric traits of Nguni cattle breed study by Tyasi et al. (2020) confirmed sternum height as the best predictor of body weight. Yilmaz et al. (2011) described sternum height as the distance between the height point of the wither and the ground. Their results on Kangal Type Akkaraman sheep revealed sternum height could be a candidate trait for estimating body weight. Patbandha et al. (2018) findings also state that sternum height could be used to predict body weight.

In a study on Female Etawah Grade Goats, Dakhlan et al. (2020) found that body weight correlated with sternum height. Similarly, Baleseng et al. (2016) conducted research on goats and sheep, indicating that shoulder height is statistically significantly correlated with animal weight. These findings suggest that shoulder height can potentially serve as a predictor of weight in both goats and sheep. These reports suggest that shoulder height can potentially be a predictor of weight in both goats and sheep. The study by Musa et al. (2012) showed heart girth is a better proxy measure of weight than shoulder height; however, both can be used to estimate the weight of goats and sheep under communal grazing.

Rump height

Based on Olawumi and Farinnako (2017), rump height is measured as the distance from the surface of a platform to the rump in a standing West African Dwarf Goat. A study by Sun et al. (2020) indicated that rump height had a high statistical relationship with body weight in 1 to 2 years of age Jamuna sheep. Lavvaf et al. (2012) and Melesse et al. (2013) findings are in agreement with results obtained from Jamuna sheep that body weight has a strong positive

relationship with rump height (Berhe, 2017).

Deribe et al. (2018) used correlational analysis to estimate the relationship between two variables. Linear body measurements of Begait, Gumz, and Rutana sheep were used to estimate body weight. Results showed a positive correlation between body weight and some linear body measurements, with rump height as one of the traits in Begait, Gumz, and Begait sheep, rump height was found to be the trait statistically correlated to body weight. Asefa et al. (2017) report on indigenous sheep of the Bale zone agrees with the above findings by Deribe et al. (2018).

Mahmud et al. (2014) documented a study on the estimation of body weight using cannon bone length and other body measurements in Nigerian breeds of sheep. Body weight was correlated to rump height as one of the linear body measurements in sheep under 12 months of age. Lavvaf et al. (2012) found similar results in a study conducted on sheep. Özen et al. (2019) report on Awassi sheep showed rump height was the most accurate trait to predict body weight. Ambacıoğlu et al. (2017) added that linear body measurements could help farmers estimate their livestock's body weight for management purposes, and rump height appeared to be the best candidate to be used to estimate body weight.

Prediction methods for weight measurement

The regression analysis method is the most widely used in multivariate statistical analysis to estimate the association between dependent and independent variables (Mohammad et al., 2012). A study by Mokoena et al. (2022) reveals that classification and regression trees are the optimum models with body length as the essential linear body measurement for estimating the body weight of Kalahari Red goats. Multivariate adaptive regression splines showed that age and wither height influenced the body weight in Nguni cows. In contrast, the results obtained from the regression tree data mining algorithm indicated that body length played a significant role in the body weight estimation of Nguni cows in the study conducted by Hlokoe et al. (2022). Additionally, it was noted that marker-assisted selection is the best-fit model for estimating body weight in Nguni cows.

Mathapo (2022) utilized data mining algorithms to analyze South African non-descript indigenous goats, concluding that body length alone could predict body weight based on a chi-square automatic interaction detector and classification and regression tree methods.

Avijit et al. (2022) employed recursive partitioning and regression trees (RPART) and stepwise regression model tools to predict body weight using linear body measurements, RPART, and stepwise regression models indicated that heart girth influenced live weight. Mohammad et al. (2012) estimated body weight from withers height, body length, and chest girth measurements using the Regression Tree (RT) Method. Statistically significant correlation coefficients were detected between body weight and wither height.

CONCLUSION

The present review indicated the use of growth traits as the most convenient method for estimating body weight, especially for farmers who lack weighing scales to determine the weight of their animals for breeding, nutrition, marketing purposes, and health management. Body length, heart girth, and wither height are popular traits for sheep breeds. However, more studies need to be conducted to predict body weight using more linear body measurements and other growth traits on different breeds to provide more information on improving the growth of the small stock.

