Comparative analysis of sheep and goat production indicators under semi-intensive management systems in lower Gangetic plains of West Bengal

T.C. Dhara[1], R. Tiwari[1*], S. Negi[1], A. Das[2], T. Dutt[3]

[1]Division of Extension Education, [2]Agricultural Technology Information Center [4]Director, ICAR- Indian Veterinary Research Institute, Izatnagar, Bareilly 243122, Uttar Pradesh, India
[*]Corresponding Author: rtiwarirupasi@gmail.com

Abstract

Livestock production is a pivotal sector of India's rural economy, with sheep and goats individually playing a key role in sustainment of marginal farmers' and landless laborers' livelihood. With conventional extensive systems under pressure and intensive ones inaccessible to majority of small farmers, semi-intensive ones became effective substitutes through balanced management and better performance. This study is intended to compare and evaluate the growth, reproduction characteristics, health indicators, and economic factors of sheep and goats raised under identical semi-intensive production systems in West Bengal's Lower Gangetic Plains. A total of 600 animals (300 ewes and 300 does) from 120 farms chosen from four districts were examined. Major determinants were the progression of body weight, body condition score, reproduction achievements, litter size, mortality rates, and breeding season. Spring balance measurements and interviews with farmers provided the data, which were analyzed through SPSS. Outcomes indicated goats had greater growth rates, earlier maturation, and better bodily condition, whereas sheep expressed better prolificacy and breeding seasonality. Death rates were similar. Findings identify species-specific benefits under semi-intensive management and underscore the importance of species-specific advisory services. They provide useful information to improve the productivity of small ruminants in resource-constrained, high potential farming regions.

Keywords: Small ruminants, Lower Gangetic plains, Average body weight, Body Condition Score, Litter size

Introduction

Livestock farming is a cornerstone of India's agrarian economy, particularly in rural areas where it supports livelihoods, nutritional security, and supplementary income. Among livestock species, small ruminants like sheep and goats hold special importance for tribal communities, small and marginal farmers, and landless labourers (Kumar et al., 2021). The livestock sector contributes 30.19% to the Gross Value Added (GVA) of agriculture and allied sectors and 5.73% to the national GVA, with production levels reaching 221.6 million tonnes of milk, 126.6 billion eggs, 33.13 million kg of wool, and 9.29 million tonnes of meat (BAHS, 2024). According to the 20th Livestock Census (2019), India possesses over 148 million goats and 74 million sheep, ranking first globally in goat population and third in sheep population (DAHD, 2019).

Goats and sheep are well known for their hardiness, adaptability, and ability to survive under low-input conditions, making them integral to mixed farming systems. Goats are often referred to as the "poor man's cow" due to their faster growth, milk yield, and meat quality, while sheep are valued for wool, mutton, and reproductive efficiency under favorable conditions (Alemu, 2020; Rout & Behera, 2021). Together, they contribute significantly to household income, food security, and employment, while also serving as financial insurance against crop failure tglobally (Salvana et al., 2019; Shivakumara et al., 2020). Beyond economics, sheep and goats play important socio-cultural roles, including religious practices and serving as a major source of animal protein without cultural taboos (Zailani et al., 2016).

Traditional extensive production systems reliant on open grazing are increasingly constrained by shrinking grazing lands, land degradation, and rising disease pressure (Pandey & Upadhyay, 2022). Conversely, intensive systems, though productive, are often unaffordable and unsustainable for smallholders due to high feed and infrastructure costs (Shivakumara, 2019). Semi-intensive systems have emerged as a viable alternative, combining controlled feeding and management with limited grazing, thereby improving productivity and animal health at relatively lower cost (Mandal et al., 2022).

The Lower Gangetic Plains (LGP), covering eastern Uttar Pradesh, Bihar, West Bengal, and northern Jharkhand, is a fertile, densely populated agro-climatic region with high rainfall and alluvial soils (Singh, 2012). Despite its potential, livestock productivity remains sub-optimal due to poor management practices, low awareness, and limited veterinary services (Raja et al., 2012). Scientific semi-intensive small ruminant farming could substantially enhance productivity in this region.

While several studies have assessed sheep and goat production separately, direct comparative evaluations under identical farm-level, semi-intensive conditions are scarce. This study addresses this gap by comparing growth performance, reproductive traits, health parameters, and economic returns of sheep and goats under semi-intensive management in the Lower Gangetic Plains. The findings aim to provide evidence-based guidance for farmers, extension workers, and policymakers on species suitability, profitability, and resilience in this under-researched yet agriculturally significant region.

