American Journal of Animal and Veterinary Sciences

Literature Review

Prediction of Body Weight from Linear Body Measurements in Sheep: A Systematic Review

[1,2]Mathemba Kwezi Molosi, [2]Lubabalo Bila and [3]Thobela Louis Tyasi

[1]Department of Rural Development and Agrarian Reform Amahlathi Office, P.O. Box 166, Stutterheim, South Africa
[2]Department of Agriculture and Animal Health, College of Agriculture and Environmental Sciences, University of South Africa, Florida, South Africa
[3]School of Agricultural and Environmental Sciences, Department of Agricultural Economics and Animal Production, University of Limpopo, Private Bag X1106, Sovenga, Limpopo, South Africa

Article history
Received: 24-05-2024
Revised: 30-07-2024
Accepted: 17-08-2024

Corresponding Author:
Thobela Louis Tyasi
School of Agricultural and Environmental Sciences, Department of Agricultural Economics and Animal Production, University of Limpopo, Private Bag X1106, Sovenga, Limpopo, South Africa
Email: louis.tyasi@ul.ac.za

Abstract: The aim of the study was to systematically review the literature on the prediction of the body weight from linear body measurement traits in sheep using four databases: Google Scholar, PubMed, Science Direct and Web of Science. The findings showed that eighteen (n = 18) articles with 22% (n = 4) were from South Africa certified to be utilised in this study after screening. Moreover, the outcomes showed that the highest publication of articles were in 2021 with 22% (n = 4). The Dorper sheep breed reported to be the commonly used breed with 3% (n = 5). The results indicated that 56% of article used revealed that the principal component analysis (PCA) statistical technique was the mostly used in predicting body weight. About 72% of articles reported wither height as the best linear body measurement trait in sheep. A total of eighteen articles (n = 18) used showed a significant association between the body weights and used linear body measurement features in varied sheep types. Findings of this systematic review might be used as the evidence of which linear body measurement trait might be used to predict live body weight in sheep in the absence of weighing scale and which traits might be used to improve body weight during breeding.

Keywords: Sheep Breeds, Body Weight, Linear Body Measurement Traits

Introduction

The sheep population is predicted to be approximately 1.263 million and about 400 million are in African countries (DAFF, 2015). In South Africa, 21.43 million of the sheep population is owned by resource-limited farmers (DAFF, 2015). Sabbioni *et al.* (2020) Reported that sheep farming plays a huge part in developing cities, as it is of economic importance through job creation, and poverty mitigations and holds a social value in many rural areas. Sheep are vital small-stock animals that contribute a fundamental role in various rural areas, as a source of protein and through job creation (Silva Souza *et al.*, 2019). The body weight of sheep animals has been identified as one of the most economically important traits in the livestock industry, particularly for market price determination, knowing an animal's body weight is also crucial for optimal feeding, medicine administration, breeding purposes, mainly for communal areas where the weighing scales are inaccessible and unaffordable (Ormachea *et al.*, 2023). Communal genetic selection methods are selection strategies, that only focus, on animal body weight information, and have an association with linear body measurements traits such as body length, heart girth, withers height, and sternum height. Even though there are studies that have been discussed on linear body measurements of animals, there is no systematic review documented on sheep breeds. Hence, the objective of this study was to systematically review the prediction of body weight from linear body measurements in sheep. Lastly, this systematic review will help sheep keepers understand the relationship between body weight and linear body measurement traits.

Materials and Methods

Eligibility Criteria

Identification of the Population, Exposure, and Outcomes (PEO) components of the research questions was done for this systematic review as described by Bettany-Saltikov (2010). The "sheep" was defined as the population of the study, with the "linear body measurements", OR "growth", OR "biometric" OR "morphological traits" as exposure and "body weight" as outcomes. A pilot search of the PEO components on the

Google Scholar Database was conducted prior to deciding to conduct the study.

