



On-farm characterization of Vrindavani cattle in India

RANA RANJEET SINGH¹, TRIVENI DUTT², AMIT KUMAR³, A K S TOMAR⁴ and MUKESH SINGH⁵

Navsari Agricultural University, Navsari, Gujarat 396 450 India

Received: 13 October 2010; Accepted: 11 December 2010

ABSTRACT

Vrindavani cattle are recently developed synthetic crossbred cattle strain of India. It has the exotic inheritance of Holstein-Friesian, Brown Swiss, Jersey and indigenous inheritance of Haryana cattle. The present study was undertaken to characterize the Vrindavani cattle maintained at cattle and buffalo farm, Indian Veterinary Research Institute, Izatnagar, Bareilly, India. The physical, morphological characteristics and production performances of Vrindavani cattle were studied. The coat colour of Vrindavani was predominantly brown though some animals had black, white and beige coat colour. Head was clean cut well proportionate with prominent poll and concave forehead. The ears were medium sized, laterally orientated with round edge. Hip bone was broad and prominent with wide, smooth and level pin bone. Udder was generally trough type. These animals were docile to moderate in temperament. Morphometric measurements of males were higher than females. The mean birth weight of Vrindavani calves were 22.13 ± 0.12 kg. The mean lactation milk yield, 305 day milk yield and peak yield was 3219.75 ± 41.09 , 3047.42 ± 33.8 and 16.58 ± 0.16 kg, respectively. The average age at first successful service, age at first calving, service period and dry period was 746.28 ± 8.94 , 1012.14 ± 9.32 , and 149.54 ± 4.55 and 99.65 ± 5.75 days respectively.

Key words: Animal reproduction, Cattle, Phenotypic measurements, Vrindavani cattle

The crossbred cattle constitute 13.3% (24.6 million) of the total cattle population (185.1 million), whereas the population of indigenous cattle was 86.7% (160.4 million) (GoI 2006). In 2003–04, the production of milk in the country was 88.1 million tonnes with a compound annual growth rate (CAGR) of 3.37%. This volume of milk was contributed by in milk population of 35.80 million cows and 33.3 million buffaloes. Data of livestock censuses of 1997 and 2003 have revealed that India's crossbred cattle population increased by 22.82% and indigenous cattle population decreased by 10.23%, the overall increase in milk production clearly indicates the preference of farming community towards the crossbred cattle population (GOI 2006). Over the past 40 years, attempts have been made to synthesize new crossbred strains of cattle in India by crossing indigenous breeds with temperate exotic cattle. These attempts were intensified only after 1970 when the Indian Council of Agricultural Research (ICAR) focussed on it and established major projects on crossbreeding of indigenous cattle. Development of

Vrindavani cattle was one of the outcome of all these efforts towards the augmenting the country's milk production. Characterization is usually based on common physical characteristics such as colour, size, and shape and also on shared genetic and historical origins (Cunningham 2005). The phenotypic characteristics including adaptive characteristics are important in identifying breed attributes in ways that are relevant to the immediate farming community needs and utility. Morphological descriptions have been used to rank animal populations according to their levels of phylogenetic distinction, thus allowing distinction between breeds and strains (Gatesy and Arctander 2000). FAO has formulated breed descriptor list by which a breed is being characterized globally (FAO 1986). Since information on growth, production and reproduction performance of Vrindavani is limited and no information on physical characteristics of Vrindavani is available, present investigation was carried out to characterize the Vrindavani cattle and assess their economic traits.

MATERIALS AND METHODS

Location and temperature: The present study was carried out at cattle and buffalo farm of the Indian Veterinary Research Institute, Izatnagar, which is located at an altitude of 169.2 m above the mean sea-level, at latitude of $28^{\circ}22'$ north and at longitude of $79^{\circ}24'$ east. The place falls in upper

Present address:¹Assistant Professor (e mail: drexPLICIT@gmail.com), Department of Livestock Production and Management, College of Veterinary Science and Animal Husbandry.

²Joint Director, Extension Education; ³Scientist, Animal Genetics Division, LAR Section; ^{4,5}Senior Scientists, Livestock Production and Management Division, Indian Veterinary Research Institute, Izatnagar 243 122 India.

