Phenotypic, genetic and cytogenetic characterization of Ghumusari cattle of Odisha- a newly accredited breed

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ABSTRACT

Ghumusari cattle are raised in the eastern province of Odisha of India by farming families in mixed farming system. The breed numbers are declining very fast, due to non-availability of quality bulls in the native tract. Animals are small in size with mature body weight of 170-210 kg for bulls and 140-185 kg for cows, quite uniform in colour (white/grey) and body conformation, have moderate dewlap and reduced umbilical folds and relatively large hump in males. Animals are heat tolerant, sustain on low quality feed intake under high ambient temperature, resistant to many diseases prevailing in the region and cows have good mothering ability. Productivity of the breed in terms of milk is low but bullocks are very good draft animals. Reproduction performance excels like that of other small sized indigenous zebu cattle breeds. Cytogenetic profiling revealed their typical *Bos indicus* status (acrocentric Y chromosome). Genetic characterization based on 21 FAO-recommended microsatellite markers demonstrated high genetic variability prevailing in Ghumusari cattle population. Efforts should be made to stop the decline in the breed numbers and to conserve the breed as an asset for production under harsh environment of the native tract.

Kay Words: body conformation, heat tolerant, mothering ability, draft animals

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INTRODUCTION

Population size, species and breed diversity of the indigenous domestic livestock are declining at an ever accelerating rate throughout the world. Some of the breeds of the domestic species existing in different regions of the world are endangered or at risk of becoming extinct. Species and breeds with low production potential are the most endangered. Indigenous cattle of India are on top of this list. Typical Ghumusari cattle are kept in small numbers on small-scale traditional farms in the eastern province of Odisha of India. The breed has neither been described in the literature nor inventoried in Masons' World Dictionary of Livestock Breeds (Mason, 1996) or the FAO/UNEP World Watch List for Domestic Livestock Diversity (Scherf, 1995). The breed has only recently been accredited as a new breed of Indian cattle (NBAGR 2010).

Agriculture in Odisha is effectively dependant on work animals i.e. bullocks for farm power. Prime objective of the farming community in the breeding of cattle continues to be the draftability of work animal. After the large scale mechanization in agriculture in several states of the country, Odisha is among the few remaining states, which is still predominantly dependant on work animals for farm power. Therefore, inclination of farm families towards production of work animals is a driving force in the breeding and management of cattle and buffalo. However, there is no effective governmental policy for the sustainable development of livestock of Odisha. In the absence of a systematic and coherent institutional policy to improve and conserve, the Ghumusari cattle may become extinct and a potentially valuable genetic material may be lost forever.

The objective of this study was to characterize the Ghumusari breed by providing basic information on its origin, population statistics, ecology, natural habitat, production system, utilisation, physical and adaptive features and production characteristics.

MATERIALS AND METHODS

The animals included in this study were located in farmers' herds in the native breeding tract. Information on 3230 animals of all ages maintained by 458 farm families was collected through a survey covering 48 villages in the native tract of the breed. Phenotypic data and animal measurements were taken from animals of both sexes at different ages. Farmers were interviewed

for land holding, breed choice, utility, purpose, sale and purchase of animals, animal housing, calf rearing, herd size, breeding and feeds and fodders available in the breeding tract. Milk yield was recorded in some of the cases at farmers' door. The external body measurements included in this study were: height at withers (HW) taken from the ground level to the highest point of withers, body length (BL) taken from the point of the shoulder to the pin bone, heart girth (HG) the circumference around the chest at the fourth ribs, paunch girth (PG) the circumference around paunch (just before the hip bones), head length (HL) from the pole to the lower chin, tail length (TL) from the base of the tail to its tip, horn length (HL) form the horn base to the tip and ear length (EL) from the base of the ear to its tip. The data thus collected were subjected to appropriate statistical analysis.

Cytogenetic analysis: Sterile blood samples were collected from 6 male and 8 female representative Ghumusari cattle in heparin tubes from the breeding tract and shipped to laboratory for further processing. Blood leukocyte cultures were established in RPMI 1640 culture medium fortified with fetal calf serum, antibiotics and pokeweed mitogen. The cultures were harvested after 72 hours culture at 37oC using standard procedure for the preparation of metaphase chromosome spreads. At least 25 metaphase spreads were analyzed per animal to determine its chromosomal constitution. Representative karyotypes were prepared using the automatic karyotyping software- *Genus*.

Microsatellites based Genetic Characterization: Blood samples were collected from 48 true to type Ghumusari cattle from different villages covering a wider area of the native tract of the breed. The farmers were interviewed in detail to ensure unrelatedness among the sampled animals. Genomic DNA was extracted by standard phenol-chloroform method following the procedure of Sambrook and Russell (2001). The animals were genotyped at 21 FAO recommended bovine microsatellite markers. The forward primer for each locus was labelled with one of the four fluorescent dyes FAM, HEX, NED and PET (Applied Biosystems, USA). Polymerase chain reaction was performed with a total reaction volume of 25 µl, using the following thermal conditions, 94°C for 2 min, followed by 30 cycles of 94°C for 1 min, specific annealing temperature for 1 min and 72°C for 1 min and a final extension at 72°C for 10 min. The amplified PCR products containing different dyes were electrophoresed together after multiplexing in six sets in an automated DNA sequencer with GS500LIZ as internal lane control (Applied Biosystems, USA). The allele size data for each sample was then extracted using GENEMAPPER software.

