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T Karuthadurai

Assistant Professor,
Department of Animal
Genetics and Breeding,
Veterinary College and
Research Institute, Tamil
Nadu Veterinary and Animal
Sciences University, Tamil
Nadu, India

M Seevagan

Assistant Professor,
Department of Animal
Genetics and Breeding,
Veterinary College and
Research Institute, Tamil
Nadu Veterinary and Animal
Sciences University, Tamil
Nadu, India

P Gopu

Professor, Department of
Animal Genetics and Breeding,
Veterinary College and
Research Institute, Tamil
Nadu Veterinary and Animal
Sciences University, Tamil
Nadu, India

T Ravimurugan

Professor and Head,
Department of Animal
Genetics and Breeding,
Veterinary College and
Research Institute, Tamil
Nadu Veterinary and Animal
Sciences University, Tamil
Nadu, India

Corresponding Author:

T Karuthadurai
Assistant Professor,
Department of Animal
Genetics and Breeding,
Veterinary College and
Research Institute, Tamil
Nadu Veterinary and Animal
Sciences University, Tamil
Nadu, India

Morphometric characterization of non-descriptive buffaloes in Tirunelveli district of Tamil Nadu

T Karuthadurai, M Seevagan, P Gopu and T Ravimurugan

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Abstract

The present study was conducted to Morphometric characterize the non-descript buffalo population of Tirunelveli district, Tamil Nadu, and to generate baseline phenotypic information for their identification, conservation, and genetic improvement. A total of 200 healthy non-descript buffaloes of different age groups and both sexes were surveyed from six major buffalo-rearing regions, namely Manur, Palayamkottai, Nanguneri, Ambasamudram, Gopalamuthiram, and Pappakudi. Quantitative traits including head length, ear length, horn length, body length, and body weight were recorded using standard morphometric procedures. The collected data were analyzed using SPSS Version 21.0, and descriptive statistics were calculated at a 5% level of significance ($p < 0.05$). The results revealed a significant ($p < 0.05$) increase in all morphometric traits with advancing age in both sexes. Male buffaloes consistently exhibited higher measurements than females across all age groups, indicating pronounced sexual dimorphism. Mean head length increased from 20.42 ± 0.14 cm to 52.35 ± 2.10 cm in males and from 18.00 ± 0.00 cm to 47.72 ± 0.30 cm in females between the youngest and oldest age groups. Similarly, ear length increased from 15.14 ± 0.29 cm to 26.39 ± 0.42 cm in males and from 14.32 ± 0.30 cm to 21.94 ± 0.22 cm in females, while horn length increased from 8.81 ± 0.16 cm to 63.89 ± 1.69 cm in males and from 8.78 ± 0.23 cm to 49.16 ± 2.19 cm in females. Body length increased from 51.01 ± 2.07 cm to 125.09 ± 0.18 cm in males and from 49.29 ± 2.10 cm to 119.25 ± 0.73 cm in females. Likewise, body weight increased from 88.79 ± 2.16 kg to 383.19 ± 1.18 kg in males and from 79.63 ± 2.10 kg to 359.18 ± 5.09 kg in females. The study demonstrates that age and sex significantly influence morphometric traits in non-descript buffaloes. The generated baseline data will be valuable for phenotypic characterization, breed identification, conservation planning, and future genetic improvement programmes aimed at sustainable utilization of indigenous buffalo genetic resources.

Keywords: Morphometric characterization, body weight, head length, body length, non-descript buffaloes

Introduction

Animal genetic resources (AnGR) are indispensable for ensuring global food security, sustainable livestock production, and resilience to climate change. Indigenous livestock populations have evolved through long term natural selection under diverse agro-ecological conditions, enabling them to possess unique adaptive traits such as heat tolerance, disease resistance, reproductive efficiency, and the ability to thrive under low-input production systems. The conservation and characterization of these genetic resources are therefore considered global priorities by the Food and Agriculture Organization (FAO), as they provide the biological foundation for future livestock improvement programmes and contribute significantly to sustainable agricultural development (FAO, 2023) [4].