Search Strategy

The literature from research articles was collected by all the authors through the use of four databases Google Scholar, PubMed, Science Direct, and Web of Science from the 8th of January 2024 to the 29th of February 2024, using the combination of the following keywords: "Sheep", predicting/estimating body weight, growth biometric/linear body measurements and morphological traits. Keywords were combined in various combinations during the search. Lastly, the results were limited to English language papers only. This search was organized following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) as explained by Moher *et al.* (2009).

Inclusion Criteria

All the retrieved articles were screened for eligible studies according to several standards and were considered eligible if they met the following criteria: Sheep, attributes, and mass. Secondly, keywords such as "sheep", predicting/estimating body weight, were used for searching articles.

Exclusion Criteria

The exclusion criteria of the current study contained: Three (3) duplicate records two (2) records of irrelevant and unusable articles (language barriers, study design mismatch) to keywords of the study, ten (10) article papers were not assessable and one (1) study which was in the form of an abstract without the full text of the article. Overall, the research papers were narrowed in articles to 18 research papers which were used and cited.

Data Extraction

All three investigators independently extracted the data of the current study and agreement was reached concerning all items. The information obtained from each article consisted of the first author, year of publication, and sheep breed.

Ethical Considerations

Plagiarism, misconduct, informed consent, data falsification, and fabrication were considered ethical issues by all authors when performing this systematic review.

Results

Searched Results

A total of seventy-five (n = 75) articles were retrieved through a publication search. Three (n = 3) of these articles were duplicates and were removed. As a result, a total of seventy-two articles (n = 72) were considered appropriate for the selection of title and abstract. Ten articles (n = 10) were not assessable, two (n = 2) were removed due to irrelevance, two (n = 2) were eliminated after a review of the title and abstract and another article (n = 1) was eliminated after a review of the full text with reasons stated in (Figure 1). Lastly, a total of eighteen (n = 18) full-text articles qualified for inclusion in the study. Figure (1) Flow chart of identification and selection of studies for systematic review.

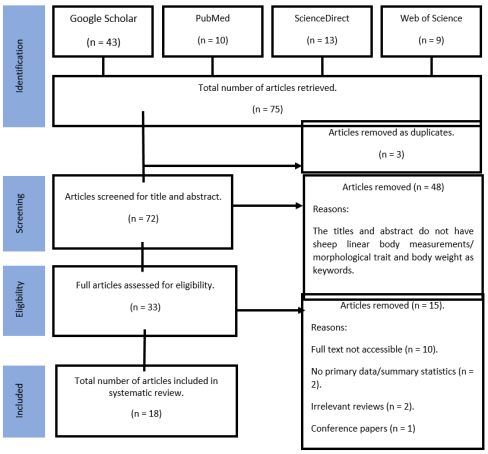

Fig. 1: Flowchart of identification and selection of studies for systematic review

Table 1: Characterization of included articles

Reference	Country	Size	Breed	Sex
Shehata (2013)	Egypt	139	Barki	M&F
Zewdu *et al.* (2008)	Ethiopia	1575	Bonga and Horro	M&F
Michael *et al.* (2016)	Ethiopia	630	Indigenous	M&F
Kumar *et al.* (2018)	India	349	Harnali	M&F
Silva Souza *et al.* (2019)	Brazil	48	Santa Ines	M&F
Huma and Iqbal (2019)	Pakistan	131	Balochi	M
Santos *et al.* (2020)	Brazil	25	Dorper and Santa Ines	M&F
Okeke *et al.* (2020)	Nigeria	149	Balami, Uda, Yankasa and West Africa Dwarf	M&F
Haque *et al.* (2020)	Blangadesh	508	Barind	M&F
Becker & Fourie (2021)	South Africa	409	Yankasa, Namaqua Afrikaner, Zulu (Nguni), Dorper and Damara	M&F
Abbas *et al.* (2021)	Pakistan	152	Thalli	F
Selala and Tyasi (2022)	South Africa	28	Dorper	F
Ali Rather *et al.* (2020)	India	349	Kashmir merino	M&F
Selala and Tyasi (2022)	South Africa	51	Dorper	M&F
Djaout *et al.* (2022)	Algeria	54	Tazegzawt	M&F
Madikadike *et al*. (2022)	South Africa	50	Dorper	M&F
Ormachea *et al.* (2023)	Puno	380	Creole	M&F
Tirink *et al.* (2023)	Poland	344	Suffolk, polish merino, and crossbreds	M&F