Materials and Methods

West Bengal (21°25' N to 27°13' N latitude and 85°50' E to 89°50' E longitude) was purposively selected to get a better comparative assessment of sheep and goat production indicators. This selection was backed by the fact that West Bengal had the highest growth rate of one of the small ruminants, goats (41.49%), and this area also had some important small ruminant breeds like Black Bengal goat and Garole sheep. The lower Gangetic plain in West Bengal consists of seven districts, namely Nadia, Murshidabad, Hooghly, Howrah, Kolkata, and North and South 24 Parganas. From these four districts were purposively selected, two for goats - Howrah, Hooghly, and two for sheep- North and South 24 Parganas. One block from each district was purposively selected based on the highest number of small ruminant farms. Clusters were identified, and one cluster from each block was randomly selected. From each cluster, 30 farms were randomly selected that had a flock size of at least 30. So, a total of 60 goat and 60 sheep farms were selected. For convenient data collection, 5 female animals from each farm were chosen, which were in the age group of 12 to 18 months. A total of 600 animals (300 ewes and 300 does) were obtained to study the following production indicators, average body weight at different stages of life (at birth, 3 months, 6 months, 9 months, and 12 months of age), body condition score, age of marketing, age of first kidding/lambing, litter size, mortality rates, and breeding season. Ewes and does (600) were weighed by spring balance, and information about other production indicators was collected through a semi-structured interview schedule. To measure the body condition score, a BCS scale developed by Villaquiran *et al.* (2005) was used. The BCS scoring for ewes and does utilizes the scale ranging from 1 to 5, where 1 denotes emaciated and 5 indicates obesity. Data collection was done from May to October 2023. Empirical data were tabulated and analyzed using suitable statistical methods with the assistance of the Statistical Package for Social Sciences (SPSS).

Result and Discussion

Body weight is a very important indicator of productivity and performance of growth in small ruminants. The current work identifies considerable variation in the pattern of growth in goats and sheep raised in semi-intensive systems in the Lower Gangetic Plain of West Bengal. Table 1 provided information on the average body weight of goats and sheep at various life stages, including birth, 3 months, 6 months, 9 months, and 12 months. The average body weight of goats at birth was 1.81±0.04 kg, which increased to 19.23±0.29 kg in 12 months. Notable weight gain was seen between 6 and 9 months. In comparison, for sheep, average body weight at birth, 3 months, 6 months, 9 months, and 12 months were 0.98±0.07 kgs, 3.63±0.03 kgs, 7.21±0.05 kgs, 10.61±0.07 kgs, and 13.37±0.07 kgs, respectively. The growth was seen between 3 and 6 months. An independent sample "t" test suggested a highly significant ($p<0.01$) disparity between goats and sheep in terms of average body weight at every life stage. Goats showed a higher average body weight at birth compared to that of sheep, and the trend was consistent in all ages up to 12 months. Goats showed a linear and fast rate of body weight increase. Goats showed the maximum increase in body weight in the 6 to 9 months interval of life, which may have resulted from a better establishment of the rumen and enhanced consumption and efficiency in forage due to semi-intensive system supplementation. Sheep showed a relatively poorer rate of increase in body weight, whereas a relatively satisfactory increase in body weight was noticed in the interval of 3 to 6 months of life in sheep, which might have resulted from early weaning and adaptation to solid food. Sheep trailed far behind the pattern of body weight increase in the case of goats at all ages. The findings support the earlier work that suggested a quicker rate of body weight increase and feed efficiency in the case of emitting/breed type of goats as opposed to the bulk of the sheep breed under the same systems of management (e.g., Faruque *et al.,* 2010; Devi *et al.,* 2020; Solaiman *et al.,* 2020; and Mondal *et al.,* 2023). Their better growth rate in semi-intensive production systems makes the goat more preferable for the production of meat under conditions requiring quick turnover. Sheep, however, might need to stay longer on their rations to reach market weight, which might impact feed budget, marketing approach, and profitability.