India possesses the world's largest livestock population, with 535.78 million animals recorded in the 20th Livestock Census, accounting for more than 17% of the global livestock population (DAHD, 2020) [2]. Among these, buffaloes (*Bubalus bubalis*) constitute 109.85 million, representing approximately 56% of the world's buffalo population, making India the global centre of buffalo genetic diversity. Buffaloes are one of the most economically important dairy species in the country due to their superior milk composition, higher fat and total solids content, greater adaptability to tropical environments, and efficient utilization of low-quality feed resources. According to the Basic Animal Husbandry Statistics (BAHS) 2025, India produced 247.87 million tonnes of milk during 2024-25, maintaining its position as the world's largest milk producer.

Buffaloes contributed approximately 43% of the national milk production, with indigenous and non-descript buffaloes accounting for a substantial proportion of this output, thereby playing a crucial role in ensuring nutritional security and improving the livelihoods of millions of rural households (DAHD, 2025)^[3].

India currently recognizes 20 registered buffalo breeds, including Murrah, Jaffarabadi, Surti, Mehsana, Banni, Pandharpuri, and Toda, each possessing distinct morphological and productive characteristics (ICAR-NBAGR, 2024). Nevertheless, a considerable proportion of the buffalo population remains classified as non-descript, indicating the absence of systematic phenotypic and genetic characterization. These populations have evolved under local environmental conditions through generations of natural and farmer-led selection and therefore may possess valuable adaptive traits, including tolerance to heat stress, resistance to endemic diseases, longevity, and efficient utilization of locally available feed resources. However, indiscriminate breeding, genetic admixture, mechanization of agriculture, and changing production systems have accelerated the erosion of these unique genetic resources. Consequently, the identification and characterization of non-descript buffalo populations have become essential for conserving genetic diversity and ensuring their sustainable utilization in future breeding programmes.

Morphometric characterization is internationally recognized as one of the most reliable and cost-effective approaches for the preliminary identification and classification of livestock populations. It involves the systematic measurement of external body dimensions and qualitative morphological traits to quantify phenotypic variation within and between populations. Morphometric traits such as body length, height at withers, chest girth, paunch girth, face length, horn dimensions, ear length, tail length, and body weight provide valuable information regarding body conformation, growth pattern, productive potential, and adaptation to local environmental conditions. Furthermore, several studies have reported significant associations between morphometric traits and economically important production and reproductive parameters, making morphometric characterization an indispensable component of breed improvement and conservation programmes.

Recognizing the urgent need to document and conserve indigenous livestock diversity, the ICAR-National Bureau of Animal Genetic Resources (ICAR-NBAGR) initiated the Mission towards Zero Non-descript Animal Genetic Resources (AnGR) of India. The primary objective of this national programme is to systematically survey, characterize, register, and conserve all unidentified livestock populations across the country. This initiative aims to reduce the proportion of non-descript animal populations by identifying genetically distinct populations that qualify for breed registration, thereby facilitating their inclusion in scientifically designed breeding and conservation programmes. The mission also supports India's commitment to the Global Plan of Action for Animal Genetic Resources advocated by the FAO, emphasizing sustainable utilization and long-term conservation of indigenous livestock biodiversity.

Tamil Nadu is one of the important livestock producing states of southern India and harbours diverse indigenous buffalo populations distributed across different agro-climatic regions. While the Toda buffalo has been officially

recognized as a distinct indigenous breed, the majority of buffaloes maintained by smallholder farmers in the southern districts remain non-descript and inadequately characterized. Tirunelveli district, characterized by semi-arid climatic conditions and mixed crop-livestock farming systems, supports a substantial population of indigenous buffaloes that contribute significantly to household milk production, organic manure, and rural livelihoods. However, comprehensive information on their morphometric characteristics and phenotypic diversity is limited, hindering scientific evaluation of their genetic potential and restricting opportunities for breed recognition and conservation.