Characterization of Included Articles

Eighteen (n = 18) included articles of the seventy-five (n = 75) analyzed were reserved for inclusion in the literature review flow chart (Figure 1). The retained articles ranged from the year 2008 to 2023. Moreover, several sheep breeds (Table 1) we used in the study including breeds such as Barki (Shehata, 2023) and Harnali (Edea *et al.*, 2017) respectively.

Origin of the Articles by Country

Figure (2) shows the number of articles used per country. The results showed that articles were from eighteen (n = 18) different countries. South Africa with most (22%) articles (n = 4) articles followed by Pakistan with 11% (n = 2) (Huma and Iqbal, 2019; Abbas *et al.*, 2021), Brazil with 11% (n = 2) (Silva Souza *et al.*, 2019; Santos *et al.*, 2020), India with 11% (n = 2) (Kumar *et al.*, 2018; Ali Rather *et al.*, 2020) and Ethiopia with 11% (n = 2) (Zewdu *et al.*, 2008; Michael *et al.*, 2016) and Nigeria with 11% (n = 2) (Okeke *et al.*, 2020).

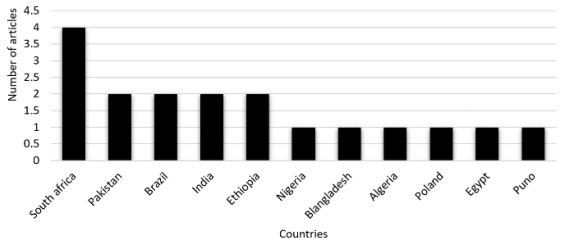

Fig. 2: Publications by country distribution

Distribution of the Articles by Year

The results on the distribution of included articles by year (Figure 3) indicated that articles were from eighteen (n = 18) different countries, with the highest articles published in 2021 with 22% (n = 4), followed by 2020 and 2022 with 17% (n = 3) and in 2019 and 2023 with 11% (n = 2).

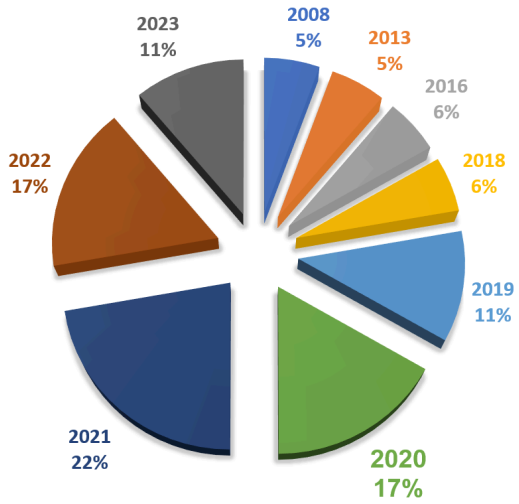

Fig. 3: Distributions of articles by year

Distribution of Included Articles by Journals

The results of articles used by journals (Figure 4) indicated that the Veterinary World was the top journal used with 17% (n = 3) followed by the Iraqi Journal of Agricultural Science and Advanced in Animal and Veterinary Science with 11% (n = 2).