Gangetic plain region of India (Sastry 1995). The mean annual temperature is about 21°C. The mean monthly temperature ranges between around 13°C in January and 30°C in May, whereas the extreme temperature ranges between about 5°C and 40°C.

Origin and distribution of Vrindavani: During the year 1968 an ad hoc scheme was started at the Indian Veterinary Research Institute, Izatnagar, Bareilly, India for crossbreeding of indigenous Haryana cattle with Holstein-Friesian, Brown Swiss and Jersey. This scheme was later on converted into All India Co-ordinated Research Project (AICRP) with the objective to evolve a dairy cattle breed which could produce average 3 000 kg or more milk per lactation during its lifetime. A total of 400 Haryana cows were available as foundation stock out of which 200, 100 and 100 cows were inseminated with semen of Holstein-Friesian, Jersey and Brown Swiss bull to produce half-breds. Out of the 200 Holstein-Friesian half-breds produced, 100 were inseminated with Jersey and another 100 with Brown Swiss semen. The halfbreds of Jersey and Brown Swiss were inseminated with Holstein-Friesian semen to produce 3-breed crosses. These halfbreds and 3-breed crosses were mated *inter-se* and tested for their production, reproduction traits, heat tolerance, and growth and disease resistance parameters and repeated up to 7 generations. Performance evaluation of half breds and 3 breeds crosses revealed that performance of FH (1/2 Holstein-Friesian + 1/2 Haryana), FBH (1/2 Holstein-Friesian + 1/4 Brown Swiss + 1/4 Haryana) and FJH (1/2 Holstein-Friesian + 1/4 Jersey + 1/4 Haryana) *inter-se* crosses were superior to other genetic combinations (Pandey *et al.* 1988, Dutt *et al.* 1998, Dutt and Kumar 1999, Dutt and Kumar 2000). The performance of FH, FBH and FJH *inter-se* crosses revealed that these crosses had almost similar performance (Dutt and Kumar 1999). Therefore, inter-breeding among these groups irrespective of genotype and rigorous selection of male and female animal was practiced in order to multiply and improve the synthetic crossbred cattle strain. The bulls

were selected on the basis of their dam performances and were culled on the basis of their daughter performances. Finally, the synthetic population of crossbred cattle strain having exotic inheritance between 50 and 75% and Haryana inheritance between 50 and 25% has been named 'Vrindavani' (Pandey *et al.* 2006).

Feeding and management: Vrindavani animals are maintained at this farm under loose housing and group management system. Nutritional requirements of animals are met through a balanced combination of dry and green fodder with concentrate mixture supplementation. Milk recording starts from first day of calving till date of drying, and calves were weaned on the day of their birth. Teaser bulls were used for detection of cows in heat twice daily (in early morning and evening). Vaccination, deworming and spraying of these animals were done regularly as per schedule. This breed is well adapted to the local agro-climatic conditions and is very popular among dairy farmers of Uttar Pradesh, Uttarakhand, Rajasthan and adjoining areas (DARE/ICAR Annual Report 2007-08). The actual population of this breed under field condition is not known. However, cattle and buffalo farm of the IVRI, Izatnagar, is supplying the semen and live animals of Vrindavani cattle through auction/sale for its propagation and multiplication in the adjoining areas over the years.

The available information of Vrindavani cattle on habitat, managemental practices, morphological characters, performance and behavioral traits were recorded as per FAO (1986) cattle breed descriptor with some alteration /addition whatever felt pertinent. This investigation was carried out during the period May 2007- December 2008 at Cattle and Buffalo farm, IVRI, Izatnagar, India. Coat colour, pattern of coat colour and colour of muzzle, tail switch, forehead and hoof were observed for 658 animals of different age groups using South African Development Co-operation (SADC 2001) farm animal genetic resources survey colour chart, 2001 (ILRI, Nairobi, Kenya). Different body measurements

Table 1. Least squares mean (\pm SE) for morphometric measurements of Vrindavani cattle