Therefore, the present study was undertaken to morphometrically characterize the non-descript buffalo population of Tirunelveli district, Tamil Nadu, through detailed evaluation of qualitative and quantitative morphological traits. The study aims to generate baseline phenotypic information, assess morphometric variability within the population, identify unique breed characteristics, and provide scientific evidence to support future breed registration, genetic improvement, and conservation strategies for indigenous buffalo genetic resources.

Materials and Methods

Location of study

The present study was conducted in the Department of Animal Genetics and Breeding, Veterinary College and Research Institute, Tirunelveli, Tamil Nadu, to morphometrically characterize the non-descript buffalo population of Tirunelveli district. The study was carried out in six major buffalo-rearing areas, namely Manur, Palayamkottai, Nanguneri, Ambasamudram, Gopalamuthiram, and Pappakudi. These locations were selected to represent the buffalo population maintained under different field conditions in the district. Healthy non-descript buffaloes reared by farmers under the traditional production system were included in the study. The objective was to assess the phenotypic variability of the local buffalo population and generate baseline information for their identification, genetic improvement, and conservation.

Morphometric characterization was carried out according to the standard guidelines of the ICAR-National Bureau of Animal Genetic Resources (ICAR-NBAGR), Karnal, Haryana. The morphometric measurements included body weight, body length, height at withers, chest girth, paunch girth, face length, horn length, horn circumference, horn span, ear length, and tail length. All measurements were recorded using standard anatomical landmarks to ensure uniformity and accuracy. Information on physical characteristics, age, sex, and management practices was collected using a pre-designed questionnaire developed by ICAR-NBAGR along with direct observation of the animals. The data generated from this study will provide valuable information on the morphological characteristics and phenotypic diversity of the non-descript buffalo population of Tirunelveli district and will be useful for future breed characterization, conservation, and breeding programmes.

Statistical analysis

The data obtained from the morphometric characterization of non-descript buffaloes were compiled and analyzed using the Statistical Package for the Social Sciences (SPSS), Version 21.0 (IBM Corp., Armonk, NY, USA).

Results and Discussion

Different morphometric traits in Non-descript buffaloes

1. Head Length

In the present investigation, the head length of male buffaloes was higher than females in all age groups. At 0-1 year of age, males recorded a mean head length of 20.42 ± 0.14 cm compared to 18.00 ± 0.00 cm in females. The difference between sexes became more prominent with increasing age, with males showing higher values of 23.50 ± 0.29 cm, 47.30 ± 0.37 cm, 50.67 ± 0.27 cm, and 52.35 ± 0.21 cm in the respective age groups of 1-2 years, 2-3 years, 3-4 years, and above 4 years. Females showed comparatively lower values of 21.00 ± 0.12 cm, 34.52 ± 1.13 cm, 41.20 ± 1.40 cm, and 47.29 ± 0.30 cm in the same age categories. The higher head length observed in males suggests the influence of sexual dimorphism, where male buffaloes generally exhibit greater skeletal growth and larger body conformation compared to females. The marked increase in head length between 1-2 years and 2-3 years indicates that buffaloes undergo considerable skeletal growth during this developmental phase. This period corresponds to rapid growth and maturation, which may explain the substantial increase in morphometric measurements.

The findings of the present study are in agreement with those of Chendge, (2025) ^[1], who reported that male buffaloes had significantly higher head length than females across different age groups. Chendge (2025) ^[1] recorded a mean head length of 47.72 ± 0.66 cm in males and 33.37 ± 0.47 cm in females, indicating a clear sexual dimorphism in cranial measurements. Similarly, Rahman *et al.* (2015) ^[8] also observed that the head length of male buffaloes was greater than that of females, reporting values of 48.78 ± 3.17 cm in males and 42.70 ± 2.66 cm in females. The results of the present investigation are therefore consistent with these earlier reports, confirming that male buffaloes possess larger head dimensions than females. This difference is likely due to the greater skeletal growth and body development in males, which is influenced by genetic factors and sex hormones.