Computation and data analysis for evaluation of within breed diversity was carried out using standard analysis software. Observed number of alleles, effective number of alleles, observed and expected heterozygosities were computed using Popgene software (Yeh et al. 1999). Polymorphism information content (PIC) was calculated from allele frequencies using the formula of Botstein et al. (1980). Chi-square test based departure from Hardy Weinberg equilibrium was executed using Popgene software (Yeh et al. 1980). Heterozygote deficiency at each locus was tested using FSTAT software (Goudet 2002). The population was also tested for any recent genetic bottleneck by the qualitative graphical test of mode shift in allele frequency distribution.

RESULTS AND DISCUSSION

Socio-economic status of farmers: All sections of people in the native tract keep Ghumusari cattle along with other livestock and poultry. The average landholding of farm families is less than 2 acres. Ghumusari cattle in its purest form is in the hands of landless and marginal farmers as they never go for artificial insemination with exotic cattle semen with the belief that sophisticated management would be required for maintenance of crossbred cattle and the male calf will be useless for agricultural operations. Women in the family take care of the calves and lactating cows and in majority of the cases they clean the shed, milk the cows and feed them both in the morning as well as evening. All the milk products i.e. ghee, curd and chhenna are prepared by female members of the household. Drying of cow dung for use as fuel, especially in rainy season, is one of the most important activities performed by female members. In most of the cases the male members take care of the bullocks.

Native tract: Ghumusari cattle derive their name, like majority of the Indian livestock breeds, from the place of their origin- the Ghumusur region presently comprising the Bhanjnagar subdivision of Ganjam district in Odisha. Heavy concentration of Ghumusuri cattle was observed, in its conventional form, in

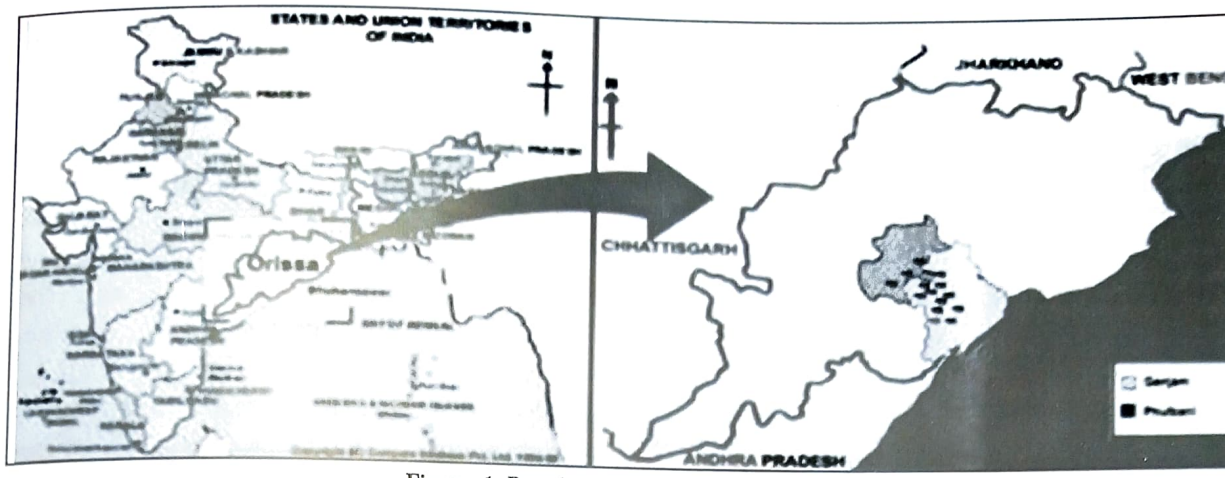

Figure 1. Breeding tract of Ghumusari cattle

Bhanjnagar, Aska, Dharakote and Sorada areas (Fig. 1). Adjoining areas also harbour this cattle, but in lesser concentration. The native tract of the breed is distributed over 84° 16' to 85° 18' East longitude and 19° 10' to 20° 28' North latitude spread over an area of about 4000 sq. km. The major area of the breeding tract is covered with sandy loam soil with low water holding capacity. The climate is generally hot, semi-arid tropical in nature. The average minimum and maximum temperature recorded in the breeding tract was 11.6° C and 45.2° C observed in the months of January and May, respectively. The relative humidity ranged between 39.2 and 87.4 % during the year with an average rainfall of 1353.8 mm in a span of 114 days during monsoon season. The seasons observed were cold (November to February), summer (March to July) and rainy (August to October). The breeding tract is famous for the production of rice, sugarcane, ragi, pulses and vegetables.

Management practices: Ghumusari cattle are maintained primarily under semi-intensive management system with very low input without any concentrates or feed supplement. Feeding of straw, little amount of rice bran and kitchen waste to lactating cows and working bullocks is a routine practice. Animals essentially get their feeding through grazing. Usually one or two persons take all grazing animals of a village for grazing in the morning and bring back in the evening (Fig.2). Grazing land essentially comprises nearby hillocks, forest land, harvested farmers' fields and roadside fallow land.

