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Morphometric Traits and Body Indices to Assess the Type and Function of Native Ganjam Goats Reared on Different Flooring Systems in Coastal Odisha

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ABSTRACT

A study was undertaken to assess the type and function of Ganjam goats native to coastal Odisha based on morphometric traits and their indices. Different flooring systems, *viz.* conventional earthen flooring (CEF), bamboo-slatted flooring (BSF) and plastic-slatted flooring (PSF) were applied for rearing the growing goats in multilocation trials involving 54 kids (~4 months age) of either sex in equal ratio. The goat kids were equally distributed i.e. eighteen in each group (6 animals × 3 locations) and reared on free range system followed by in-house sheltering at night after the browsing hours on these three floor types. The body weight (BW) and morphometric parameters like, body length (BL), withers height (WH), chest girth (CG), paunch girth (PG), rump height (RH) and their indices were assessed fortnightly. Kids reared on all the three floor-types exhibited age-dependent increase in BW and in all the morphometric parameters. There was improved performance (BW, BL, WH, CG) of kids on PSF compared to CEF, while the difference between BSF and PSF was non-significant. The functional indices characterized Ganjam goats as longiline with good proportionality, medium thoracic development, prolific and dual type. The correlation between BW and morphometric parameters exhibited highest for CG followed by WH, RH, BL and PG. The BW of Ganjam goats can suitably be predicted from CG, WH and RH with R^2 value 0.914. The importance of morphometric parameters and their indices classify Ganjam goats as a promising dual-purpose breed and impetus to its performance is better achieved with improved shelter management involving plastic-slatted floor in coastal Odisha.

Key words: Flooring system, Ganjam goats, Growth performance, Morphometry.

INTRODUCTION

Goats are particularly very useful and hardy animals that sustain productivity even in the environmental conditions that do not support rearing of other livestock and thus, goat farming has been the main stay of livelihood in rural India, especially for small, marginal and landless families (Rout and Behera, 2021). Odisha is an under developed state of India and 25% of its rural population's livelihood are completely dependent on goat rearing (Mallick *et al.,* 2024). Alongside, a persistent rise in demand for animal products and expanding markets has provided ample scope for the rural farmers to augment their socio-economic livelihood. The coastal region of Odisha receives recurrent rain (>1400 mm) and its weather remains humid (60-80%) with a temperature range of 27-32°C (NIC, 2022). Therefore, the conventional shelter with earthen floor remains damp with continuous addition of excreta (faeces and urine). Goats usually prefer dry and highland area, which has led to construction of bamboo-slated floor by many of the medium-resource farmers (Majumdar *et al.,* 2023). It is stressed that the welfare of animals can be effectively managed through innovative and scientific shelter management that minimize environmental stress (De *et al.,* 2013), which provides scope for the animal to achieve its full genetic potential. An ideal floor should be hygienic, dry, resilient, temperature resistant and comfortable to animals (Wadhwani *et al.,* 2016). It is also advocated to provide multiple flooring options in commercial goat rearing systems to meet their physiological and behavioural needs (Sutherland *et al.,* 2017). Recent modification of rearing goats on a raised platform by fixing square (2×2 feet) polypropylene blocks is expected to provide comfort and cleanliness with better hygienic measures and may have a positive impact on growth performance. Further, a definite correlation does

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exist between different morphometric traits and body weights that is usually referred in assessing future animal performance (Fahim *et al.,* 2013; Mule *et al.,* 2014; Kumar *et al.,* 2018; Parvathi *et al.,* 2020; Saleh *et al.,* 2022; Assefa *et al.,* 2023). Therefore, morphometric traits and body indices relating to growth performance was assessed in Ganjam goat kids during early growth phase to characterize their future genetic potential as meat or dairy type breeds under different flooring systems.

MATERIALS AND METHODS

Location and weather conditions

The Ganjam goats are native to Ganjam districts of Odisha and the study was undertaken in three different locations extending over more humid July to comfortable December for a period of six months. The environmental data recorded average temperature 29.37°C with relative humidity 67.81% (NIC, 2022).

Experimental animals and housing management

Fifty-four Ganjam goat kids of about 4 months of age were distributed randomly in to three treatment groups, *viz.* conventional earthen flooring (CEF), bamboo-slatted flooring (BSF) and plastic-slatted flooring (PSF) of 18 animals (6 animals × 3 locations) having equal numbers of males and females (3 males + 3 females). The mean body weight (BW) of the three treatment groups was 7.63 ± 0.11, 7.68 ± 0.17, 7.59 ± 0.19 kg for CEF, BSF and PSF, respectively. All the animals were dewormed and vaccinated against PPR (*Peste des petits ruminants*), enterotoxaemia and goat pox as per the standard schedule followed by the State Animal Husbandry Department. The goats in all the three locations were reared on free range system followed by in-house sheltering at night on the three floor types to assess their performance as meat or dairy type based on morphometric indices. A similar routine was followed on cleaning and sanitation in the three house-types after the goats are freed for grazing and browsing in all the three locations.