Table 1: Head length in different age group of buffaloes (Cm)

S. No	Age group (years)	No of animals		Male	Female
		Male	Female		
1	0-1	2	15	20.42 ± 0.14	18.00 ± 0.00
2	1-2	3	30	23.50 ± 0.29	21.00 ± 0.12
3	2-3	3	40	47.30 ± 0.37	34.52 ± 1.13
4	3-4	2	35	50.67 ± 0.27	41.20 ± 1.40
5	More than 4 years	2	68	52.35 ± 0.21	47.29 ± 0.30
		12	188		

2. Ear length

The present study demonstrated a progressive increase in ear length with advancing age in both male and female non-descript buffaloes. In the 0-1 year age group, the mean ear length was 15.14 ± 0.29 cm in males and 14.32 ± 0.30 cm in females. As age advanced to 1-2 years, the corresponding values increased to 16.79 ± 0.49 cm and 15.69 ± 0.22 cm in males and females, respectively. A marked increase was observed during the 2-3 years age group, where males recorded a mean ear length of 22.60 ± 0.71 cm, while females exhibited 18.72 ± 1.10 cm. The ear length continued to increase in the 3-4 years age group, reaching 24.41 ± 0.29 cm in males and 20.21 ± 0.79 cm in females. The highest

mean ear length was observed in buffaloes above 4 years of age, measuring 26.39 ± 0.42 cm in males and 21.94 ± 0.22 cm in females.

The gradual increase in ear length across successive age groups indicates continuous somatic and skeletal development until the animal's attained physiological maturity. The comparatively smaller increment observed after four years of age suggests that the growth of the external ear had nearly stabilized, corresponding with the completion of overall body growth. Throughout all age groups, male buffaloes consistently exhibited greater ear length than females, demonstrating the influence of sexual dimorphism on morphometric characteristics. The larger ear dimensions in males may be attributed to their higher growth potential, greater skeletal development, and the anabolic effects of androgens, which contribute to increased body size and the development of associated anatomical structures.

The present findings are in agreement with those of Chendge (2025) ^[1], who also reported significantly greater ear length in male buffaloes (47.72 ± 0.66 cm) than in females (33.37 ± 0.47 cm). Similarly, Rahman *et al.* (2015) ^[8] observed higher ear length in males (48.78 ± 3.17 cm) compared with females (42.70 ± 2.66 cm). Although the absolute measurements reported by these authors were higher than those observed in the present investigation, such variations may be attributed to differences in breed, genetic background, age composition, nutritional management, environmental conditions, and measurement methodology. Nevertheless, the consistent trend of male buffaloes exhibiting greater ear length than females across all studies supports the role of sex as an important determinant of ear morphometry in buffaloes.

Table 2: Ear length in different age group of buffaloes (Cm)

S. No	Age group (years)	No of animals		Male	Female
		Male	Female		
1	0-1	2	15	15.14 ± 0.29	14.32 ± 0.30
2	1-2	3	30	16.79 ± 0.49	15.69 ± 0.22
3	2-3	3	40	22.60 ± 0.71	18.72 ± 1.10
4	3-4	2	35	24.41 ± 0.29	20.21 ± 0.79
5	More than 4 years	2	68	26.39 ± 0.42	21.94 ± 0.22
		12	188		

3. Horn Length (Cm)

The present investigation revealed a progressive increase in horn length with advancing age in both male and female non-descript buffaloes. In the 0-1 year age group, the mean horn length was 8.81 ± 0.16 cm in males and 8.78 ± 0.23 cm in females, indicating negligible sex-related variation during the early postnatal period. At this stage, horn growth is primarily associated with the initial development of the horn bud and the underlying frontal bone, whereas the influence of sex hormones on horn development is minimal.

In the 1-2 years age group, the mean horn length increased to 13.14 ± 0.91 cm in males and 9.90 ± 2.12 cm in females. The relatively greater increase observed in males suggests the onset of sexual dimorphism during the juvenile phase. This difference may be attributed to endocrine-mediated regulation of skeletal growth, particularly the anabolic effects of androgens, which enhance osteogenesis and promote accelerated horn development in males. A substantial increase in horn length was observed in the 2-3 years age group, with mean values of 40.10 ± 1.76 cm in

males and 29.15 ± 3.14 cm in females. This period coincides with rapid somatic growth and the attainment of sexual maturity, during which horn growth is markedly accelerated. The significantly greater horn length in males reflects their higher growth potential, prolonged skeletal development, and increased androgenic stimulation, resulting in enhanced horn elongation compared with females.