DECLARATIONS

Availability of data and materials

Datasets and materials generated during the current study are available at the University of Limpopo and are accessible from the corresponding author upon reasonable request.

Acknowledgments

Sincere acknowledgments are offered to the University of Limpopo Department of Agricultural Economics and Animal Production.

Ethical considerations

Consent to publication and misconduct, plagiarism, data fabrication and double submission of the manuscript, and redundancy and other ethical issues were checked by the authors.

Funding

The study was supported by National Research Funding (NRF) with Grant-holder number: 138972.

Authors' contributions

Molabe Kagisho Madikadike and Tyasi Thobela Louis designed the study, Molabe Kagisho Madikadike wrote the review, and Tyasi Thobela Louis proofread the review. All authors confirmed the last content of the article before publication.

Competing interests

There is no competing interest to declare.

REFERENCES

Abbas A, Ullah MA, and Waheed A (2021). Body weight prediction using different data mining algorithms in Thalli sheep: A comparative study. Veterinary World, 14(9): 2332. DOI: https://www.doi.org/10.14202%2Fvetworld.2021.2332-2338

Abd-Alla MS (2014). A comparative study on body measurements and carcass characteristics in Egyptian sheep and goats. Asian Journal of Animal and Veterinary Advances, 9: 292-301. http://www.doi.org/10.3923/ajava.2014.292.301

Abdel-Mageed I and Ghanem N (2013). Predicting body weight and longissimus muscle area using body measurements in subtropical goat kids. Egyptian Journal of Sheep and Goats Sciences, 8(1): 95-100. DOI: https://www.doi.org/10.12816/0005029

Agamy R, Abdel-Moneim AY, Abd-Alla MS, Abdel-Mageed II, and Ashmawi GM (2015). Using linear body measurements to predict body weight and carcass characteristics of three Egyptian fat-tailed sheep breeds. Asian Journal of Animal and Veterinary Advances, 10(7): 335-344. DOI: https://www.doi.org/10.3923/ajava.2015.335.344

Akpa GN, Suleiman IO, and Alphonsus C (2011). Effect of age, hair type and body condition score on body conformation traits in Yankasa Rams. Nigerian Journal of Animal Science, 13: 32-37. Available at: https://www.ajol.info/index.php/tjas/article/view/80089

Ambacıoğlu P, Kaya U, Ozen D, and Gürcan IS (2017). An examination of the relationships between live weight and body measurements in Karacabey Merino sheep through the path analysis approach. Kafkas Universitesi Veteriner Fakultesi Dergisi, 23(6): 857-863. DOI: https://www.doi.org/10.9775/kvfd.2017.17659

Asefa B, Teshome A, and Abera M (2017). Prediction of live body weight from heart girth measurement for small ruminant in ethiopia: A review article. International Journal of Agricultural Research, Sustainability, and Food Sufficiency, 4(4): 193-201. Available at: https://archive.org/stream/Asefa_et_al/Asefa_et_al_djvu.txt

Avijit H, Prasenjit P, Sarbaswarup G, and Subhransu P (2022). Body weight prediction using recursive partitioning and regression trees (RPART) model in Indian black Bengal goat breed: A machine learning approach. Indian Journal of Animal Research, 57(9): 1251-1257. DOI: http://www.doi.org/10.18805/IJAR.B-4894

Ayichew D (2019). Dorper sheep cross breeding with indigenous sheep breed in Ethiopia. Journal of Applied and Advanced Research, 4(1): 36-41. DOI: http://www.doi.org/10.21839/jaar.2019.v4i1.250

Babale DM, Abaya UH, and Gworgwor Z (2018). Relationship between liveweights, linear body measurements and cost prices of small ruminants sold in and around Mubi environs, Adamawa state, Nigeria. Journal of Dairy, Veterinary and Animal Research, 7(6): 273-277. DOI: https://www.doi.org/10.15406/jdvar.2018.07.00226

Baleseng L, Kgosikoma OE, Makgekgenene A, Coleman M, Morley P, Baker O, and Bahta S (2016). Performance of goats and sheep under communal grazing in Botswana using various growth measures. 7th International Conference on Agricultural Statistics, Rome, pp. 320-326. Available at: https://www.istat.it/storage/icas2016/b07-baleseng.pdf