Body weight and morphometric measurements

The BW of goat kids was recorded on a weighing scale at the beginning*and* subsequently at fortnightly intervals consecutively for two days in the morning hours prior to allow for grazing and watering. The morphometric parameters such as body length (BL), withers height (WH), chest girth (CG), paunch girth (PG) and rump height (RH) were recorded by using a measuring tape (Accuracy: 0.1 cm) (Fahim *et al.,* 2013). The conformation indices based on morphometric parameters that characterize future genetic potential as meat or dairy type breeds are calculated from the following equations:

Eq. 1.

$$\text{Body index} = \frac{\text{Body length}}{\text{Chest girth}}$$

Eq. 2.

$$\text{Proportionality index} = \frac{\text{Wither height}}{\text{Body length}}$$

Eq. 3.

$$\text{Thoracic index} = \frac{\text{Chest girth}}{\text{Wither height}}$$

Eq. 4.

$$\text{Compact index} = \frac{\text{Body weight}}{\text{Wither height}}$$

Eq. 5.

$$\text{Pelvic index} = \frac{\text{Punch girth}}{\text{Rump height}}$$

Eq. 6.

$$\text{Dairy trait index} = \frac{\text{Punch girth}}{\text{Chest girth}}$$

Eq. 7.

$$\text{Meat trait index} = \frac{\text{Wither height}}{\text{Rump height}}$$

Body weight prediction

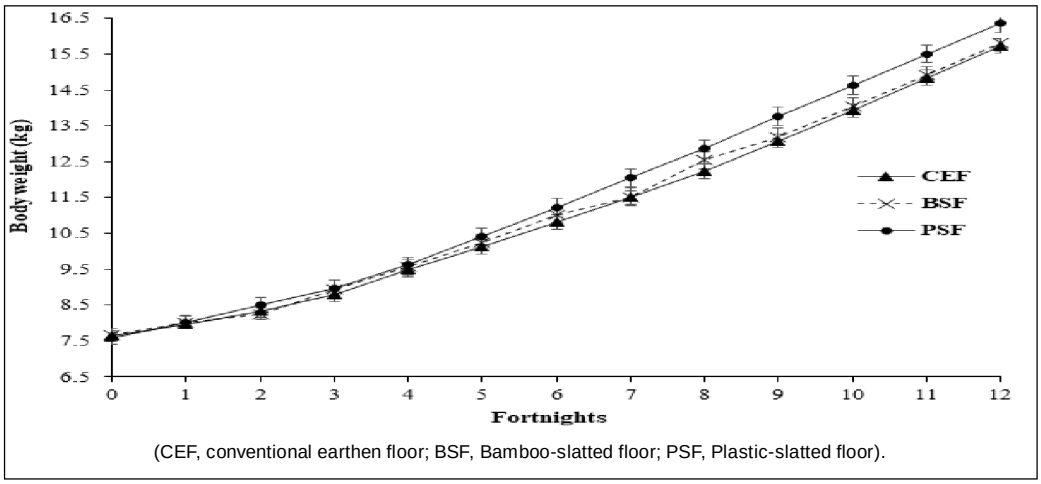
The multiple regression of body weight as dependent variable and confirmation traits in different combinations was estimated and the coefficient of determination (R^2) for each equation was calculated for the purpose of selecting best prediction equation. The best fitted regression equation was selected using step-wise regression method of Topal *et al.* (2003) based on correlation matrix of BW with all the morphometric predictors *i.e.* BL, WH, CG, PG and RH.

Statistical analysis

Analysis of data was carried out by standard statistical procedures as per Snedecor and Cochran (1989) by using software package SAS (version 9.3). The effect of treatments and periods (age of kids) were included, while location and sex were not included as variables in this analysis. The significance difference was declared at $P<0.05$, while a trend towards significance is referred at $0.05 < P < 0.10$.