Horn length continued to increase during the 3-4 years age group, reaching 55.27 ± 2.17 cm in males and 36.29 ± 5.17 cm in females, indicating that horn growth remained active until the animals approached full maturity. The highest mean horn length was recorded in buffaloes above 4 years of age, measuring 63.89 ± 1.69 cm in males and 49.16 ± 2.19 cm in females. The relatively smaller increment observed beyond four years of age suggests that horn growth had approached its asymptotic or mature stage. Nevertheless, the persistent sex-related differences observed throughout adulthood clearly demonstrate the expression of sexual dimorphism in horn morphology. The superior horn length recorded in males may be attributed to their greater genetic growth potential, prolonged skeletal maturation, and sustained endocrine influences that continue until complete physiological maturity. These findings indicate that both age and sex are major determinants of horn development and should be considered when evaluating morphometric characteristics in non-descript buffaloes.

The present findings are in agreement with Chendge (2025)^[1], who reported higher horn length in male non-descript buffaloes compared with females, indicating the influence of sex on horn development. Similarly, Khatke *et al.* (2023)^[6] observed considerable variation in horn-related morphometric traits among non-descript buffaloes of Maharashtra. Pundir *et al.* (2015)^[7] also reported variation in horn length among buffalo populations and suggested that morphometric traits are influenced by genetic constitution, sex, and environmental factors. The higher horn length observed in males in the present study may be attributed to sexual dimorphism, differential growth patterns, and hormonal influences associated with male development.

Table 3: Horn Length in different age group of buffaloes (Cm)

S. No	Age group (years)	No of animals		Male	Female
		Male	Female		
1	0-1	2	15	8.81 ± 0.16	8.78 ± 0.23
2	1-2	3	30	13.14 ± 0.91	9.90 ± 2.12
3	2-3	3	40	40.10 ± 1.76	29.15 ± 3.14
4	3-4	2	35	55.27 ± 2.17	36.29 ± 5.17
5	More than 4 years	2	68	63.89 ± 1.69	49.16 ± 2.19
		12	188		

4. Body weight (Kg)

The present study demonstrated a progressive increase in body weight with advancing age in both male and female non-descript buffaloes, indicating the influence of age-related growth and physiological development on body mass accumulation. Significant variation in body weight was observed between sexes, with males consistently exhibiting higher values than females across all age groups, reflecting the presence of sexual dimorphism in growth performance. In the 0-1 year age group, the mean body weight was recorded as 88.79 ± 2.16 kg in males and 79.63 ± 2.10 kg in

females. The comparatively higher body weight of male calves during the early growth stage suggests their greater inherent growth potential. During this period, rapid development of skeletal tissues, muscular structures, and internal organs contributes substantially to overall weight gain. However, the relatively narrow difference between males and females indicates that body weight during early life is primarily influenced by genetic makeup, birth weight, maternal nutrition, and management practices, with limited contribution from sex-related hormonal effects. Similar observations were reported by Thiruvankadan *et al.* (2009)^[10] in Murrah buffalo calves, where males exhibited higher body weights than females throughout the growth period. They reported mean body weights of 87.9 ± 0.95 kg at six months and 134.16 ± 1.41 kg at twelve months of age, demonstrating the rapid increase in body weight during the early growth phase.