Table 1: Distribution of sheep/goats according to their average body weight at different stages of life

Animals	Average body weight (Kg)				
	At birth	3 months	6 months	9 months	12 months
Goat (n=300)	1.81±0.04	4.78±0.09	9.68±0.17	15.33±0.41	19.23±0.29
Sheep (n=300)	0.98±0.07	3.63±0.03	7.21±0.05	10.61±0.07	13.37±0.07
"t" test	11.844**	11.443**	13.719**	11.452**	19.665**

**Significant at 1% level ($p<0.01$)

Table 2: Distribution of farms according to the age at first kidding/lambing of ewe/doe and average mortality rate of the neonates

Species	Age at first mating (months)						Average mortality rate (%)				
	< 12	12-18	> 18	Mean ± SE	Range	t-test value	Low (<5)	Medium (5-10)	High (>10)	Mean ± SE	Range
Goat (n=60) (%)	35 (58.33)	25 (41.67)	0 (00)	11.38 ± 0.23	10–17	5.486**	39 (65)	4 (6.67)	17 (28.33)	5.44 ± 1.01	0 – 20
Sheep (n=60) (%)	17 (28.33)	43 (71.67)	0 (00)	13.61 ± 0.18	11-15		36 (60)	3 (5)	21 (35)	5.62 ± 0.95	0 – 25

**Significant at 1% level ($p<0.01$)

Table 2 presented the distribution of farms based on the age at first kidding in does and first lambing in ewes. Among goat farmers, a majority (58.33%) reported that does gave birth for the first time at less than 12 months of age, whereas only 28.33 per cent of sheep farmers observed first lambing in this age group. In contrast, the majority of sheep (71.67%) experienced their first lambing between 12–18 months, compared to 41.67 per cent of goats. No animals in either group had their first parturition after 18 months of age. The mean age at first kidding for goats was 11.38 ± 0.23 months, while for sheep it was significantly higher at 13.61 ± 0.18 months. The range varied from 10 to 17 months in goats and 11 to 15 months in sheep. An independent sample t-test revealed a highly significant difference ($p < 0.01$) in the age at first parturition between goats and sheep. This variation may be attributed to species-specific physiological differences, breed characteristics, and better adaptability of goats to early breeding under semi-intensive systems. Early parturition in goats offers potential economic benefits by reducing the generation interval and increasing lifetime productivity. However, early breeding should be supported by adequate nutrition and health care to avoid negative impacts on reproductive

performance and offspring viability. These findings emphasize the need for species-specific reproductive management strategies to optimize production outcomes. Faruque *et al.* (2010) reported similar results of first parturition of goat under 12 months of age in a semi-intensive system of rearing.

The mortality rate in sheep and goats refers to the proportion of animals within these species that die during a specific period (0 to 3 months of age), typically expressed as a percentage. Young goat and sheep mortality rate (0–3 months) serves as an indicator of early-life management efficiency. As outlined in Table 2, majority of goat and sheep farms exhibited a low average mortality rate, defined as being less than 5% (65% for goats and 60% for sheep). Furthermore, a significant percentage of farms reported a high mortality rate, exceeding 10% (28.33% for goats and 35% for sheep), while the remaining farms fell within the medium range, with a mortality rate ranging from 5% to 10% (6.67% for goats and 5% for sheep). The average mortality rate for goat farms was calculated to be 5.44 per cent, and for sheep farms, it was 5.62 per cent, with a range of 0 to 20% for goat farms and 0 to 25% for sheep farms. In the current study, the majority of the farms had low mortality rates (<5%), but a considerable proportion of farms recorded high mortality rates (>10%), which were 35 per cent in sheep and 28.33 per cent in goats, pointing towards areas that lack adequate neonatal management and disease control. Although the averages are similar, the larger range in sheep farms (0–25%) indicates the potential for higher variability and management differences. These results highlight the need for enhanced neonatal health management, adequate colostrum supply within a timely schedule, and disease prevention to limit early mortality and increase the economic viability of small ruminant production. These also compare to Chandran *et al.* (2021) report showing the average mortality rate as 4.67 in the 0 to 3-month group in Kerala.

Body Condition Score (BCS) is a critical indicator of nutritional and health status in small ruminants. Table 3 furnished details on the Body Condition Score (BCS) of both ewes and does between the ages of 12 to 18 months.