Veterinary World Journal (VWJ), Multidisciplinary Digital Publishing Institute Journal of Animal (MDPIJA), Iraqi Journal of Agriculture Science (IJAS), Journal of Natural Science (JNSR), Advance Animal and Veterinary Science (AAVS), American Journal of Animal and Veterinary Science (AJAVS), Nigerian Journal of Animal Production (NJAR), Revista Brasilia de Saude Producao Animal Journal (RBSPA), World Veterinary Life Science and Agriculture (SJLSA)

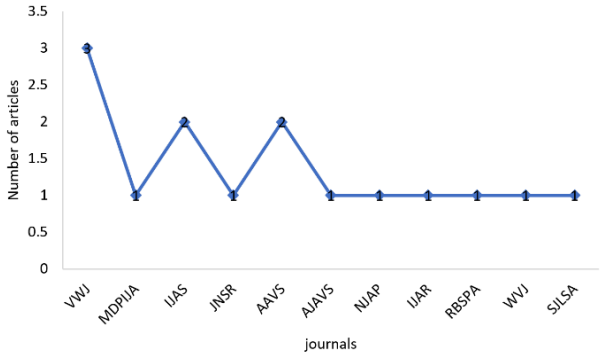

Fig. 4: Publication of articles by journals

Distribution of Included Articles by Sheep Breeds

The results of the included articles by sheep breeds (Figure 5) showed that the Dorper sheep breed was commonly used with 3% (n = 5), followed by Santa with 2 % (n = 2) while other breeds were the least with 1% (n = 1).

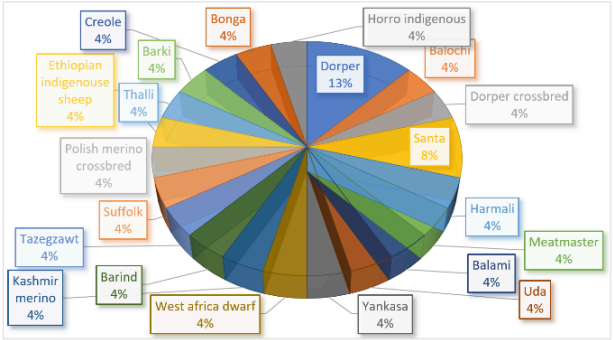

Fig. 5: Distribution of included articles by sheep breeds

Distribution of Included Articles by Statistical Techniques

Fifty-six percent (n = 10) of articles revealed that the Principal Component Analysis (PCA) statistical technique was the most technique used in predicting BW (Figure 6). The results showed Chi-square test accounted

for 33% (n = 6) as the second highest statistical technique used in predicting BW. Then, 11% (n = 2) of articles reported Classification And Regression Tree (CART) algorithms and Chi-Squared Automatic Interaction Detection (CHAID) provide the as least in predicting body weight (Abbas *et al.*, 2021; Tirink *et al.*, 2023).

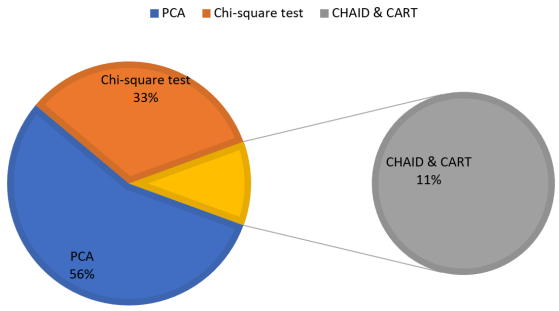

Fig. 6: Distribution of articles by statistical technique

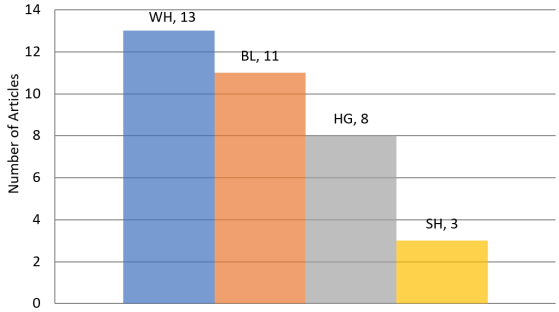

Fig. 7: Common traits used; Wither Height (WH), Body Weight (BW), Body Length (BL), Heart Girth (HG), Sternum Height (SH)

Distribution of Articles by Linear Body Measurement Traits Used to Predict Body Weight

Seventy-two percent (n = 13) of articles reported that WH was the best linear body measurement trait in predicting BW of sheep animals (Figure 7)., 61% (n = 11) articles revealed BL, as the second highest linear body measurement trait used in predicting BW of sheep animals. The results further indicated that HG as the third highest linear body measurement trait used, accounted for 44% (n = 8) of articles, and lastly, 17% (n = 3) of SH as the least trait observed.