Figure 2. A pooled herd of Ghumusari cattle being taken for traditional grazing

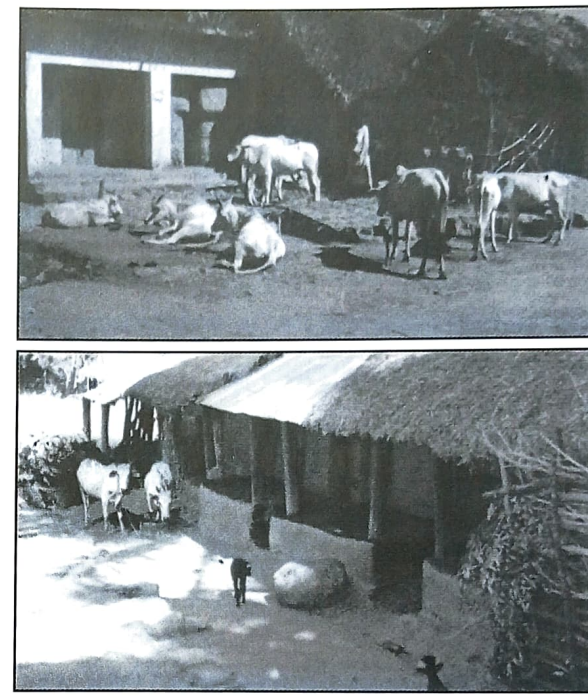

Figure 3. Housing and open space provided to Ghumusari cattle

About 87.7% of the farmers housed their animals only at night and only 12.3% both during day and night. Housing was generally open (92%). Majority of the animal houses were kutcha type (86%) with kutcha flooring and drainage for urine exit indicated poor sanitary conditions. Animal house (in 86% cases) was a part of the owner's residence predominantly (Fig. 3),

signifying that the farmers were resource poor and there was lack of proper attention towards animals, largely perhaps due to prevailing illiteracy. Usually one female member of the family takes care of the milch cows as well as newborn calves.

Ghumusari cattle owners do not maintain individual breeding bull in their respective herds, but there are usually few bulls available for breeding in a village. Two to three bulls could be seen in a herd of 80-100 cows. Most of the breeding activities take place in the grazing fields. As the villages are close by, bulls from herds of nearby villages also breed with females of other villages. Usually the strongest bull in the herd mates the cow in heat. Few resource rich farmers opt for crossbreeding through artificial insemination with Jersey semen. But majority of the farmers prefer mating with local bulls to get good bullocks for draft which also fetch good price when sold. An adult pair of bullocks fetched Rs 12000-20000 in 2008 (Das and Sethi 2008). As majority of the male calves are reared as bullocks there is scarcity of quality bulls for breeding in the entire breeding tract.

Physical characteristics: Ghumusari is small sized, horned, strong, draft type docile cattle with good posture. Bulls look very strong, vigorous with well-developed hump. Penis, naval flap and dewlap are medium in growth. A representative Ghumusari bull and cow with calf are shown in Fig. 4. Coat colour of bullocks is predominantly white (about 95%). The hump, neck and some region of face and back are black in colour irrespective of the coat colour of the males. The dark colour develops at the time of maturity. However, the coat colour remains predominantly white if the males are castrated (bullocks). Colour of muzzle and tail switch is black. The cows are grayish in colour having proportionate and compact body with graceful appearance. Calves are white or grayish at birth and develop to white colour at adult age. The bulls have majestic gait.

Head is small with flat and straight forehead, depressed in between the eyes. Both sexes are horned. Small strong and stumpy horns with rounded tips are an important feature of this breed. The ears are small to medium in size and horizontal in orientation. The average ear length in adult males and females were 18.71±0.34 and 18.67±0.84 cm respectively. The pin bones are distinct and quite wide apart compared with the body conformation. Udder is bowl shaped, which is distinctly seen from both sides as well as from behind in lactating cows. The milk vein is less prominent in appearance. Teats are small to medium with rounded tips. Vulva is comparatively larger. The tail extends well below the hock with voluminous black switch. Dewlap is thin, small and soft.

Body weights and measurements: The means with standard errors for body weights and conformation traits of Ghumusari cattle (males and females) at different ages are provided in Table 1. The average adult body weight of males and females were 208.52±4.56 and 166.76.05±3.25 kg, respectively. The males were heavier as well as taller than females. The average height at withers were 108.09 ±1.51 and 102.91±1.58 cm in males and females, respectively, which was found to be higher than Motu, and Khariar but lower than Binjharpuri cattle breeds of Odisha as reported by Swain (2003), Sahoo (1989), Dhal (2007), Das and Sethi