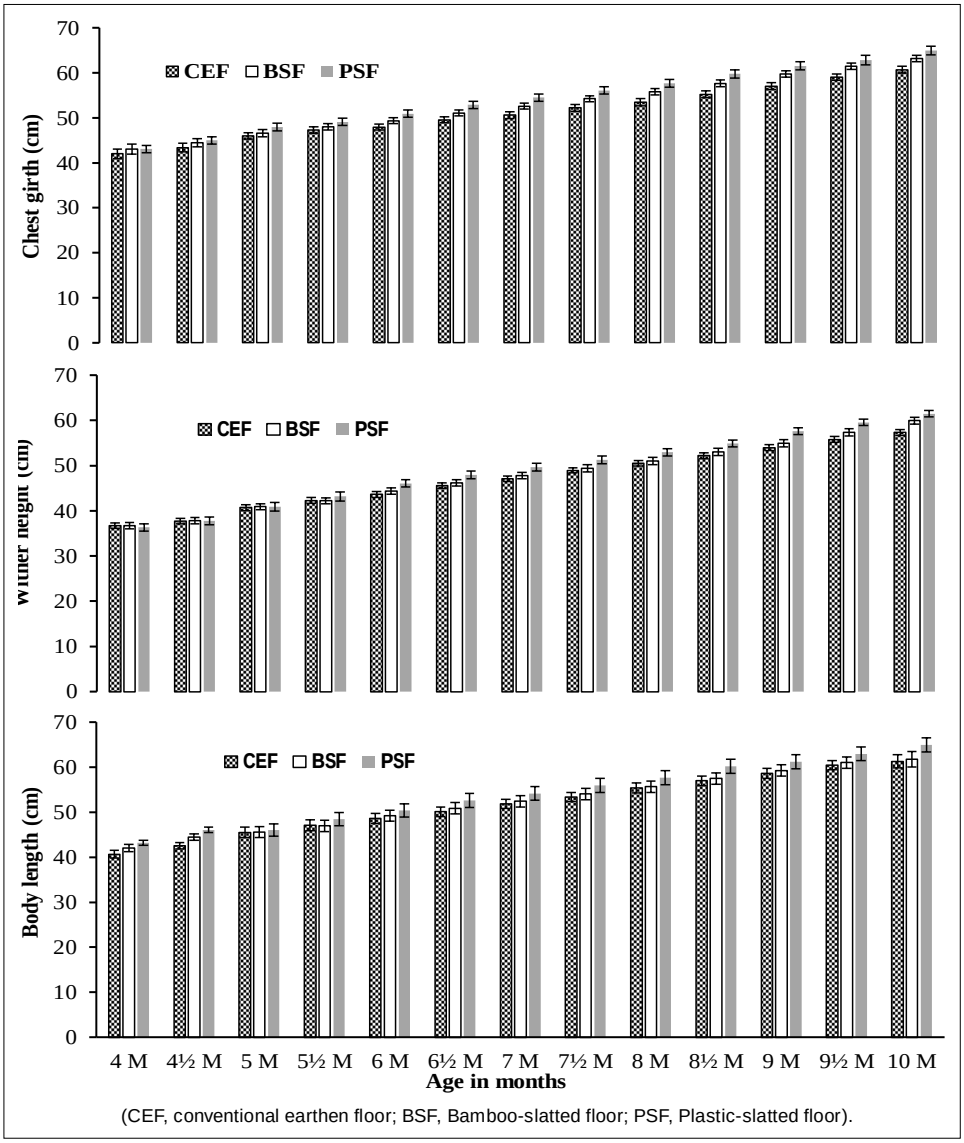
RESULTS AND DISCUSSION

Besides the findings on periodic growth pattern of kids, the relationship of the principal morphometric parameters *viz.* BL, WH, CG, PG and RH as an index of breed characteristics during the early life would help in selection and management for ascertaining future productivity. The present study intervened housing management with the improvement in floor-types from conventional earthen floor (CEF) to bamboo-slatted floor (BSF) and plastic-slatted floor (PSF) and assessed the performance of goat kids during 4 to 10 months of age to showcase phenotypic characters in Ganjam breed of goats in coastal Odisha.



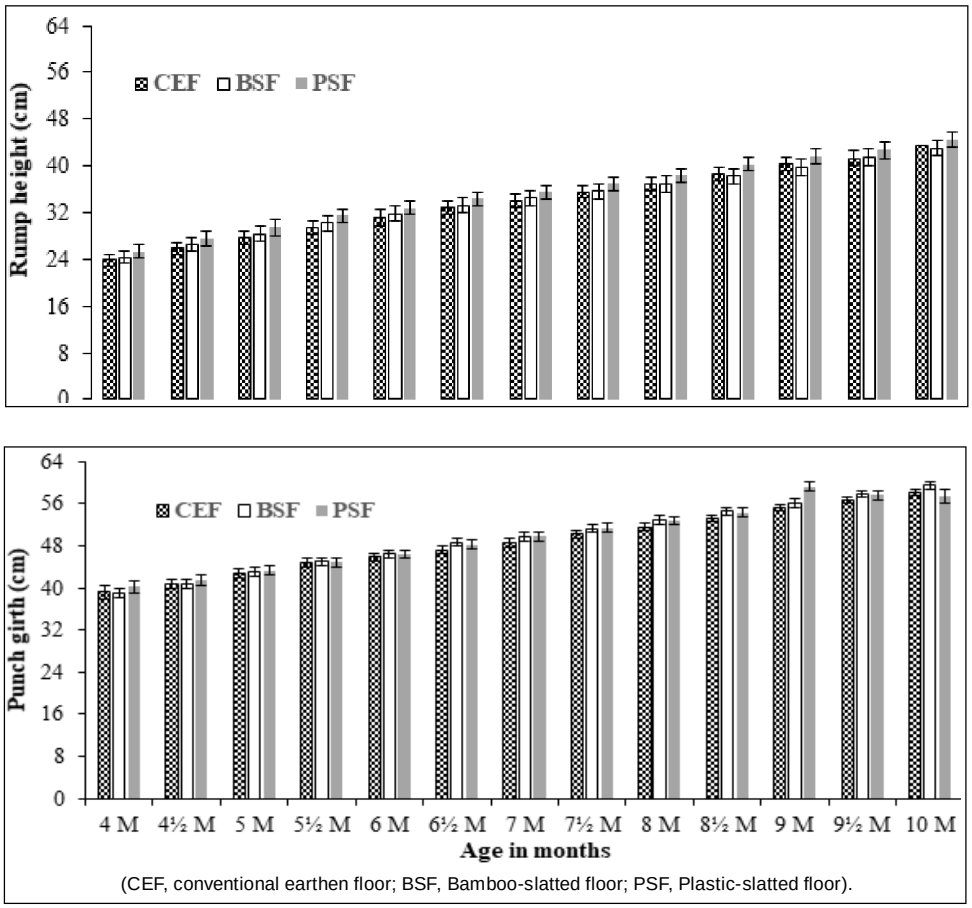
(CEF, conventional earthen floor; BSF, Bamboo-slatted floor; PSF, Plastic-slatted floor).