Morphometric traits	Age groups				
	0-3 months	More than 3 months to 1 year	More than 1 year to 3 years	More than 3 years of age (female)	More than 3 years of age (bull)
Height at wither (cm)	71.62 \pm 0.87(71)	86.25 \pm 0.62(140)	107.53 \pm 0.53(196)	121.62 \pm 0.47(240)	127.45 \pm 2.22(11)
Body length (cm)	73.70 \pm 1.46(71))	92.64 \pm 1.04(140)	128.05 \pm 0.88(196)	155.88 \pm 0.79(240)	171.45 \pm 3.71(11)
Heart girth (cm)	78.85 \pm 1.65(71)	104.85 \pm 1.18(140)	142.65 \pm 0.99(196)	171.73 \pm 0.90(240)	195.18 \pm 4.20(11)
Ear length (cm)	14.24 \pm 0.22(71)	17.24 \pm 0.15(140)	21.02 \pm 0.13(196)	23.05 \pm 0.12(240)	23.44 \pm 0.55(11)
Face length (cm)	23.16 \pm 0.42(71)	30.11 \pm 0.30(140)	39.75 \pm 0.25(196)	46.42 \pm 0.23(240)	49.11 \pm 1.07(11)
Face width (cm)	11.25 \pm 0.18(71)	14.09 \pm 0.13(140)	17.10 \pm 0.11(196)	19.05 \pm 0.10(240)	22.50 \pm 0.46(11)
Neck length (cm)	27.09 \pm 0.73(71))	34.69 \pm 0.52(140)	46.83 \pm 0.44(196)	58.83 \pm 0.40(240)	53.11 \pm 1.86(11)
Height at hip bone (cm)	76.06 \pm 0.86(71)	90.61 \pm 0.61(140)	110.51 \pm 0.52(196)	123.13 \pm 0.47(240)	122.68 \pm 2.18(11)
Height at pin bone (cm)	70.09 \pm 0.77(71)	84.61 \pm 0.55(140)	102.55 \pm 0.46(196)	112.86 \pm 0.42(240)	113.14 \pm 1.96(11)
Rump length (cm)	23.7 \pm 0.49(71)	29.62 \pm 0.35(140)	40.03 \pm 0.30(196)	48.56 \pm 0.27(240)	58.44 \pm 1.25(11)

Figures in parentheses are the numbers of animals used to derive mean.

were taken on these animals and were classified into different age groups (Table 1). However, only 261 animals were available for studying udder and teat traits. Under physical traits characteristics of different body parts (forehead, muzzle, dewlap, eyes, ears, neck, legs, ribs, pin bone, hip bone and tail) and behavioural parameters (temperament, incidence of breeding and calving in different months of the year) were studied for 326 animals (animals above 2.5 years of age). The evaluation of growth, production and reproduction traits was done for live animals and passed animals by collecting the data from history cum pedigree sheets for a period of 2000 to 2008. Special morphological and behavioural traits were weighted with a separate score and their frequencies in the population were recorded and studied. Statistical analysis of body measurement, growth, production and reproduction records were carried out by using least square model LSML package (Harvey 1990).

RESULT AND DISCUSSION

Physical characteristics: The coat colours of in Vrindavani cattle are predominantly brown although in some animals it is black, white and beige. These colours are present in mainly uniform followed by pied, shaded and spotty pattern. The muzzle is mostly grey. The forehead is mainly white though

in some animals it is also brown, black and beige. Tail switch is black in half of the population and white in remaining half of the population. Figs 1–4 show distinct features of Vrindavani cattle. In majority of animals head is clean cut well proportionate with prominent poll and concave forehead. Muzzle is medium size and dewlap small in females and medium size in males. The body is medium and compact. Eyes are of medium size and with bright expression. The ears are of medium size and laterally orientated with round edge. Long lean and clean cut type of neck is predominantly present in the population. The legs are of medium size and firmly and squarely placed under body. The ribs are flat and well sprung. Hairs on body are glossy and straight type and the length of hair is small to medium. Four types of udder (trough, bowl, round and pendulous) are present in Vrindavani. Among them, trough type of udder is most predominant (40.43%) in the population followed by bowl (27.05%), round (22.94%) and pendulous (9.58%) type of udder. Front udder, rear udder and teats are of medium size. The cylindrical shaped teat is most frequent (56.37%), however funnel (36.42%) and pear (7.21%) shaped teats were also found. The Vrindavani animals are docile to moderate in temperament. Although Vrindavani cattle are not seasonal breeder, the maximum incidence of breeding is found in the



Figs 1–4. 1. Vrindavani bull, 2. Vrindavani cow, 3. Vrindavani calves, 4. Vrindavani cows

month of November and minimum in the month of June whereas incidence of calving is maximum in the month of August and minimum in May.