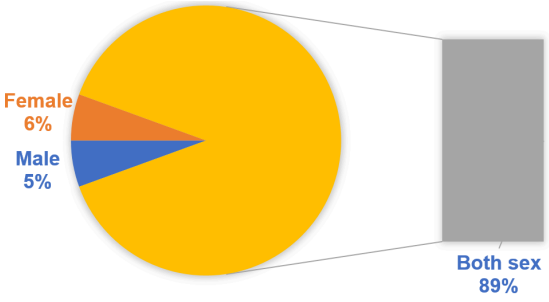

Fig. 8: Articles by sex

Distribution of Article by Sex

The majority of the articles used reported on both male and female sheep in terms of gender diversity with 89% (n = 16) as the highest (Figure 8). While on the other hand, articles reported on females alone accounted for 6% (n = 1) and males as the least with 5% (n = 1) (Abbas *et al.*, 2021; Huma and Iqbal, 2019).

Discussion

Live body weight is an important measure of animal performance and determines the major concern for all sheep buyers (Huma and Iqbal, 2019). Ali Rather *et al.* (2020) reported that the live body weight of animals can be estimated using both linear body measurements and phenotypic traits. Moreover, the linear body measurement traits can be described as a continuous growth process during the livestock life span. Linear body measurement traits can be measured including traits such as body length, withers height, sternum height, rump length, and heart girth (Tirink *et al.*, 2023). This systematic review was conducted to explore linear body traits and their association with live body weight in sheep breeds. Exposing the linkage between linear body traits might help in estimating the live body weight of sheep. As such a total of eighteen (n = 18) articles out of seventy-five (n = 75) retrieved articles were reserved for inclusion and utilized for the development of this systematic review. The utilized articles reported that 22% (n = 4) of the included articles were from South Africa, followed by 11% (n = 2) of them from Pakistan, Brazil, India, and Ethiopia (Zewdu *et al.*, 2008; Michael *et al.*, 2016). The outcomes of this review revealed that the Dorper sheep breed was the most explored sheep breed (Becker & Fourie, 2021; Santos *et al.*, 2020) which accounts for 3% of the included articles. This might be an outcome that the Dorper sheep breed is the most common domineering sheep type found in the eighteen countries included in this systematic review. This could be due to the availability of sheep breeds across the globe as well as the potential of a variety of sheep breeds adapting in different ecological zones and easy handled to conduct studies. The findings further indicated that the most included articles 56% utilized the PCA statistical technique in predicting body weight, while 33% of the included articles used the Chi-square test technique and (11%) of included articles used CART algorithms and CHAID in predicting body weight (Abbas *et al.*, 2021; Tirink *et al.*, 2023). The results indicated that 72% of included articles observed withers height as the best linear body measurement trait in predicting body weight, while 61% of included articles revealed body length as the second linear body measurement trait. Eighty-nine percent (n = 16) of included articles reported on both male and female sheep in terms of sex used, while the remaining articles females alone accounted for 6% and males with 5% (Abbas *et al.*, 2021; Huma and Iqbal, 2019). The findings revealed that out of 18 articles