Fig 1: Alteration in body weight of goats under different treatments at fortnight intervals.



(CEF, conventional earthen floor; BSF, Bamboo-slatted floor; PSF, Plastic-slatted floor).

Fig 2: Age-dependent alteration in body length, wither height and chest girth of goats under different treatments.



(CEF, conventional earthen floor; BSF, Bamboo-slatted floor; PSF, Plastic-slatted floor).

Fig 3: Age-dependent alteration in punch girth and rump height of goats under different treatments.

Live weight gain

Goat kids attained incremental BW as they get matured during the experimental period extending over 4 to 6 months of age (Fig 1). The kids at 4 months of age had initial BW of 7.63 ± 0.11, 7.68 ± 0.17 and 7.59 ± 0.19 kg that reached to 15.73 ± 0.21, 15.82 ± 0.22 and 16.37 ± 0.26 kg at 10 months of age in CEF, BSF and PSF, respectively. Above all, there was significant ($P<0.05$) increase in BW gain of kids raised on PSF compared to kids raised on other floor-types during 6 to 8 and 4 to 10 months of age. The age dependent increase in BW relates to growth and development of kids, which may be referred as breed-specific characters of Ganjam goats in the coastal regions of Odisha. Similar observations on Ganjam goats were also reported earlier (Rao *et al.,* 2007; Verma *et al.,* 2015; Karna *et al.,* 2020; Majumder *et al.,* 2023). An improved performance of kids raised on PSF compared to CEF may be attributed to better welfare and less stress in animals that supported early growth performance. It is reiterated that floor-type in housing management has significant bearing on growth and productivity of small ruminants (Wadhwani *et al.,* 2016; Sutherland *et al.,* 2017), especially in high-humid and high rainfall coastal regions of Odisha.

Morphometric parameters

The morphometric parameters BL, WH and CG, which have a direct correlation with BW and are often referred to in many predictive equations, are depicted in Fig 2. All the measurements showed an age-dependent increase in kids confirming incremental growth as they get matured. The managemental intervention has no bearing on BL, but the kids raised on PSF showed higher WH compared to CEF during 8 to 9 months of age, while the difference between PSF and BSF was non-significant. Finally, kids aged 10 months raised on both BSF and PSF exhibited higher WH (59.94±0.70 and 61.44±0.71 cm) than CEF (57.33±0.64). Improved flooring invariably associated with better welfare (Sutherland *et al.,* 2017) that supports higher BW attainment (Pandu *et al.,* 2023) and it consequently relates to increment in WH. A higher ($P<0.05$) CG was noted in kids after two months of rearing on PSF (*i.e.* during 6 to 10 months of age) and after 4 months in BSF compared to kids on CEF, while the difference between BSF and PSF was non-significant ($P>0.05$). A relative comfortable flooring to kids during early-life boosted BW as well as CG that were highly correlated. The CG increased from 42.00±1.09, 43.06±1.13 and 43.06±0.79 cm at 4 months of age to 60.72±0.73, 63.22±0.68 and 65.00±0.96 cm at 10 months of age in CEF,

BSF and PSF, respectively. The morphometry of the posterior portion of the animal, more specifically the pelvic region measured as PG and RH is depicted in Fig 3. The kids raised on all the three floor-types had similar PG and RH and they accumulated higher PG and showed incremental gain in RH during 4 to 10 months of age. This is in line with age-dependent early growth and development of kids. The pattern of increase in PG during 4 to 10 months of age indicated breed specific growth of Ganjam kids as reported earlier (Verma *et al.,* 2015; Majumder *et al.,* 2023). Similarly, the RH increased from 23.83-25.28 to 43.06-44.44 cm during 4 to 10 months of age. Interestingly, RH was correlated higher at third place compared to BL (Table 8) and it relates to meat traits in Ganjam breeds. Sam *et al.* (2016) observed a similar higher correlation between BW and RH and recommended use of highly correlated morphometric parameters with BW for selection of West-African dwarf goats for enhancing meat production.