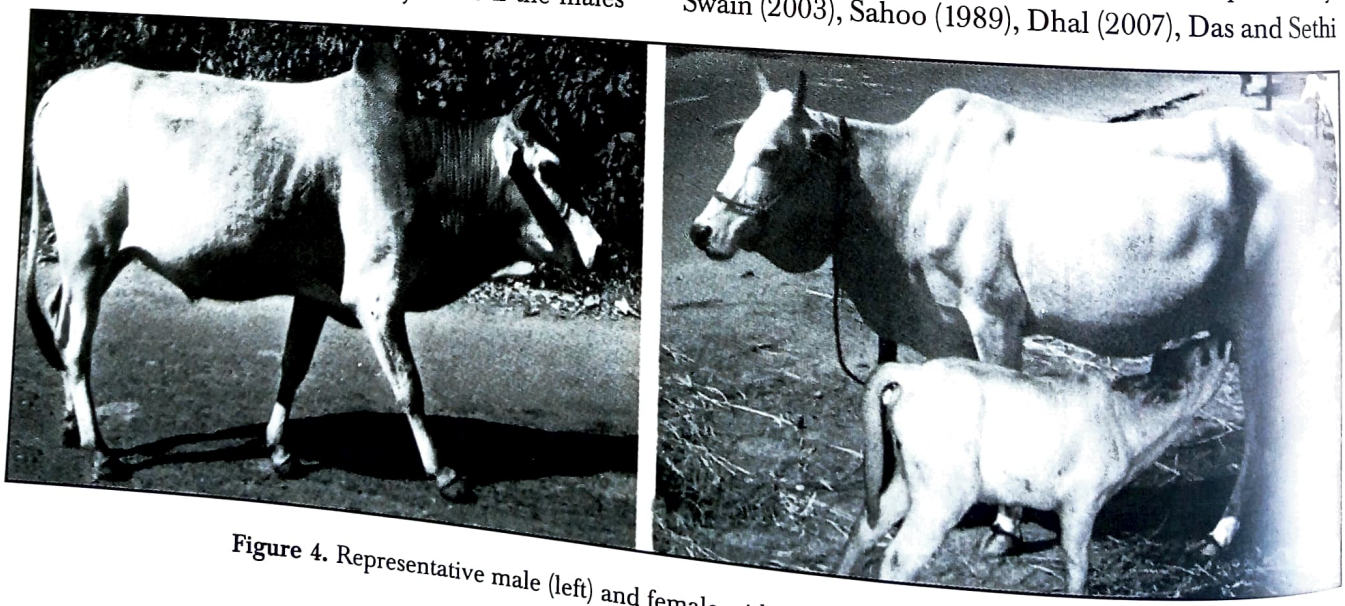

Figure 4. Representative male (left) and female with calf (right) Ghumusari cattle

2008 and Das et al (2010). Thus Ghumusari cattle ranks second in weight and body measurements after Binjharpuri and are heavier and taller than Motu and Khariar breeds of its native state, Odisha. The body weights and three body measurements (HG, HW and BL) of Ghumusari cattle were also compared with those of 25 other cattle breeds of India (Gaolao, Malvi, Nimari, Kangayam, Umblachery, Deoni, Ongole, Gir, Motu, Binjharpuri, Khariar, Amritmahal, Dangi, Bachaur, Khillar, Hallikar, Hariana, Kankrej, Mewati, Nagori, Punganur, Rathi, Sahiwal, Siri and Vechur) for which information was available in the form of breed descriptors (NBAGR 2008a, 2008b, 2008c, 2009 and 2010). It emerged that Ghumusari breed had slightly higher adult body weight and body parameters than only three Indian breeds (Vechur, Motu and Khariar), was comparable with Punganur and had conspicuously lower adult body weight and body measurements than the remaining 21 Indian breeds for which information could be accessed (NBAGR 2008a, 2008b, 2008c, 2009 and 2010). Ghumusari is, thus, amongst the smallest of Indian cattle breeds.

Reproductive parameters : Ghumusari heifers attained their puberty at an average age of 1169.58 ±11.19 days and gave birth to the first calf at 1496.87 ±12.28 days (49.2 months). In the entire life-span the cows on an average produced 8.43 calves with average calving interval of 412.22± 3.41 days and gestation length of 279.44±4.16 days (Table 2). Age at maturity and first calving of Ghumusari cows are comparable with those of Motu (AFC= 1593.85±6.74 days) and Kharaiar cows (AFC = 1522.86±7.54 days) but considerably inferior to that of Binjharpuri cows (AFC = 1230.73±6.42 days) from the state of Odisha (NBAGR 2010). No seasonality of breeding was noticed. About 41% cows exhibited oestrus in winter, 37.5% in rainy season and remaining 21.6% in summer season.

Production parameters : Average milk yield was around

Table 1. Body weight and body measurements of Ghumusari cattle

	SEX	BW (kg)	HW (cm)	BL (cm)	HG (cm)	PG (cm)	TL (cm)	HeL (cm)	EL (cm)	HoL (cm)
Birth	M	14.82 ±0.45	57.66 ±0.98	45.12 ±1.10	57.12 ±1.85	57.42 ±1.96	31.98 ±0.41	18.23 ±0.28	12.57 ±0.18	-
	F	13.83 ±0.65	55.89 ±0.99	43.37 ±0.93	54.66 ±1.03	57.23 ±0.87	31.95 ±0.30	17.83 ±0.31	11.89 ±0.21	-
3 month	M	34.88 ±1.12	66.87 ±1.23	57.67 ±1.41	72.56 ±1.42	72.56 ±1.62	44.98 ±0.52	25.44 ±0.62	13.15 ±0.21	-
	F	33.46 ±0.63	68.52 ±0.68	55.47 ±1.11	73.68 ±1.57	74.47 ±1.38	45.23 ±0.48	25.44 ±0.62	13.09 ±0.19	-
6 month	M	48.32 ±2.13	78.98 ±1.74	72.77 ±1.43	83.47 ±1.12	81.95 ±1.04	53.62 ±0.72	29.82 ±0.62	15.27 ±0.29	-
	F	42.17 ±1.91	76.40 ±1.33	66.24 ±1.24	80.58 ±1.42	80.24 ±1.36	52.87 ±0.75	27.37 ±0.43	15.16 ±0.25	-
12 month	M	80.58 ±2.67	87.21 0.93	84.75 ±2.00	99.02 ±2.89	96.98 ±2.51	63.46 ±1.81	33.35 ±0.42	17.36 ±0.39	2.28 ±0.14
	F	72.18 ±1.67	86.17 ±1.01	82.18 ±1.11	95.17 ±1.66	94.54 ±1.28	62.49 ±1.15	30.72 ±0.42	17.28 ±0.30	1.32 ±0.18
Adult (>2 yr)	M	208.52 ±4.56	108.09 ±1.51	116.02 ±1.69	136.14 ±2.25	137. 94 ±1.42	85.71 ±1.89	44.7 ±1.2	18.72 ±0.34	8.72 ±1.54
	F	166.76 ±3.25	102.91 ±1.58	107.86 ±0.71	126.27 ±2.31	134.32 ±2.37	82.28 ±2.41	40.1 ±0.2	18.67 ±0.84	7.47 ±1.67