Berhe WG (2017). Relationship and prediction of body weight from morphometric traits of indigenous highland sheep in Tigray, Northern Ethiopia. ISABB Journal of Biotechnology and Bioinformatics, 3(1): 1-5. DOI: https://www.doi.org/DOI:%2010.5897/AJBR2016.0006

Birteeb PT, Peters SO, Yakubu A, Adeleke MA, and Ozoje MO (2012). Multivariate characterisation of the phenotypic traits of Djallonke and Sahel sheep in Northern Ghana. Tropical Animal Health and Production, 45: 267-274. DOI https://www.doi.org/10.1007/s11250-012-0211-4

Birteebi P and Ozoje MO (2012). Prediction of live body weight from linear body measurements of West African long legged and West African dwarf sheep in Northern Ghana. Online Journal of Animal and Feed Research, 2(5): 427-434. Available at: https://www.ojafr.ir/main/attachments/article/89/Online%20J.%20Anim.%20Feed%20Res.,%202(5)%20427-434;%20B79.pdf

Cannas A, Tedeschi LO, Atzori AS, and Lunesu MF (2019). How can nutrition models increase the production efficiency of sheep and goat operations?. Animal Frontiers, 9(2): 33-44. DOI: https://www.doi.org/10.1093/af/vfz005

Chitra R, Rajendran S, Prasanna D, and Kirubakaran A (2012). Prediction of body weight using appropriate regression model in adult female Malabari goat. Veterinary World, 5(7): 409-411. Available at: https://web.s.ebscohost.com/abstract?direct=true&profile=ehost&scope=site&authtype=crawler&jrnl=09728988&AN=82716348&h=0kOvOy55o2gY%2b%2fzZN4vJfBwbOcBENF0RPsZyImNvF5WuvTBkQ3b347uvKtpMrB%2fBcFsTjgKLEUZENMC3qMHrsA%3d%3d&crl=c&resultNs=AdminWebAuth&resultLocal=ErrCrlNotAuth&crlhashurl=login.aspx%3fdirect%3dtrue%26profile%3dehost%26scope%3dsite%26authtype%3dcrawler%26jrnl%3d09728988%26AN%3d82716348

Dakhlan A, Saputra A, Hamdani MDI, and Sulastri (2020). Regression models and correlation analysis for predicting body weight of female Ettawa grade goat using its body measurements. Advances in Animal and Veterinary Sciences, 8(11): 1142-1146. DOI: http://www.doi.org/10.17582/journal.aavs/2020/8.11.1142.1146

Dekhili M and Aggoun A (2013). Path coefficient analysis of body weight and biometric traits in Ouled-Djellal breed (Algeria). Revue Agriculture, 4(2): 41-46. Available at: https://revue-agro.univ-setif.dz/documents/numero-6/Path%20coefficient%20analysis%20of%20body%20weight%20and%20biometric%20traits%20in%20Ouled%20Djellal%20breed%20(Algeria)%20Dekhili,%20Aggoun.pdf

Deribe B, Beyene D, Dagne K, Getachew T, and Gizaw S (2018). Predicting body weight of three Ethiopian Thin-Tailed sheep breeds from linear body measurements. Journal of Natural Sciences Research, 8(24): 25-39. Available at: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwibqM6wp8n8AhVFMewKHQurAzAQFnoECAwQAQ&url=https%3A%2F%2Fiiste.org%2FJournals%2Findex.php%2FJNSR%2Farticle%2Fdownload%2F45720%2F47204&usg=AOvVaw3FrxWFj6GsKjHMi8hdFkQY

Eghahi JO, Dim NJ, and Mabrama BD (2011). Body weight and body dimensions in free range West African Dwarf goats in the Guinea Savanna. Proceedings of the 16th Annual Conference of Animal Science Association of Nigeria (ASAN). Kogi State University, Ayingba Nigeria. pp. 13-15.