Structural indices

The morphometric traits of an animal express a strong relationship with productive potential since it contains the structure which supports the biological functionality of the animal. A relationship between these traits and with BW does exist that indicate type and function of a particular breed (Yemane and Melesse, 2021). The overall body shape is

Table 1: Body index of goat kids under different treatments.

Period	Treatments			Overall	SEM	Significance
(Age of kids)	CEF	BSF	PSF	mean±SE		(P value)
4 months	0.973	0.984	1.007	0.988±0.011	0.0187	0.420
4½ months	0.985	1.005	1.026	1.006±0.010	0.0170	0.244
5 months	0.987	0.978	0.970	0.978±0.015	0.0266	0.902
5½ months	0.996	0.977	0.996	0.990±0.015	0.0265	0.847
6 months	1.014	0.997	0.996	1.002±0.014	0.0247	0.855
6½ months	1.010	0.995	1.001	1.002±0.013	0.0240	0.897
7 months	1.025	0.995	0.999	1.006±0.013	0.0235	0.627
7½ months	1.023	0.994	1.003	1.007±0.013	0.0227	0.656
8 months	1.038	0.996	1.005	1.013±0.013	0.0232	0.419
8½ months	1.033	0.996	1.011	1.013±0.012	0.0209	0.447
9 months	1.029	0.991	0.993	1.004±0.009	0.0155	0.164
9½ months	1.027	0.992	1.002	1.007±0.008	0.0144	0.214
10 months	1.010	0.975	0.999	0.995±0.011	0.0195	0.435

Body index = Body length ÷ Chest girth.

CEF, conventional earthen floor; BSF, Bamboo-slatted floor; PSF, Plastic-slatted floor.

Table 2: Proportionality index of goat kids under different treatments.

Period	Treatments			Overall	SEM	Significance
(Age of kids)	CEF	BSF	PSF	mean±SE		(P value)
4 months	0.908	0.876	0.873	0.886±0.011	0.0186	0.455
4½ months	0.889	0.861	0.882	0.877±0.010	0.0164	0.609
5 months	0.905	0.907	0.905	0.906±0.018	0.0316	0.998
5½ months	0.906	0.912	0.906	0.908±0.018	0.0313	0.988
6 months	0.904	0.908	0.929	0.913±0.016	0.0277	0.798
6½ months	0.916	0.915	0.926	0.919±0.015	0.0268	0.950
7 months	0.913	0.919	0.929	0.920±0.014	0.0251	0.910
7½ months	0.923	0.920	0.928	0.924±0.014	0.0248	0.976
8 months	0.917	0.923	0.928	0.923±0.014	0.0240	0.951
8½ months	0.921	0.928	0.921	0.923±0.013	0.0225	0.968
9 months	0.925	0.930	0.948	0.934±0.010	0.0180	0.633
9½ months	0.925	0.945	0.952	0.941±0.010	0.0181	0.554
10 months	0.944	0.982	0.952	0.959±0.014	0.0241	0.499

Proportionality index = Wither height ÷ Body length.

CEF, conventional earthen floor; BSF, Bamboo-slatted floor; PSF, Plastic-slatted floor.

Means in a row with different superscripts differ significantly (P<0.05).

referred to as conformation, which is basically the result of many heritable traits, although environmental factors help shape the body of the animal. In this study, the information on different structural indices, *viz.* body index (BI), proportionality index (PrI), thoracic index (TI), compact index (CI), pelvic index (PI), dairy trait index (DtI), meat trait index (MtI) of kids is presented in Tables 1-7. These structural indices could estimate an animal's conformation and provide empirical values of much more significance compared to assessment on single measurements.

Based on the morphometry of anterior portion of goats (CG, WH), the BI of Ganjam kids was around 0.973-1.033 (Table 1), which is indicative of longiline (>0.90) conformation (Assefa *et al.,* 2023). Similarly, the PrI ranged from 0.877 to 0.959 that presented a proportionally rectangular body shape characteristic of meat-type animal (Yemane and Melesse, 2021; Getaneh *et al.,* 2022). The TI value at early age (4-5 months; 1.17-1.18) was nearing 1.2 which showed a progressive decline as the kid get mature (10 months; 1.06). This is contrary to recommended value of 1.2 indicative of good thoracic development (Dauda, 2018; Assefa *et al.,* 2023). But, describing Ganjam goats based on all these three indices (BI, PrI and TI) would explain differently, means, longiline goat with rectangular shape and relatively less increment in CG compared to WH during early growth phase would be a desirable character. A growing goat is not expected to accumulate fat in the thoracic region, but post-maturity (>10 months of age) accumulation of fat

Table 3: Thoracic index of goat kids under different treatments.