In the 1-2 years age group, body weight increased to 103.19 ± 1.10 kg in males and 91.18 ± 1.17 kg in females, reflecting active growth during the juvenile phase. This increase may be attributed to enhanced feed utilization, progressive skeletal development, and increased muscle tissue deposition. The pronounced increase in body weight was observed during the 2-3 years age group, where males attained 296.72 ± 2.45 kg and females attained 232.19 ± 2.07 kg. Similar age-related increases in body weight were reported by Gupta *et al.* (2010)^[5] in Murrah buffaloes, who recorded body weights of 103.03 ± 1.19 kg at six months, 162.67 ± 1.98 kg at twelve months, 254.92 ± 2.69 kg at eighteen months, and 344.49 ± 3.11 kg at twenty-four months, indicating rapid weight gain during the growing period. This period corresponds with accelerated somatic growth and sexual maturation, during which increased endocrine activity stimulates skeletal expansion, muscular development, and changes in body composition. The superior body weight observed in males may be associated with their prolonged growth phase, greater lean tissue accumulation, and anabolic effects of testosterone, whereas females may exhibit relatively slower weight gain due to earlier physiological maturity and partitioning of nutrients towards reproductive functions.

During the 3-4 years age group, body weight further increased to 362.10 ± 4.69 kg in males and 321.35 ± 9.72 kg in females, indicating continued growth and development towards maturity. The maximum body weight was recorded in animals above 4 years of age, with values of 383.19 ± 1.18 kg in males and 359.18 ± 5.09 kg in females. Similar observations were reported by Seth and Chopra (1992)^[9] in Murrah buffalo calves, where growth rate remained high up to 24 months and body weight at maturity (around 30 months) reached approximately 392 ± 9.9 kg under improved feeding conditions. The comparatively reduced rate of increase after four years suggests that the animals had approached mature body size and entered a phase of slower growth. Nevertheless, males maintained higher body weight than females, confirming the influence of sexual dimorphism on mature body conformation. The greater mature body weight of males may be attributed to their larger skeletal framework, increased muscle deposition, higher growth potential and genetic factors regulating body development.

Table 4: Body Weight in different age group of buffaloes (kg)

S. No	Age group (years)	No of animals		Male	Female
		Male	Female		
1	0-1	2	15	88.79 ± 2.16	79.63 ± 2.10
2	1-2	3	30	103.19 ± 1.10	91.18 ± 1.17
3	2-3	3	40	296.72 ± 2.45	232.19 ± 2.07
4	3-4	2	35	362.10 ± 4.69	321.35 ± 9.72
5	More than 4 years	2	68	383.19 ± 1.18	359.18 ± 5.09
		12	188		

5. Body Length (Cm)

In the 0-1 year age group, the mean body length recorded in the present study was 51.01 ± 2.07 cm in males and 49.29 ± 2.10 cm in females. The close similarity between male and female calves during the early growth phase indicates that sexual differences in skeletal development are not fully expressed immediately after birth. Early body development is mainly influenced by genetic constitution, birth weight, maternal nutrition, and management conditions. Similar observations were reported by Chendge (2025) ^[1] in non-descript buffaloes of Raigad district, where body measurements increased gradually with age and males showed higher values than females. The author reported adult body length values of 111.76 ± 0.68 cm in males and 87.04 ± 5.12 cm in females, demonstrating the influence of sex on mature body conformation.

During the 1-2 years age group, body length increased to 62.17 ± 0.18 cm in males and 58.16 ± 1.01 cm in females in the present study. This increase represents the active growth phase characterized by rapid skeletal development and muscle tissue deposition. Similar age-related increases in linear body measurements were observed by Pundir *et al.* (2015) ^[7] in lesser-known buffalo populations of North India. They reported that body measurements varied significantly among populations and were influenced by age, sex, and genetic background. The authors emphasized that body length is an important indicator of body size and conformation in buffaloes.

A considerable increase in body length was observed during the 2-3 years age group, with males recording 117.09 ± 2.19 cm and females recording 76.16 ± 0.96 cm. This period corresponds with puberty and rapid somatic growth, during which increased hormonal activity promotes skeletal elongation and muscle development. The greater body length observed in males indicates the development of sexual dimorphism, which may be associated with androgen-mediated stimulation of growth and greater mature body size. Comparable findings were reported by Khatke *et al.* (2023) ^[6] in non-descript buffaloes of the Konkan region of Maharashtra, where adult males exhibited greater body measurements compared with females. They recorded an average body length of 127.89 ± 0.14 cm in adult non-descript buffaloes, indicating considerable variation in body conformation among indigenous buffalo populations.