Eyduran E, Zaborski D, Waheed A, Celik S, Karadas K, and Grzesiak W (2017). Comparison of the predictive capabilities of several data mining algorithms and multiple linear regression in the prediction of body weight by means of body measurements in the Indigenous Beetal goat of Pakistan. Pakistan Journal of Zoology, 49(1): 257-265. Available at: https://go.gale.com/ps/i.do?id=GALE%7CA488007916&sid=googleScholar&v=2.1&it=r&linkaccess=abs&issn=00309923&p=AONE&sw=w&userGroupName=anon%7E3a17af51&aty=open-web-entry

Gökçe E and Atakışİ O (2019). Interrelationships of serum and colostral IgG (passive immunity) with total protein concentrations and health in lambs. Kafkas Universitesi Veteriner Fakultesi Dergisi, 25(3): 387-396. Available at: https://aperta.ulakbim.gov.tr/record/69193/files/10-9775-kvfd-2018-21035.pdf?download=1

Hlokoe VR, Mokoena K, and Tyasi TL (2022). Using multivariate adaptive regression splines and classification and regression tree data mining algorithms to predict body weight of Nguni cows. Journal of Applied Animal Research, 50(1): 534-539. DOI: https://www.doi.org/10.1080/09712119.2022.2110498

Iqbal M, Javed K, and Ahmad N (2013). Prediction of body weight through body measurements in Beetal goats. Pakistan Journal of Science, 65(4): 458-461. Available at: http://pjosr.com/index.php/pjs/article/view/411/459

Jafari S and Hashemi A (2014). Estimation of genetic parameters for body measurements and their association with yearling liveweight in the Makuie sheep breed. South African Journal of Animal Science, 44(2): 141-147. DOI: http://www.doi.org/10.4314/sajas.v44i2.6

Jahan M, Tariq MM, Kakar MA, Eyduran E, and Waheed A (2013). Predicting body weight from body and testicular characteristics of Balochi male sheep in Pakistan using different statistical analyses. Journal of Animal and Plant Sciences, 23(1): 14-19. Available at: https://www.cabdirect.org/cabdirect/abstract/20133226766

Kumar S, Dahiya SP, Malik ZS, and Patil CS (2017). Prediction of body weight from linear body measurements in sheep. Indian Journal of Animal Research, 52(9): 1263-1266. DOI: http://www.doi.org/10.18805/ijar.B-3360

Kumari R, Kumar R, Meena AS, Jyotsana B, Prince LLL, and Kumar S (2014). Genetic polymorphism of growth hormone gene in native sheep breeds of India. The Indian Journal of Small Ruminants 20(2): 15-18. Available at: https://www.indianjournals.com/ijor.aspx?target=ijor:ijsr&volume=20&issue=2&article=003

Lakew M, Tesema Z, and Zegeye A (2017). Body weight prediction from linear body measurements in Awassi Crossbred sheep of North Eastern Ethiopia. Journal of Applied Agriculture and Biotechnology, 2(2): 28-36. Available at: http://jaab.uaar.edu.pk/index.php/jaab/article/view/52/43

Lavvaf A, Noshari A, and Farahvash T (2012). Evaluation of the relationship between body measurements and carcass traits of finishing Afshari and Zandi rams. Asian Journal of Animal and Veterinary Advances, 7(2): 187-192. DOI: http://www.doi.org/10.3923/ajava.2012.187.192

Mahmud MA, Shaba P, Abdulsalam W, Yisa HY, Gana J, Ndagi S, and Ndagimba R (2014). Live body weight estimation using cannon bone length and other body linear measurements in Nigerian breeds of sheep. Journal of Advanced Veterinary and Animal Research, 1(4): 169-176. DOI: http://www.doi.org/10.5455/javar.2014.a29

Mathapo MC (2022). Assessment of relationship between body weight and morphological traits of South African non-descript indigenous goats using different data mining algorithm, Doctoral Dissertation, University of Limpopo, South Africa. Available at: http://hdl.handle.net/10386/3909

Meissner HH, Scholtz MM, and Palmer AR (2013). Sustainability of the South African livestock sector towards 2050 Part 1: Worth and impact of the sector. South African Journal of Animal Science, 43(3): 282-297. DOI: https://www.doi.org/10.4314/sajas.v43i3.5