Period	Treatments			Overall	SEM	Significance
(Age of kids)	CEF	BSF	PSF	mean ± SE		(P value)
4 months	1.147	1.176	1.189	1.171±0.016	0.0279	0.558
4½ months	1.153	1.180	1.197	1.177±0.014	0.0248	0.470
5 months	1.135	1.142	1.178	1.151±0.013	0.0216	0.334
5½ months	1.122	1.137	1.143	1.134±0.011	0.0193	0.730
6 months	1.103	1.116	1.109	1.109±0.010	0.0179	0.874
6½ months	1.090	1.108	1.105	1.101±0.009	0.0156	0.687
7 months	1.077	1.104	1.100	1.094±0.008	0.0144	0.368
7½ months	1.068	1.102	1.096	1.089±0.008	0.0137	0.194
8 months	1.061	1.096	1.091	1.083±0.009	0.0148	0.204
8½ months	1.060	1.090	1.090	1.080±0.008	0.0144	0.256
9 months	1.060	1.090	1.068	1.073±0.007	0.0123	0.222
9½ months	1.060	1.073	1.055	1.062±0.007	0.0118	0.548
10 months	1.061	1.055	1.058	1.058±0.007	0.0116	0.943

Thoracic index = Chest girth ÷ Wither height.

CEF: Conventional earthen floor; BSF: Bamboo-slatted floor; PSF: Plastic-slatted floor.

Table 4: Compact index of goat kids under different treatments.

Period	Treatments			Overall	SEM	Significance
(Age of kids)	CEF	BSF	PSF	mean ± SE		(P value)
4 months	0.208	0.210	0.209	0.209±0.0025	0.0044	0.968
4½ months	0.211	0.214	0.213	0.213±0.0023	0.0041	0.933
5 months	0.205	0.203	0.208	0.205±0.0021	0.0037	0.588
5½ months	0.209	0.212	0.208	0.210±0.0029	0.0050	0.879
6 months	0.218	0.216	0.209	0.214±0.0025	0.0043	0.304
6½ months	0.223	0.222	0.217	0.221±0.0024	0.0043	0.600
7 months	0.230	0.231	0.226	0.229±0.0026	0.0045	0.692
7½ months	0.236	0.234	0.235	0.235±0.0023	0.0040	0.926
8 months	0.243	0.247	0.243	0.244±0.0026	0.0046	0.784
8½ months	0.251	0.249	0.251	0.250±0.0022	0.0038	0.935
9 months	0.259	0.257	0.254	0.256±0.0022	0.0038	0.673
9½ months	0.267	0.260	0.260	0.263±0.0022	0.0039	0.415
10 months	0.275	0.264	0.267	0.268±0.0022	0.0036	0.091

Compact index = Body weight (kg) ÷ Wither height (cm).

CEF: Conventional earthen floor; BSF: Bamboo-slatted floor; PSF: Plastic-slatted floor.

in the thoracic region and minimal increment in WH will reverse the trend towards 1.2 as suggested earlier. Further, two times of CG to WH ratio close to 2.1 is referred as characteristics of a strong animal (traction type). Thus, the Ganjam goats are an important breed of the coastal Odisha with desirable characters for early growth. The compact index (CI) denotes to compactness of animal's body (*i.e.* how compact the animal is ?) and values above 3.15 is referred as meat-type (Dauda, 2018). The observed value showed an increasing trend from 0.209 (2.09 g/cm; 4 months) to 0.268 (2.68 g/cm; 10 months). Critically, the values float around 0.210 until 6 months of age, the early phase of accelerated post-weaning growth and then it showed an increasing trend, which if extended further, a value 0.315 (or >3.15 g/cm) reached at around 13-15 months of age. It is to note that Ganjam goats attain adult BW at around 15 months of age (AICRP, 2019) and a close CI value may be indicative of its meat-type dual characters. Moreover, this finding was in line with the observed TI. Taking cognizance of both TI and CI, it may be argued that the growing Ganjam goats raised on conventional free-range management system have a slender configuration and they accrued proportional BW based on BL, WH and CG. Earlier reports on CG and BW of Ganjam goats (Verma *et al.,* 2015; Karna *et al.,* 2020; Majumder *et al.,* 2023) are similar to the values recorded in the present investigation.

Table 5: Pelvic index of goat kids under different treatments.