In the 3-4 years age group, the present study recorded body lengths of 123.16 ± 1.03 cm in males and 98.01 ± 1.12 cm in females. The continued increase in body length indicates that skeletal growth remains active until the animals approach physiological maturity. Similar observations were reported by Chendge (2025) ^[1], who recorded higher body length in adult male non-descript buffaloes compared with females and suggested that differences in body dimensions are primarily associated with sex, genetic constitution, and

adaptation to local production environments.

The highest body length in the present study was observed in animals above 4 years of age, with values of 125.09 ± 0.18 cm in males and 119.25 ± 0.73 cm in females. The comparatively smaller increase after four years indicates that body length had approached mature dimensions and skeletal growth had reached a near-stable phase. The mature body length observed in the present study was comparable with findings of Khatke *et al.* (2023) ^[6], who reported an adult body length of 127.89 ± 0.14 cm in non-descript buffaloes of Maharashtra. Similarly, Chendge (2025) ^[1] reported adult body length values of 111.76 ± 0.68 cm in males and 87.04 ± 5.12 cm in females, although variations between studies may be due to differences in breed composition, geographical location, nutritional status, management practices, and measurement methodology. The differences observed between the present findings and previous reports may be attributed to the genetic diversity of non-descript buffalo populations. Unlike recognized buffalo breeds, non-descript buffaloes represent heterogeneous populations adapted to specific agro-climatic conditions. Environmental factors, availability of feed resources, management systems, and selection pressure may contribute to variation in growth characteristics among populations.

Table 5: Body Length in different age group of buffaloes (Cm)

S. No	Age group (years)	No of animals		Male	Female
		Male	Female		
1	0-1	2	15	51.01 ± 2.07	49.29 ± 2.10
2	1-2	3	30	62.17 ± 0.18	58.16 ± 1.01
3	2-3	3	40	117.09 ± 2.19	76.16 ± 0.96
4	3-4	2	35	123.16 ± 1.03	98.01 ± 1.12
5	More than 4 years	2	68	125.09 ± 0.18	119.25 ± 0.73
		12	188		

Conclusion

The present study provides comprehensive baseline information on the morphometric characteristics of non-descript buffaloes reared in Tirunelveli district of Tamil Nadu. The results demonstrated that all quantitative morphometric traits, namely head length, ear length, horn length, body length, and body weight, increased progressively with advancing age in both sexes, indicating normal skeletal and somatic growth from the juvenile stage to physiological maturity. Across all age groups, male buffaloes consistently exhibited significantly higher ($p < 0.05$) morphometric measurements than females, confirming the existence of marked sexual dimorphism in the studied population.

Among the age groups, the most rapid increase in morphometric traits was observed between 2 and 3 years of age, corresponding to the period of accelerated skeletal growth and sexual maturation. Thereafter, the rate of increase gradually declined, and most traits approached

mature dimensions in animals above four years of age, suggesting the attainment of physiological maturity. The superior morphometric measurements recorded in males may be attributed to their greater genetic growth potential, prolonged skeletal development, higher muscle deposition, and the anabolic effects of androgens.

The morphometric values obtained in the present investigation were generally comparable with earlier reports on indigenous and non-descript buffalo populations, although variations were observed due to differences in genetic background, environmental conditions, nutritional management, and geographical location. These findings emphasize that both age and sex are important determinants of morphometric variation and should be considered while evaluating buffalo populations for breed characterization.

Overall, the study generated valuable phenotypic data that contribute to the scientific documentation of the non-descript buffalo population of Tirunelveli district. The information generated can serve as a baseline for breed identification, phenotypic characterization, genetic evaluation, and formulation of selective breeding strategies. Furthermore, these findings support the objectives of the ICAR-NBAGR Mission towards Zero Non-descript Animal Genetic Resources by providing evidence for the conservation, sustainable utilization, and possible recognition of this indigenous buffalo population as a distinct genetic resource. Future studies integrating morphometric, molecular genetics, and production performance data are recommended to establish the genetic uniqueness of this population and facilitate its registration as a recognized buffalo breed.

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