Melesse A, Banerjee S, Lakew A, Mersha F, Hailemariam F, Tsegaye S, and Makebo T (2013). Variations in linear body measurements and establishing prediction equations for live weight of indigenous sheep populations of southern Ethiopia, Scientific Journal of Animal Science, 2(1): 15-25. Available at: https://www.cabdirect.org/cabdirect/abstract/20133094553

Mohammad MT, Rafeeq M, Bajwa MA, Awan MA, Abbas F, Waheed A, Bukhari FA, and Akhtar P (2012). Prediction of body weight from body measurements using regression tree (RT) method for indigenous sheep breeds in Balochistan, Pakistan. Journal of Animal and Plant Sciences, 22(1): 20-24. Available at: http://thejaps.org.pk/docs/v-22-1/18.pdf

Mokoena K, Molabe KM, Sekgota MC, and Tyasi TL (2022). Predicting body weight of Kalahari Red goats from linear body measurements using data mining algorithms. Veterinary World, 15(7): 1719-1726. DOI: http://www.doi.org/10.14202/vetworld.2022.1719-1726

Moradian C, Mohamadi N, Razavi-Sheshdeh SA, Hajihosseinlo A, and Ashrafi F (2013). Effects of genetic polymorphismat the growth hormone gene on growth traits in Makooei sheep. European Journal of Experimental Biology, 3(3): 101-105. Available

at: https://www.primescholars.com/abstract/effects-of-genetic-polymorphismat-the-growth-hormone-gene-on-growth-traitsin-makooei-sheep-91089.html

Musa AM, Idam NZ, and Elamin KM (2012). Heart girth reflect live body weight in Sudanese Shogur sheep under field conditions. World's Veterinary Journal, 2(4): 54-56. Available at: https://wvj.science-line.com/attachments/article/14/World's%20Vet.%20J.%202(4)%2054-56%202012.pdf

Norris D, Brown D, Moela AK, Selolo TC, Mabelebele M, Ngambi JW, and Tyasi TL (2015). Path coefficient and path analysis of body weight and biometric traits in indigenous goats. Indian Journal of Animal Research, 49(5): 573-578. Available at: https://www.indianjournals.com/ijor.aspx?target=ijor:ijar1&volume=49&issue=5&article=002

Olawumi S and Farinnako EA (2017). Evaluation of the relationship between body weight and linear measurements in West African Dwarf goat as influenced by sex and agro-vegetational zone in the Southwestern Region of Nigeria. International Journal of Veterinary Science and Animal Husbandry, 3(1): 13-17. Available at: https://scialert.net/abstract/?doi=sciintl.2017.63.67

Özen D, Kocakaya A, Ünal N, and Özbeyaz C (2019). A recursive path model for estimation of the live weight using some body measurements in Awassi sheep. Ankara Üniversitesi Veteriner Fakültesi Dergisi, 66(3): 303-310. DOI: http://www.doi.org/10.33988/auvfd.512959

Patbandha TK, Pata BA, Trivedi SP, Gohil BC, Boradiya PC, Sharma A, and Savalia KB (2018). Evaluating phenotypic correlation between body weight and biometric traits of migratory goats. Journal of Entomology and Zoology Studies, 6(1): 560-564. Available at: http://www.entomoljournal.com/archives/2018/vol6issue1/PartH/5-6-309-143.pdf

Petrovic MP, Petrovic VC, Muslic RD, Iliæ Z, Spasiæ Z, Stojkoviæ J, and Makshimovic N (2012). Genetic and phenotypic of the body measured traits in Merinolandschaf breed of sheep. Biotechnology in Animal Husbandry, 28(4): 733- 741. DOI: http://www.doi.org/10.2298/BAH1204733P

Prasad J (2010). Goat, sheep, and pig production and management, 4th Edition. Kalyani Publishers., Daryagani, New Delhi, pp. 1-451.