Period	Treatments			Overall	SEM	Significance
(Age of kids)	CEF	BSF	PSF	mean ± SE		(P value)
4 months	1.678	1.633	1.622	1.645±0.031	0.0540	0.739
4½ months	1.611	1.577	1.545	1.577±0.029	0.0507	0.653
5 months	1.573	1.553	1.509	1.545±0.029	0.0503	0.652
5½ months	1.547	1.523	1.458	1.509±0.028	0.0484	0.409
6 months	1.489	1.488	1.441	1.473±0.025	0.0437	0.673
6½ months	1.459	1.490	1.424	1.457±0.023	0.0395	0.503
7 months	1.441	1.467	1.418	1.442±0.022	0.0378	0.659
7½ months	1.428	1.465	1.408	1.433±0.020	0.0355	0.523
8 months	1.418	1.457	1.391	1.422±0.019	0.0332	0.366
8½ months	1.395	1.448	1.362	1.401±0.019	0.0329	0.186
9 months	1.384	1.431	1.431	1.416±0.019	0.0340	0.537
9½ months	1.372	1.409	1.367	1.383±0.021	0.0373	0.685
10 months	1.354	1.398	1.302	1.351±0.020	0.0339	0.144

Pelvic index = Punch girth÷Rump height.

CEF: conventional earthen floor; BSF: Bamboo-slatted floor; PSF: Plastic-slatted floor.

Table 6: Dairy trait index of goat kids under different treatments.

Period	Treatments			Overall	SEM	Significance
(Age of kids)	CEF	BSF	PSF	mean ± SE		(P value)
4 months	0.932	0.907	0.932	0.924±0.0083	0.0144	0.365
4½ months	0.940	0.920	0.919	0.926±0.0069	0.0120	0.367
5 months	0.931	0.927	0.903	0.920±0.0056	0.0094	0.084
5½ months	0.948b	0.937ab	0.914a	0.933±0.0055	0.0090	0.034
6 months	0.956b	0.942b	0.912a	0.936±0.0052	0.0081	0.001
6½ months	0.953b	0.953b	0.912a	0.939±0.0049	0.0074	<0.001
7 months	0.959b	0.945b	0.913a	0.939±0.0056	0.0088	0.002
7½ months	0.961b	0.944b	0.916a	0.941±0.0051	0.0078	0.001
8 months	0.965b	0.947b	0.916a	0.943±0.0055	0.0083	<0.001
8½ months	0.966b	0.945b	0.909a	0.940±0.0054	0.0077	<0.001
9 months	0.969b	0.939ab	0.923a	0.944±0.0052	0.0085	0.045
9½ months	0.961b	0.940ab	0.917a	0.939±0.0048	0.0073	<0.001
10 months	0.956b	0.940b	0.902a	0.932±0.0064	0.0083	<0.001

Dairy trait index = Punch girth ÷ Chest girth.

CEF: conventional earthen floor; BSF: Bamboo-slatted floor; PSF: Plastic-slatted floor.

Means in a row with different superscripts differ significantly (P<0.05).

Table 7: Meat trait index of goat kids under different treatments.

Period (Age of kids)	Treatments			Overall mean ± SE	SEM	Significance (P value)
	CEF	BSF	PSF			
4 months	1.597	1.559	1.483	1.546±0.042	0.0733	0.537
4½ months	1.506	1.472	1.420	1.466±0.036	0.0638	0.635
5 months	1.511	1.488	1.428	1.476±0.037	0.0655	0.653
5½ months	1.471	1.448	1.401	1.440±0.034	0.0591	0.696
6 months	1.428	1.432	1.431	1.430±0.032	0.0564	0.998
6½ months	1.417	1.421	1.417	1.418±0.029	0.0504	0.997
7 months	1.406	1.421	1.416	1.414±0.028	0.0495	0.978
7½ months	1.403	1.421	1.406	1.410±0.028	0.0487	0.959
8 months	1.397	1.417	1.394	1.403±0.026	0.0465	0.931
8½ months	1.373	1.415	1.378	1.389±0.025	0.0447	0.767
9 months	1.358	1.405	1.394	1.386±0.024	0.0414	0.711
9½ months	1.355	1.405	1.418	1.393±0.027	0.0464	0.599
10 months	1.343	1.415	1.403	1.387±0.025	0.0441	0.474

Meat trait index = Wither height ÷ Rump height.

CEF: Conventional earthen floor; BSF: Bamboo-slatted floor; PSF: Plastic-slatted floor.

Table 8: Regression showing body weight prediction based on constants and variables.

Types	Regression equations	R	R^2	Significance (P value)
Eq1	BW = -8.082 + 0.367CG	0.926	0.858	<0.001
Eq2	BW = -7.327 + 0.194CG + 0.174WH	0.947	0.897	<0.001
Eq3	BW = -5.553 + 0.070CG + 0.0.197WH + 0.106RH	0.956	0.914	<0.001
Eq4	BW = -5.930 + 0.069CG + 0.0.187WH + 0.088RH + 0.030BL	0.957	0.916	<0.001
Eq5	BW = -6.273 + 0.040CG + 0.0.174WH + 0.072RH + 0.031BL + 0.060PG	0.958	0.918	<0.001

BW- Body weight; BL- Body length; WH- Wither height; CG-Chest girth; PG- Punch girth; RH- Rump height.