utilized in this systematic review, eighteen articles showed a significant association between body weights and linear body measurements in sheep breeds. Shehata (2013) showed a significant association correlation coefficient between linear body measurements and live body weight in males, more than in females, and further, reported heart girth as the effective predictor for body weight. The body length is reported as a linear body trait that truly estimates body weight with high significant association (Silva Souza *et al.*, 2019). Djaout *et al.* (2022), revealed males as heavier and higher in weight and height than female sheep. The strength of this systematic review is that, to the best of our knowledge there are no similar studies documented as systematic reviews on the prediction of body weight from linear body measurement traits in sheep. The contribution of this systematic review to the body of knowledge is to suggest that there is a relationship that exists between live body weight and certain linear body measurement traits in different sheep breeds. This systematic review further suggests that there is limited evidence of the relationship between body weight and linear body measurement traits in sheep breeds. Therefore, there is a need to conduct investigation studies on the association between body weight and linear body measurement traits measurements in sheep to assist farmers lacking weighing scales, especially in communal setups.

Conclusion

The current study revealed evidence that body weight has an association with linear body measurement traits in sheep breeds. The results of the study suggest that height is the most important linear body measurement trait that can be used to predict body weight in sheep. Moreover' results indicated that body length, heart girth, and sternum height, truly estimate body weight with accurate levels. The PCA found as the commonly used statistical method in the estimation of live body weight in sheep which might be due to high correlation coefficients between used traits.

Acknowledgment

This systematic review has been supported and approved by the University of South Africa.

Funding Information

Financially, this systematic review is self-supported. (Postgraduate: Reference number: 2024/CAES-AREC/2568)

Authors's Contributions

Mathemba Kwezi Molosi: Wrote drafted manuscript, searched articles on databases, excluded and inclusion criteria of articles, data extraction, and approved the manuscript for submission.

Lubabalo Bila and Thobela Louis Tyasi: Revied drafted manuscript, searched articles on databases, exclusion and inclusion criteria of articles, data extraction, and approved the manuscript for submission.

Ethics

Issues around ethics, informed consent, plagiarism and data fabrication, were considered by the authors.

Conflict of Interest

The writers claim that there isn't a conflict of interest.

Availability of Data

Upon request to the corresponding author, all data generated during this investigation are made available.

References

Abbas, A., Ullah, M. A., & Waheed, A. (2021). *Body weight prediction using different data mining algorithms in Thalli sheep: A comparative study*. Veterinary World. https://doi.org/10.14202/vetworld.2021.2332-2338

Ali Rather, M., Bashir, I., Hamdani, A., Nabi Khan, N., A. Ahangar, S., & Nazki, M. (2020). Prediction of Body Weight From Linear Body Measurements in Kashmir Merino Sheep. In *Advances in Animal and Veterinary Sciences* (Vol. 9, Issue 2, pp. 189-193). https://doi.org/10.17582/journal.aavs/2021/9.2.189.193

Becker, S. J., & Fourie, P. J. (2021). Phenotypic characterisation of Meatmaster sheep using quantitative and qualitative trait analysis. *Tropical Animal Health and Production*, *53*(2), 326. https://doi.org/10.1007/s11250-021-02768-2

Bettany-Saltikov, J. (2010). Learning how to undertake a systematic review: part 2. *Nursing Standard*, *24*(51), 47-56. https://doi.org/10.7748/ns2010.08.24.51.47.c7943

Department Agriculture Forestry and Fisheries-South Africa (DAFF). (2015). A profile of the South African wool market value chain. *E-Print*.

Djaout, A., El-Bouyahiaoui, R., Belkheir, B., Moulla, F., Mansouri, H., & Benidir, M. (2022). Prediction of the Body Weight of Algerian Tazegzawt Sheep Breed From Body Measurements. *Iraqi Journal of Agricultural Sciences*, *53*(5), 1138-1144. https://doi.org/10.36103/ijas.v53i5.1627

Edea, Z., Dessie, T., Dadi, H., Do, K.-T., & Kim, K.-S. (2017). Genetic Diversity and Population Structure of Ethiopian Sheep Populations Revealed by High-Density SNP Markers. *Frontiers in Genetics*, *8*, 218. https://doi.org/10.3389/fgene.2017.00218