BW = Body weight; HW=- Height at withers; BL = Body length; HG = Heart girth; PG= Paunch girth; TL = Tail length; HeL= Head length; HoL = Horn length; EL = Ear length

Table 2. Reproduction traits of Ghumusari cattle

Sl. No	Traits	Mean±SE
1	Age at first oestrous (days)	1169.6 ±11.19
2	Oestrus cycle duration (days)	21
3	Oestrus duration (hrs)	24
4	Age at 1st mating (days)	1217.2 ±12.28
5	Age at 1st calving (days)	1496.9 ±12.17
6	Age at 2nd calving (days)	1908.3 ±11.76
7	Service period (days)	133.5±5.65
8	Calving interval (days)	412.2± 3.41
9	Gestation length (days)	279.4±4.16
10	Life time no. of calvings	8.43

Table 3. Dairy performance of Ghumusari cattle in different lactations

Dairy performance	Lactation			
	I	II	III	IV
Daily milk yield(litres)	1.64±0.14	1.72 ±0.13	1.92 ± 0.16	1.95 ± 0.11
Peak milk yield(litres)	2.12	2.28	2.52	2.52
Days to reach peak yield	58.4	60.6	56.3	55.5
Lactation length (days)	280.7 ± 3.26	306.3 ± 3.75	316.4 ± 4.23	322.2 ± 4.23
Lactation milk yield (litres)	460.3	526.9	607.6	628.4
Fat %	4.91	4.88	4.86	4.86
SNF %	8.52	8.53	8.54	8.54
Dry period(days)	131.57	105.90	95.78	89.99

1.8 litres per day in two milkings without supplementation of concentrate. Peak yield of about 2.5 litres was attained around 58th day of lactation. Average milk fat and SNF was estimated as 4.88% and 8.53%, respectively. Cows were docile and woman member of the family usually milk the lactating cows. The highest lactational yield was recorded as 628.35 litres, with an average lactation length of 322.23 ± 4.23 days during fourth lactation. The lactation wise dairy performance of Ghumusari cows is presented in Table 3. Ghumusari is superior in dairy performance to Motu and Khariar but inferior to Binhjarpuri breeds from its native state of Odisha (NBAGR 2010).

Work Performance of Ghumusari bullocks : Ghumusari bullocks are well known for their working ability in agricultural operations (Fig. 5). The bullocks are swift

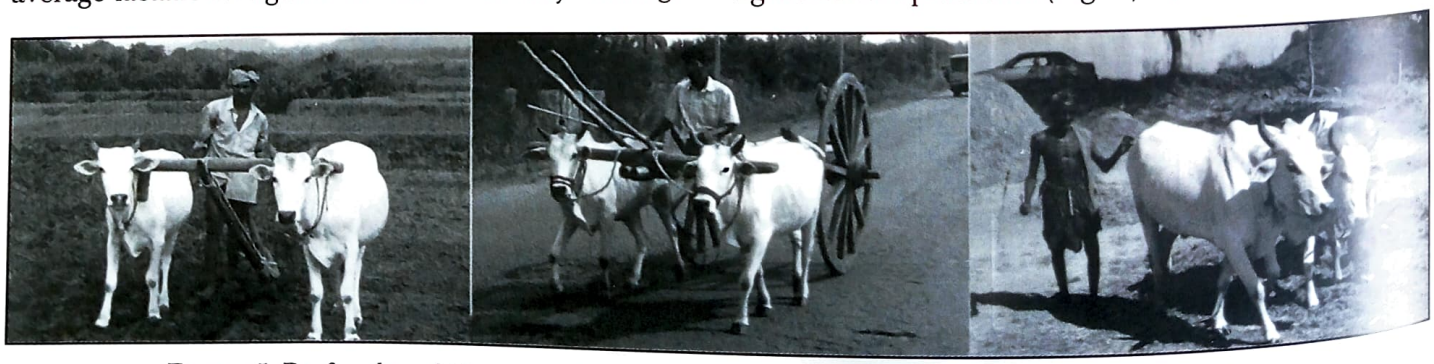

Figure 5. Draft utility of Ghumusari bullocks in various operations (ploughing, carting, thrashing)

and hardy despite the hot and humid climate of the breeding tract. A pair of Ghumusari bullocks working for 6 hours a day could plough 3031.9± 8.24 sq meter of field in clay soil and 4087.6± 11.24 sq meter of wet soil (Das and Sethi 2008). Similarly a pair of Ghumusari bullocks could pull a cartload of 1293.5±17.24 kg with a speed of 3 km/per hour on plain pucca road and 1031.2±14.74 kg with a speed of 2.5 km/hr on undulated kutcha road (Das and Sethi 2008).

Cytogenetic characteristics of Ghumusari cattle : All the animals investigated possessed a somatic chromosome count of 60, typical of cattle. The normal karyotype of Ghumusari cattle comprised of 29 pairs of autosomes and a pair of sex chromosomes. All the 29 pairs of autosomes were acrocentric. The X chromosome was a large metacentric while the Y chromosome was a small acrocentric which could not be morphologically distinguished from smaller pairs of autosomes. Representative metaphase spreads and karyotypes of a male and a female Ghumusari cattle (2n=60) are presented in Fig 6. The karyotype of Ghumusari cattle is a typical *Bos indicus* type characterized by an acrocentric Y chromosome in contrast to metacentric Y chromosome of *Bos taurus* cattle. The normal karyotype of Ghumusari cattle is similar to that of other cattle breeds of India (Gupta et al. 1974, Kumar et al. 1995, Tomar and Goswami 2000, Balaji et al. 2006, Kumarasamy et al 2008, Das et al. 2010, Sai Reddy et al. 2011).