Table 3: Distribution of sheep/goats according to the body condition score at 18 months of age

BCS	Goat (n=300) (%)	Sheep (n=300) (%)
Emaciated (1)	34 (11.33)	41 (13.67)
Thin (2)	133 (44.33)	122 (40.67)
Average (3)	85 (28.33)	107 (35.66)
Fat (4)	45 (15)	30 (10)
Obese (5)	3 (1)	0 (00)
Mean ± SE	2.5 ± 0.05	2.42 ± 0.04
Chi-square	9.649*	

*Significant at 5% level (p<0.05)

Table 4: Distribution of sheep/goats according to their litter size

Litter size	Goat (n=300) (%)	Sheep (n=300) (%)
Single	93 (31)	70 (23.33)
Twins	183 (61)	180 (60)
Triplets	24 (8)	45 (15)
Quadruplet	0 (00)	5 (1.67)
Mean ± SE	1.77 ± 0.03	1.95 ± 0.04
"t" test	3.514**	

**Significant at 1% level (p<0.01)

Table 5: Distribution of farms according to the age of sheep/goat at marketing and breeding seasons of ewe/doe

Species	Age at marketing					Breeding seasons				Chi-square
	< 12 months	12-18 months	> 18 months	Mean ± SE	Range	Sept-Oct	March-April	June-July	Indiscriminate breeding	
Goat (n=60) (%)	12 (20)	46 (76.67)	2 (3.33)	16.67 ± 0.4	10 - 24	25 (41.67)	10 (16.67)	5 (8.33)	20 (33.33)	26.667**
Sheep (n=60) (%)	15 (25)	20 (33.33)	25 (41.67)	16.63 ± 0.41	10 - 21	50 (83.33)	0 (00)	0 (00)	10 (16.67)	

**Significant at 1% level (p<0.01)

The majority of goats (44.33%) and sheep (40.67%) fell into the thin (2) BCS category. Only 1% of goats were classified under the obese (5) BCS category, and none of the sheep were categorized as obese (5). The average BCS for goats was 2.5, and for sheep, it was 2.42. A "Chi-square" test indicated a significant ($p<0.05$) difference between goats and sheep concerning body condition scores. The average BCS was slightly higher in the case of the goats (2.5) in comparison to the sheep (2.42), which implies slightly better body stores in the goats under the same management. Only 1% of the goats alone showed the obese condition of BCS 5, since none of the sheep achieved this condition, showing a general lack of over-conditioning in both species. These findings indicate the need for specific feeding strategies to improve body condition in sheep, which seem slightly more prone to being in the under-conditioned status in the semi-intensive systems. Reshma *et al.* (2022) also found the same trend in their study, whereby the body condition score of 2-year-old goats was 2-3 (2.82).Litter size, in the context of sheep and goats, pertains to the number of offspring born during a single birthing event. Litter size is a key reproductive performance indicator that directly influences flock productivity and economic returns. As outlined in Table 4, the predominant occurrence for both goats and sheep were the birth of two kids or lambs in a single event (61% for goats and 60% for sheep). This was followed by instances of one kid or lamb (31% for goats and 23.33% for sheep), and three kids or lambs (8% for goats and 15% for sheep). Additionally, a small percentage of sheep (1.67%) gave birth to four lambs, while no goats had four kids. On average, the litter size for goats was 1.77, and for sheep, it was 1.95. An independent sample "t" test indicated a highly significant ($p<0.01$) difference between sheep and goats in terms of litter size. The average litter size was significantly higher in sheep (1.95) compared to goats (1.77). This variation may stem from genetic differences, breed-specific reproductive traits, and better fecundity in certain sheep breeds. The findings suggest that, under semi-intensive systems in the lower Gangetic plains, sheep may offer a reproductive advantage over goats in terms of offspring output. However, increased litter sizes must be matched with improved management practices to ensure survival and growth of all offspring. These findings align with Mandal (2017), who reported similar trends in the prolificacy rate of Garole sheep (1.63 to 2.27), and Haldar *et al.* (2014), who documented the average litter size of Black Bengal goats (1.75) in West Bengal.