Rather MA, Bashir I, Hamdani A, Khan NN, Ahangar SA, and Nazki M (2021). Prediction of body weight from linear body measurements in kashmir merino sheep. Advances in Animal and Veterinary Sciences, 9(2): 189-193. DOI: https://www.doi.org/10.17582/JOURNAL.AAVS%2F2021%2F9.2.189.193

Sandeep K, Dahiya SP, Malik ZS, and Patil CS (2017). Prediction of body weight from linear body measurements in sheep. Indian Journal of Animal Research, 52(9): 1263-1266. DOI: http://www.doi.org/10.18805/ijar.B-3360

Shehata MF (2013). Prediction of live body weight and carcass traits by some live body measurements in Barki lambs. Egyptian Journal of Animal Production, 50(2): 69-75. Available at: https://journals.ekb.eg/article_94302_16ce5bcdfde68b0a3ad4e69123867023.pdf

Shirzeyli FH, Lavvaf A, and Asadi A (2013). Estimation of body weight from body measurements in four breeds of Iranian sheep. Songklanakarin Journal of Science and Technology, 35(5): 507-511. Available at: https://www.thaiscience.info/journals/Article/SONG/10890966.pdf

Sun MA, Hossain MA, Islam T, Rahman MM, Hossain MM, and Hashem MA (2020). Different body measurement and body weight prediction of Jamuna Basin sheep in bangladesh. SAARC Journal of Agriculture, 18(1): 183-196. DOI: http://www.doi.org/10.3329/sja.v18i1.48392

Tariq MM, Eyduran E, Bajwa MA, Waheed A, Iqbal F, and Javed Y (2012). Prediction of body weight from testicular and morphological characteristics in indigenous Mengali sheep of Pakistan using factor analysis scores in multiple linear regression analysis. International Journal of Agriculture & Biology, 14: 590-594. Available at: http://www.fspublishers.org/published_papers/54354_.pdf

Tsegaye D, Belay B, and Aynalem HA (2013). Linear body measurements as predictor of body weight in Hararghe Highland goats under farmers environment, Ethiopia. Global Veterinaria, 11(5): 649-656. Available at: https://www.idosi.org/gv/gv11(5)13/24.pdf

Temoso O, Coleman M, Baker D, Morley P, Baleseng L, Makgekgenene A, and Bahta S (2017). Using path analysis to predict bodyweight from body measurements of goats and sheep of communal rangelands in Botswana. South African Journal of Animal Science, 47(6): 854-863. DOI: https://www.doi.org/10.4314/SAJAS.V47I6.13

Tyasi TL, Mathye ND, Danguru LW, Rashijane LT, Mokoena K, Makgowo KM, Mathapo MC, Molabe KM, Bopape PM, and Maluleke D (2020). Correlation and path analysis of body weight and biometric traits of Nguni cattle breed. Journal of Advanced Veterinary and Animal Research, 7(1): 148-155. DOI: http://www.doi.org/10.5455/javar.2020.g404

Verma SK, Dahiya SP, Malik ZS, Patil CS, and Patil HR (2016). Biometrical characterization of Harnali sheep: A new synthetic strain. Indian Journal of Animal Research, 25(1): 16-21. Available at: https://www.indianjournals.com/ijor.aspx?target=ijor:ijvr&volume=25&issue=1&article=003

Weldeyesus G and Yayneshet T (2016). Morphological characterization of Indigenous Highland Sheep population of Tigray, Northern Ethiopia. Journal of Natural Sciences Research, 6(3): 64-72. Available at: https://iiste.org/Journals/index.php/JNSR/article/view/28852/29616

Yilmaz A, Tepeli C, Tekin ME, Akmaz A, Garip M, Polat ES, Coşkun B, and Çağlayan T (2011). Determination of live weights and body measurements of Kangal Type Akkaraman sheep in producers conditions. Journal of Food, Agriculture and Environment, 9(2): 366-370. Available at: https://www.wflpublisher.com/Abstract/2125

Yilmaz O, Cemal I, and Karaca O (2013). Estimation of mature live weight using some body measurements in Karya sheep. Tropical Animal Health and Production, 45: 397- 403. DOI: http://www.doi.org/10.1007/s11250-012-0229-7

Younas U, Abdullah M, Bhatti JA, Pasha TN, Ahmad N, Nasir M, and Hussain A (2013). Inter-relationship of body weight with linear body measurements in Hissardale sheep at different stages of life. Journal of Animal and Plant Sciences, 23(1): 40-44. Available at: http://thejaps.org.pk/docs/v-23-1/07.pdf