Microsatellite derived within breed genetic diversity : All the 21 microsatellite markers were found to be polymorphic in the investigated Ghumusari cattle

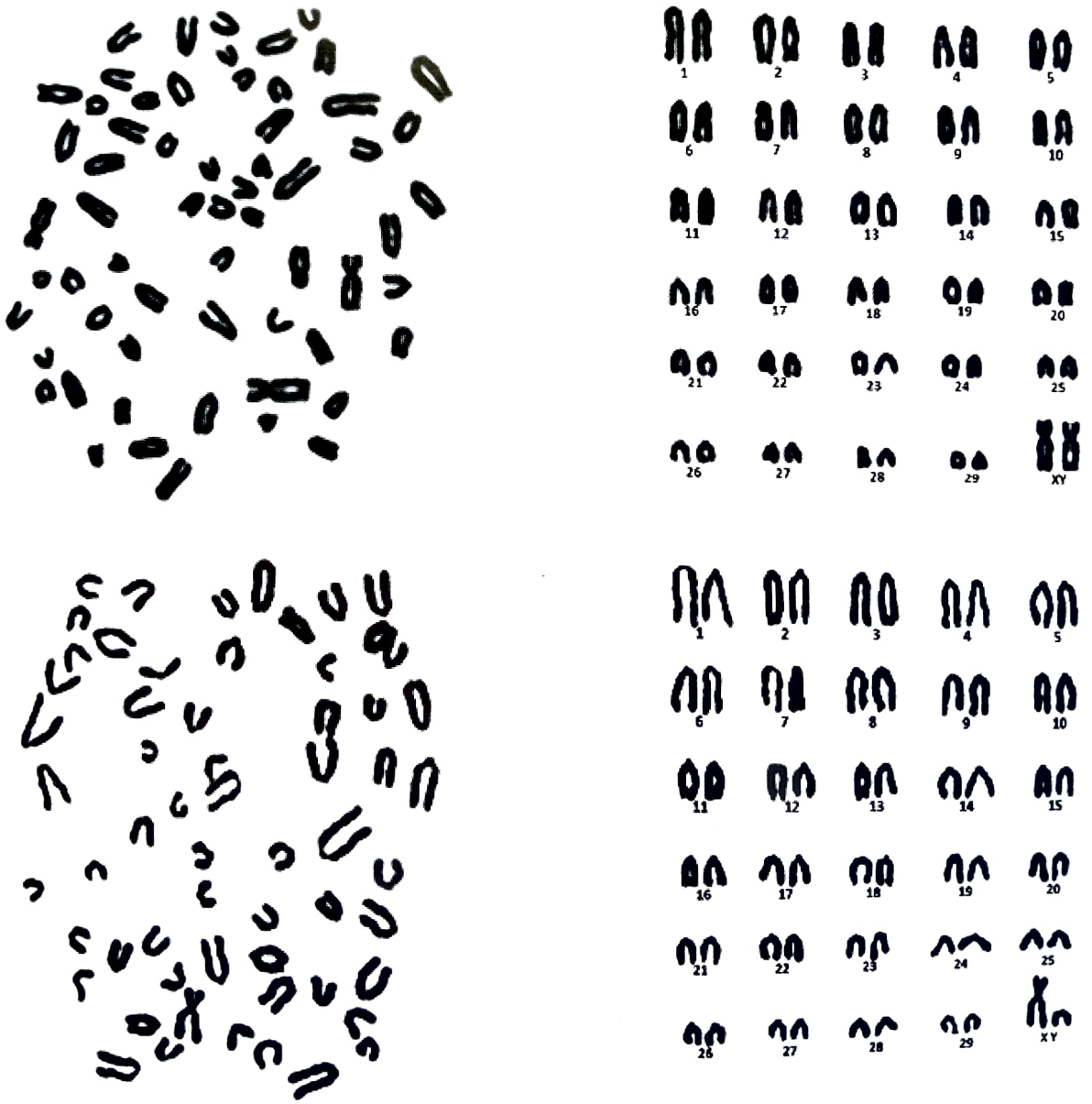

Figure 6. Metaphase spread and karyotype of a female (above) and male (below) Ghumusari cattle

population. Various overall measures of genetic variability like observed numbers of alleles (Na), effective number of alleles (Ne), polymorphism information content (PIC) and gene diversity are presented in Table 4. Allelic polymorphism varied between 3 (BM1824) to 26 (ILSTS 05). A total of 256 alleles were observed with a mean of 12.19±1.374 alleles/locus across the population. The effective number of alleles varied between 1.895(CSSM08) to 7.758 (CSSM33) with a mean population value of 5.548±0.672. The mean polymorphism information content was 0.618 with a range of 0.198 (ILSTS 019) and 0.821 (HEL 013).