The experiment demonstrated a considerable difference in the seasonality of goat and sheep breeding under semi-intensive conditions. Table 5 presents the distribution of farms based on the breeding seasons of ewes (sheep) and does (goats) under a semi-intensive system in the Lower Gangetic Plain of West Bengal. A significant variation ($p < 0.01$) was observed between species regarding their breeding season preferences. Among goat-rearing farms, 41.67 per cent reported breeding activity primarily during the September–October period, which aligns with the post-monsoon season. An additional 16.67 per cent of goat farms indicated March–April as a secondary breeding period, while 8.33 per cent reported June–July as the breeding season. Interestingly, 33.33 per cent of goat farms practiced indiscriminate or year-round breeding, likely due to a lack of controlled mating practices or insufficient awareness about seasonality. In contrast, 83.33 per cent of sheep farms reported a distinct breeding season concentrated in September–October, with no breeding recorded during March–April or June–July. Only 16.67 per cent of sheep farms engaged in indiscriminate breeding. This strong seasonal breeding tendency in sheep may be attributed to their higher photoperiod sensitivity compared to goats. These differences confirm the requirement for species-specific management of breeding. Increasing information about controlled mating in the case of goats improves productivity, whereas feed and healthcare management for sheep farmers would prove beneficial in their focused breeding window. The result aligns with that stated by Mehrotra *et al.* (2019), who observed that the largest portion of sheep farmers in the Rajasthan region breed during the winter months, accounting for 76.87 per cent of the population.

Table 5 also presents the distribution of farms based on the age at which sheep and goats are marketed under semi-intensive rearing systems. The data revealed noticeable differences in marketing patterns between goat and sheep farms, although these differences were statistically non-significant ($p > 0.05$). A majority (76.67%) of goat farms reported marketing animals between 12 to 18 months of age, suggesting a preference for marketing once animals attain moderate body weight and market value. In contrast, only 33.33 per cent of sheep farms marketed their animals within this age group. Interestingly, 41.67 per cent of sheep farms marketed animals at an age above 18 months, as compared to only 3.33 per cent in goats. This extended marketing age in sheep may be due to breed-specific growth patterns, farmer preferences for wool/meat yield, or traditional practices in the region. On the other hand, 20 per cent of goat farms and 25 per cent of sheep farms sold animals within 12 months, likely to meet urgent financial needs or due to limited feeding resources. The mean age at marketing was nearly identical for both species, 16.67 ± 0.40 months for goats and 16.63 ± 0.41 months for sheep. The marketing age range was slightly broader in goats (10–24 months) compared to sheep (10–21 months), reflecting greater flexibility in marketing decisions for goats. The results indicate the importance of advisory services in assisting the farmer to match marketing age to the performance of the animal, as well as to market trends to optimize returns. This result coincides with Mandal *et al.* (2017), who stated that most of the goat keepers in West Bengal marketed their animals after the attainment of 12 months of age.

Conclusion

The study reveals distinct differences in sheep and goat performance under semi-intensive management in the Lower Gangetic Plains. Goats exhibited faster growth, earlier maturity, and better economic returns, making them more suitable for meat production. Sheep showed slower growth but higher prolificacy and seasonal breeding advantages. Similar mortality rates in both species indicate the need for improved neonatal care. These findings support species-specific management and decision-making for farmers and planners.

Acknowledgement

References

1) Alemu, T. (2020). Review on sheep and goat management practices, constraints, opportunities, and marketing systems in Ethiopia. International Journal of Food and Nutrition Science, 5(2), 144-169.

2) Basic Animal Husbandry Statistics (BAHS). (2024). Department of Animal Husbandry and Dairying, Government of India. Retrieved on June 15, 2025, from BAHS-2024_0.pdf.

3) Chandran, D., Rojan, P. M., Venkatachalapathy, T., & Lejaniya, A. S. (2021). Mortality and morbidity patterns in goats under organized farm conditions of Kerala. Journal of Veterinary and Animal Sciences. 52(2), 175-179.

4) Department of Animal Husbandry & Dairying (DAHD), Ministry of Fisheries, Animal Husbandry & Dairying, Government of India. (2019). *20th livestock census report* [PDF]. Retrieved on June 15, 2025, from https://dahd.gov.in/sites/default/files/2019-12/20thLivestockCensusReport.pdf

5) Devi, I., Shinde, A. K., Kumar, A., & Sahoo, A. (2020). Stall feeding of sheep and goats: An alternative system to traditional grazing on community lands. Indian Journal of Animal Sciences, 90(3), 318-326.

6) Faruque, S., Chowdhury, S. A., Siddiquee, N. U., & Afroz, M. A. (2010). Performance and genetic parameters of economically important traits of Black Bengal goat. Journal of the Bangladesh Agricultural University, 8(1), 67-78.

7) Govindrajan, R. (2015). "The goat that died for family": Animal sacrifice and interspecies kinship in India's Central Himalayas. American Ethnologist, 42(3), 504-519.