Haque, M. I., Sarder, M. J., Islam, M. A., Khaton, R., Islam, M. H., & Hashem, M. A. (2020). Morphometric characterization of Barind sheep of Bangladesh. *Journal of Earth and Environmental Science;4(192):2577-0640*, *4*(192), 2577-0640. https://doi.org/10.29011/2577-0640.100192

Huma, Z. E., & Iqbal, F. (2019). Predicting the body weight of Balochi sheep using a machine learning approach. *Turkish Journal of Veterinary and Animal Sciences*, *43*(4), 500-506. https://doi.org/10.3906/vet-1812-23

Kumar, S., Dahiya, S. P., Dahiya, Z. S., & Patil, C. S. (2018). *Prediction of body weight from linear body measurements in sheep*. Indian Journal of Animal Research. https://doi.org/10.18805/ijar.b-3360

Madikadike, M. K., Mbazima, V., Gunya, B., & Tyasi, T. L. (2022). Growth Traits as Indicators of Body Weights in Dorper Sheep. *American Journal of Animal and Veterinary Sciences*, *17*(4), 332-338. https://doi.org/10.3844/ajavsp.2022.332.338

Michael, A., Kefelegn, K., & Yoseph, M. (2016). Phenotypic Characterization of Indigenous Sheep Types in Northern Ethiopia. *Journal of Natural Sciences Research*, *6*(15), 16-27.

Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. *Annals of Internal Medicine*, *151*(4), 264. https://doi.org/10.7326/0003-4819-151-4-200908180-00135

Okeke, R. O. N., B.I, I.-T., A.O., & John, P. A. (2020). Diversity of biometric and morphological traits among sheep breeds in Nigeria. *Nigerian Journal of Animal Production*, *12*(17), 13-25. https://doi.org/10.51791/njap.v47i2.51

Ormachea, V. E., Calsin, B. C., Aguilar, E. S., Ormachea, B. V., Gonzales, H. C., & Masias, Y. M. G. (2023). Principal component analysis of morphological. *Adv. Anim. Vet. Sci*, *11*(6), 903-909. https://doi.org/10.17582/journal.aavs/2023/11.6.903.909

Sabbioni, A., Beretti, V., Superchi, P., & Ablondi, M. (2020). Body weight estimation from body measures in Cornigliese sheep breed. *Italian Journal of Animal Science*, *19*(1), 25-30. https://doi.org/10.1080/1828051X.2019.1689189

Santos, H. P., Aiura, A. L. D. O., Gonçalves, G. A. M., & Aiura, F. S. (2020). Phenotypic characterization and weight prediction of crossbred Dorper × Santa Inês ewes. *Revista Brasileira de Saúde e Produção Animal*, *21*, 2121332020. https://doi.org/10.1590/S1519-99402121332020

Selala, L. J., & Tyasi, T. L. (2022). Using Morphological Traits to Predict Body Weight of Dorper Sheep Lambs. *World's Veterinary Journal*, *12*(1), 66-73. https://doi.org/10.54203/scil.2022.wvj9

Shehata, M. (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. https://doi.org/10.21608/ejap.2013.94302

Silva Souza, J. da, do Santos Difante, G., Neto, J. V. E., Lana, Â. M. Q., da Silva Roberto, F. F., & Ribeiro, Pedro Henrique Cavalcante. (2019). Biometric measurements of Santa Inês meat sheep reared on Brachiaria brizantha pastures in Northeast Brazil. *Plos One*, *14*(7), 0219343. https://doi.org/10.1371/journal.pone.0219343

Tırınk, C., Piwczyński, D., Kolenda, M., & Önder, H. (2023). Estimation of Body Weight Based on Biometric Measurements by Using Random Forest Regression, Support Vector Regression and CART Algorithms. *Animals*, *13*(5), 798. https://doi.org/10.3390/ani13050798

Zewdu, E. (2008). *Characterization of Bonga and Horro indigenous sheep breeds of smallholders for designing community-based breeding strategies in Ethiopia*.