The mean observed and expected heterozygosities were estimated to be 0.683±0.047 and 0.756±0.031 respectively. Observed heterozygosity values were lowest (0.167) at BM1824 locus and highest (0.938) at HEL09. Heterozygosities of similar magnitude have been reported in other Indian cattle breeds i.e. six breeds from western part of India Rathi, Tharparkar, Nagori, Mewati, Gir, and Kankrej (Sodhi et al. 2011); Kumauni Hill cattle of Uttarakhand (Ho, 0.64; He, 0.73; Pandey et al. 2011); Gaolao (Ho, 0.535; He, 0.689) (Chaudhari et al. 2009) and Hariana (Ho, 0.768; He, 0.777) and Mewati (Ho, 0.740; He, 0.724) (Prakash et al. 2010). Lower observed as well as expected heterozygosity values than the present study were observed in four breeds from Uttar Pradesh, Ponwar, Kherigarh, Kenkatha and Gangatiri (Ho= 0.48 to 0.58 and He=0.65 to 0.70, Sharma et al. 2009), Bachaur (Ho, 0.534; Sharma et al. (2007). The average heterozygosity deficit was significantly positive with a moderate value of 12.8% in Ghumusari cattle across the 21 loci evaluated.

The test for Hardy Weinberg equilibrium showed significant deviations at 12 out of 21 loci studied using X^2 test (Table 4). Considerable level of heterozygote deficiency was found to exist with a global deficit of

Table 4. Microsatellite marker based diversity estimates in Assamese buffaloes

Marker	Na	Ne	Ho	He	PIC	FIS	HWE (p-value)
CSRM60	21	7.732	0.792	0.871	0.862	0.101	0.000***
ETH10	7	3.044	0.646	0.671	0.619	0.049	0.000***
ILSTS11	7	2.540	0.458	0.606	0.556	0.254	0.000***
TGLA122	13	7.642	0.896	0.869	0.856	-0.020	0.203
INRA05	7	5.195	0.875	0.808	0.780	-0.073	0.041*
INRA63	9	2.727	0.646	0.633	0.594	-0.009	0.318
TGLA227	6	1.940	0.375	0.485	0.457	0.236	0.144
CSSM08	5	1.895	0.188	0.472	0.408	0.610	0.000***
HEL05	11	6.136	0.738	0.837	0.818	0.130	0.052
ILSTS05	26	5.908	0.792	0.831	0.818	0.058	1.000
ILSTS33	22	13.322	0.800	0.925	0.920	0.146	0.041*
INRA35	11	6.847	0.792	0.854	0.837	0.083	0.000***
BM1824	3	1.947	0.167	0.486	0.378	0.663	0.000***
CSSM66	10	5.020	0.717	0.801	0.776	0.115	0.266
ETH03	8	4.655	0.833	0.785	0.755	-0.051	0.000***
ETH225	15	5.064	0.750	0.803	0.781	0.076	0.774
MM12	23	11.973	0.574	0.916	0.911	0.382	0.000***
CSSM33	12	7.758	0.833	0.871	0.858	0.054	0.044*
HEL01	14	3.678	0.771	0.728	0.691	-0.048	1.000
HEL09	11	7.178	0.938	0.861	0.845	-0.079	0.521
ILSTS34	15	4.315	0.771	0.768	0.749	0.007	0.002**
Mean	12.19	5.548	0.683	0.756	0.727	0.107	
S.D	6.298	3.079	0.216	0.143	0.163		

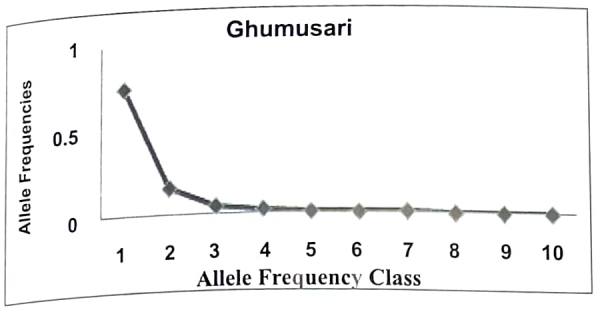

Figure 7. Normal L-shaped curve of allele frequencies depicting absence of bottleneck

11.8%. This has resulted in the significant deviations from Hardy-Weinberg equilibrium at many of the studied loci. Deviations from HWE measured by the inbreeding coefficient (f) can be ascribed to a variety of causes. Outbreeding or over-dominant selection may lead to heterozygote excess, whereas inbreeding results in heterozygote deficiency (Hartl and Clark 1997), which may result from one or more of the following reasons: presence of null alleles, small sample size and Wahlund effect i.e. presence of fewer heterozygotes in a population than predicted on account of population sub-division. The genetic analysis of 21 microsatellite loci in Ghumusari cattle, thus, revealed a high level of diversity as reflected by high mean number of observed alleles (12.19), mean polymorphism information content (0.727) and mean gene diversity (0.756). Eighteen of the 21 microsatellite loci analyzed had PIC values greater than 0.5 indicating their high degree of informativeness for population genetic studies (Botstein et al. 1980).

The Ghumusari cattle population was also evaluated to detect the occurrence of genetic bottleneck in the recent past using the qualitative graphical test. The test showed a normal L-shaped distribution of allele frequencies without any mode shift indicating the absence of any genetic bottleneck in Ghumusari cattle (Fig 7).

The study thus provides a description of the breeding tract, socio-economic status of farmers, phenotypic, production, reproduction characteristics, cytogenetic and microsatellite derived genetic characteristics of Ghumusari cattle- a newly recognized breed of Indian cattle. The breed is one of the most favoured among the four breeds of Odisha and contributes significantly to the economy of the state by providing farm draft power. Cytogenetic analysis reveals its *Bos indicus* nature typified by acrocentric Y chromosome. Genetic characterization reveals considerable genetic variability and no evidence of recent genetic bottleneck in the breed.

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REFERENCES

Balaji R, Ramesh Gupta B, Narsimha Rao G and Narsa Reddy GV. 2006. Cytogenetic characterization of Deoni cattle. *Indian Journal of Animal Research* 40:20-24.