8) Haldar, A., Pal, P., Datta, M., Paul, R., Pal, S., Majumdar, D., & Pan, S. (2014). Prolificacy and Its Relationship with Age, Body Weight, Parity, Previous Litter Size and Body Linear Type Traits in Meat-type Goats. Asian-Australasian journal of animal sciences. 27. 628-34.

9) Kumar, A., Misra, S. S., Chauhan, I. S., Gowane, G. R., & Shinde, A. K. (2021). Small ruminant production in dryland regions of India: Status, challenges and opportunities. The Indian Journal of Animal Sciences, 91(5), 350-359.

10) Mandal, A., Karmakar, P. K., Behera, R., & Pan, S. (2017). Prolific Garole Sheep: Pride of Bengal. Research and Review: Journal of Dairy Science and Technology, 6(2), 11-19.

11) Mandal, D.K., Karunakaran, M., Debbarma, A., Swain, S.K., Santra, A., Dutta, T.K., Chatterjee, A., Rai, S. 2022. Black Bengal goat husbandry-An appraisal of productive and reproductive performance under intensive management system. Journal of Livestock Science 13: 227-233 doi. 10.33259/JLivestSci.2022.227-233

12) Mehrotra, A., Pannu, U., Chopra, A., Narula, H. K., & Patel, A. K. (2019). Evaluation of reproductive traits of Chokla sheep under semi-arid conditions of Rajasthan. The Indian Journal of Animal Sciences, 89(9), 1017-1020.

13) Mondal, K., Chatterjee, J. K., Das, A., Roy, M., & Patra, G. (2023). A study on productive performance of Garole sheep in Sundarban areas of West Bengal. Indian Journal of Animal Health, 62(2), 328-339.

14) Pandey, H. O., & Upadhyay, D. (2022). Global livestock production systems: classification, status, and future trends. Emerging issues in climate-smart livestock production, 47-70.

15) Raja, R. A., T. K., Ghoshal, Sundaray J. K., De D., Biswas G., Kumar S., Panigrahi A., Kumaran M, and Pradhan J. K. (2012). Status and challenges of livestock farming community in Sundarban, India. Indian Journal of Animal Science, 82, 436-438.

16) Reshma, C. V., Anitha, A., Rao, S. J., & Muralidhar, M. (2022). Body condition score and its relation to body weight and measurements of local goats of Andhra Pradesh under field conditions. International Journal of Bio-resource and Stress Management, 13(2), 131-136.

17) Rout, P. K., & Behera, B. K. (2021). Goat and sheep farming. In Sustainability in ruminant livestock: Management and marketing (pp. 33-76). Singapore: Springer Singapore.

18) Salvaña, F.R.P., Sepelagio, E.G., Sanchez, C.B., Besana, C.M., Kamamang, J.S., Cardenas, L.B. 2019. Inventory and diversity of forages utilized by farmers raising goats in Halal way: The case of Region XII, Philippines. Journal of Livestock Science 10:118-125 doi. 10.33259/JLivestSci.2019.118-125

19) Shivakumara, C., & Kiran, S. (2019). Economics of sheep and goat rearing under extensive, semi-intensive and intensive methods of rearing. Economic Affairs, 64(3), 553-561.

20) Shivakumara, C., Reddy, B. S., & Patil, S. S. (2020). Socio-economic characteristics and composition of sheep and goat farming under extensive system of rearing. Agricultural Science Digest-A Research Journal, 40(1), 105-108.

21) Singh, A. K. (2012). Probable agricultural biodiversity heritage sites in India: XI. The upper Gangetic Plains region. Asian Agri-History, 16(1), 21-44.

22) Solaiman, M., Apu, A. S., Ali, M. Y., Fakruzzaman, M., & Faruque, M. O. (2020). Impact of community-based breeding program on breeding buck availability, growth and reproductive performance of Black Bengal goat. Bangladesh Journal of Animal Science, 49(1), 13-21.

23) Villaquiran, M., T. Gipson, R. C. Merkel, A. Goetsch, and T. Sahlu. (2005). Body condition scoring for improved management. Proceedings of 20th Annual Goat Field Day. Langston University, Langston, OK, USA, 111-117. https://www.academia.edu/5456501/Body_Condition_Scoring_for_Improved_Management

24) Zailani, S.A., Madu, H.K., Abubakar, N., Omar, N.A. 2016. Feasibility for a Sustainable and Profitable Local Goats Production in Nigeria. Journal of Livestock Science 7: 126-132