Now, based on morphometry of the posterior portion (PG, RH), the PI value, an indicative of proportionality of the hindquarters and related to reproductive fitness, recorded a decreasing trend from 1.645 to 1.351 (Table 5). This also corroborated the findings on CG and WH and the declining trend would be attributable to growing phase. The characterization with respect to selection targeting improved reproductive performance can be assessed in mature animals, because relative increase in RH will be less compared to PG. As discussed earlier, there is increase in the girth of animal even after maturity and therefore, ratio between posterior (PG) and anterior (CG) portion may be taken as a constant. Also, the PI is associated with reproductive traits (Yemane and Melesse, 2021) and provides information on animal's ability or potential of meat production (Dauda, 2018) as it correlates more than one measurement such as BL, WH, CG besides PG and RH. The DtI of Ganjam kids showed a constant value (0.920-944) during the period of observation indicating a similar pattern of growth in both PG and CG (Table 6). Interestingly, kids raised on PSF had smaller values compared to BSF and CEF, which may be attributed to relatively higher BW gain and CG, eventually supported by improved floor management. This is one of the important traits of she goat relating to dairy potential of animal and thus animals with smaller CG and larger PG (to accommodate udder) may be categorized to select for higher milk yield. Sieber *et al.* (1988) had similar inference for dairy cows based on regression analysis and recommended selection of taller cows with larger punch girth and shorter heart girth for higher milk yield. Contrary to this, growing Ganjam kids showed lower value of PG compared to CG with a ratio <1.0. But, the pattern of growth and development in female is different than that in male during puberty and thus, the DtI values after sexual maturity may reverse to show the desired value (>1.0) that have more significance to characterize goats with dairy traits for selection. Getaneh *et al.* (2022) referred this index as 'Girth index' and characterized the indigenous goats in the East Gojjam Zone of Ethiopia as longilinear and light animals that have dairy biotype. On similar line, Khargharia *et al.* (2015) characterized Assam Hill goat in Eastern Himalayan India suitable for meat production. The ratio of WH to RH, referred as MtI showed a gradual declining trend from 1.546±0.042 (4 months) to 1.387±0.025 (10 months) (Table 7). The index is also termed as body ratio (Khargharia *et al.* 2015), which provides information on conformation whether the animal is high or low in front. Besides, wither height is considered as one of the important criteria of growth in meat-type animals (Verma *et al.,* 2015; Karna *et al.,* 2020; Getaneh *et*

al., 2022; Majumder *et al.,* 2023) and thus the present findings on WH and MtI of Ganjam goats characterize Ganjam goats as one of the promising meat-type with dual dairy characters of coastal Odisha.

Above all, based on morphometry and structural indices involving both anterior and posterior portion of Ganjam goats, the native breeds of Odisha promise both meat and dairy characters to group under dual-purpose breed that can support the livestock keepers in meeting the animal protein requirement of human population by providing both meat and milk. The findings will be very much useful for breeding and selection of Ganjam goats for meat and dairy purpose that eventually strengthen the information documented in AICRP Report (2019). A short-term assessment on the advantages of goat rearing on PSF over BSF and CEF could not accommodate the long-term beneficial effect on herd health and overall reduction in morbidity and mortality rate, impetus to early kid-growth and whole-farm productivity. Earlier reports outlined higher initial investment, but enhanced profit making in long-term goat farming (Sutherland *et al.,* 2017; Pandu *et al.,* 2023).

Body weight prediction

The correlation of BW with the morphometric parameters were evaluated that demonstrated highest correlation with CG followed by WH, RH, BL and PG (Table 8). The prediction equations BW = -5.553 + 0.070CG + 0.0.197WH + 0.106RH (R2 0.914; P<0.001) seemed to predict BW of growing Ganjam goats most accurately. The present observation weighs for RH in place of BL as usually recommended in earlier reports (Singh and Mishra, 2004; Kharkar *et al.,* 2014; Verma *et al.,* 2015; Karna *et al.,* 2020). Nonetheless, the importance of CG, WH and RH for predicting BW and their contribution to meat and dairy type characters as well establishes a useful association for genetic selection based on morphometric traits.

CONCLUSION

Measurements of body conformation in goats are of value in judging the quantitative characteristics of in terms of meat and/or dairy type, which will be helpful in developing suitable selection criterion for future breeding programmes. The present study evaluated conformation traits based on BW and morphometric parameters that characterized native Ganjam goat breeds with both desirable anterior (longiline with rectangular shape, strong and compact body) and posterior characters (lower rump height, higher punch girth) to categorize as a meat-type breed with dual dairy traits that can render usefulness to breed for both meat and dairy purposes. Further, managemental impetus through improved plastic-slatted flooring to growing goats could help better performance (BW, WH, CG) in the high-humid coastal regions.

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Conflict of interest

On behalf of all the authors of the manuscript, it is certified that the authors have no conflict of interest.

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