Botstein D, White RL, Skolnick M and Davis RW. 1980. Construction of genetic linkage maps in man using restriction fragment length polymorphism. *American Journal of Human Genetics 32:314–331.*

Chaudhari MV, Parmar SNS, Joshi CG, Bhong CD, Fatima S, Thakur MS and Thakur SS. 2009. Molecular characterization of Kenkatha and Gaolao (Bos indicus) cattle breeds using microsatellite markers. *Animal Biodiversity and Conservation* 32.2: 71–76.

Das SK and Sethi BP. 2008. Cattle genetic resources of Orissa- Ghumusari. Orissa Livestock Resources development Society (OLRDS) and Orissa University of Agriculture and Technology, Bhubaneshwar pp 1-25.

Das SK, Sethi BP, Rao PK and Prakash B. 2010. Evaluation and cytogenetic profiling of Binjharpuri cattle of India in its native tract. *Journal of Livestock Biodiversity* 2:59-63.

Dhal BK. 2007. "Genetic performance of Khariar cattle in its native tract" M.V.Sc. Thesis, Orissa University of Agriculture and Technology, Bhubaneswar.

Goudet J. 2002. FSTAT computer package for PCs. Institute of ecology, UNIL, Lausanne, Switzerland.

Gupta P, Singh G and Ray Chaudhuri L. (1974). Chromosomes of Indian breeds of cattle. *The Nucleus* 17:129-132.

Hartl DL and Clark AG. 1997. In: Principles of Population Genetics. 3 ed. Sinauer Associates, Sunderland, Massachusetts. 542.

Kumar Pushpendra, Prakash B., Joshi BK and Tantia MS. 1995. Chromosome studies in Hariana cattle. *Indian Journal of Livestock Production and Management* 11:151-155.

Kumarasamy P, Sivaselvam SN, Rajendran R, Thangaraju P and Mahalinga Nainar A. 2008.

Chromosomal characterization of Umblachery breed of cattle (Bos indicus) – a famous South Indian breed of Tamilnadu, India. *Indian Journal of Science and Technology* 6:1-3.

Mason IL. 1996. A world dictionary of livestock breeds, types and varieties. CAB INTERNATIONAL.

National Bureau of Animal Genetic Resources. 2008a. Special feature: Breed descriptors of cattle. *Indian Journal of Animal Sciences* 78:667-673.

National Bureau of Animal Genetic Resources. 2008b. Special feature: Breed descriptors of cattle. *Indian Journal of Animal Sciences* 78:894-901.

National Bureau of Animal Genetic Resources. 2008c. Special feature: Breed descriptors of cattle. *Indian Journal of Animal Sciences* 78:1170-1175.

National Bureau of Animal Genetic Resources 2009. Special feature: Breed descriptors of cattle. *Indian Journal of Animal Sciences* 79:955-968.

National Bureau of Animal Genetic Resources 2010. Special feature: New breeds of cattle and buffalo. *Indian Journal of Animal Sciences* 80:1045-1055.

Pandey AK, Sharma R, Singh LV, Maitra A, Mishra BP and Kumar D. 2011. Estimation of genetic variability parameters in Kumaun hill cattle (Kumauni cattle) by STR markers. *Indian Journal of Animal Sciences* 81: 194–95.

Prakash B, Deepika and Salar Raj Kumar. 2010. Minor differentiation despite high genetic diversity among closely related Hariana and Mewati cattle breeds from Northern India. *Journal of Livestock Biodiversity* 2:7-14.

Sahoo SP. 1989. Characteristics and performance of Ghumusari cattle. M.V.Sc. Thesis, Orissa University of Agriculture and Technology, Bhubaneswar.

Sai Reddy S, Ramesh Gupta B, Vinoo R, Sudhakar K and Mahender M. 2011. Karyological studies on embryo transfer and artificial insemination born Ongoles. *Tamilnadu Journal of Veterinary and Animal Sciences* 7:39-44.

Sambrook J, Fritsch EF and Maniatis T. 1989. Molecular Cloning: A Laboratory Manual. Cold Spring Harbour Lab. Press. Cold Spring Harbour. N.Y.

Scherf BD. (ed). 1995. World Watch List for Domestic Animal Diversity. Food and Agriculture Organization of the United Nations, Rome.

Sharma R, Pandey AK, Singh SCP, Singh Y, Mishra BP, Singh SR, Mandal GK, Singh PK, Singh G and Ahlawat SPS. 2007. Diversity assessment of Bachaur cattle from India: A draft breed still relevant in mechanized Era. *Korean Journal of Genetics* 29: 369–78.

Sharma R, Pandey AK, Singh Y, Prakash B, Mishra BP, Kathiravan P, Singh PK and Singh G. 2009 Evaluation of genetic variation and phylogenetic relationship among north Indian cattle breeds. *Asian Australasian Journal of Animal Sciences* 22: 13-19.

Sodhi M, Mukesh M, Mishra BP, Ahlawat SPS, Prakash B and Sobti RC. 2011. Analysis of genetic population structure of zebu cattle (Bos indicus) breeds from North Western Region of India. *Animal Biotechnology* 22: 16-29.

Swain KT. 2003. 'Performance and conformation of Motu cattle found in Malkangiri District of Orissa' M.V.Sc. Thesis, Orissa University of Agriculture and Technology, Bhubaneswar.

Tomar SS and Goswami SL. 2000. Banding pattern induced by isoschizomeric restriction endonuclease Msp I and Hpa II on chromosomes of cattle. *Indian Journal of Animal Sciences* 71: 556-58.