Morphometric characteristics: Morphometric measurements (height at wither, body length, heart girth, ear length, face length, face width, neck length, height at hip bone, height at pin bone and rump length) were taken on 658 Vrindavani animals of different age groups and are given in Table 1. Among all these measurements heart, girth was highest followed by body length, height at hip bone and height at wither in different categories of animals. The mean udder length, width, depth, circumference, teat length and teat diameter were 52.06 ± 0.64 , 59.25 ± 0.76 , 21.27 ± 0.38 , 93.47 ± 0.95 , 5.33 ± 0.11 and 2.22 ± 0.04 cm respectively. The udder and teat measurements of multiparous cows were higher than primiparous cows (Table 2).

Body weight at different stages: Male calves (22.39 ± 0.17 kg) were heavier than female calves (21.86 ± 0.14 kg) at birth and detail of weight traits are given in Table 3. For male animal body weight at 3 (WT3), 6 (WT6), 12 (WT12), 18 (WT8) and 24 (WT24) months of age were 47.51 ± 0.49 ,

83.40 ± 1.15 , 155.76 ± 2.54 , 247.98 ± 5.50 , 291.94 ± 10.42 kg, respectively, whereas for females these weights were 45.78 ± 0.34 , 80.93 ± 0.60 , 142.48 ± 1.08 , 211.70 ± 1.59 and 268.49 ± 2.26 kg respectively (Table 3). The weight at first service, first successful service and first calving were 271.80 ± 2.84 , 283.19 ± 3.22 and 326.84 ± 5.08 kg respectively.

Milk production traits: The average lactation milk yield was $3\ 219.75 \pm 41.09$ kg with an average lactation length of 337.73 ± 2.29 days. The average 305 days milk yield and peak yield for Vrindavani cows were $3\ 047.42 \pm 33.83$ and 16.58 ± 0.16 kg respectively. We observed that total lactation milk yield and 305 days milk yield were lowest in first lactation cows and had increasing trend up to fourth lactation and thereafter it showed a declining trend in subsequent lactations (Table 4). Longest lactation length (344.34 ± 3.03 days) was observed in the first lactation, whereas shortest lactation length (328.52 ± 6.58 days) in the fifth lactation. The Vrindavani animals had an average peak yield of 16.58 ± 0.16 kg and it was lowest (14.03 ± 0.21 kg) in the first lactation and was highest (18.07 ± 0.36 kg) in the fourth lactation. These animals attained the peak yield in an average 52.79 ± 1.95

Table 2. Least squares mean (\pm SE) for udder and teat measurements of Vrindavani cattle

	Udder length (cm)	Udder width (cm)	Udder depth (cm)	Udder circumference (cm)	Teat length (cm)	Teat diameter (cm)
Overall	$52.06 \pm 0.64(261)$	$59.25 \pm 0.76(261)$	$21.27 \pm 0.38(261)$	$93.47 \pm 0.95(261)$	$5.33 \pm 0.11(261)$	$2.22 \pm 0.04(260)$
Age group						
Primiparous cow	$56.39^a \pm 1.15(53)$	$53.80^a \pm 1.36(53)$	$18.68^a \pm 0.69(53)$	$87.79^a \pm 1.69(53)$	$4.91^a \pm 0.19(53)$	$2.00^a \pm 0.07(52)$
Multiparous cow	$47.73^b \pm 0.58(208)$	$64.71^b \pm 0.69(208)$	$23.86^b \pm 0.35(208)$	$99.16^b \pm 0.85(208)$	$5.75^b \pm 0.10(208)$	$2.43^b \pm 0.03(208)$

Figures in parentheses are the numbers of animals used to derive mean; LSM showing different superscripts in lower case in a column differ significantly at $P \leq 0.05$.

Table 3. Least squares mean (\pm SE) for body weights of Vrindavani cattle at different ages

	BWT (kg)	WT3 (kg)	WT6 (kg)	WT12 (kg)	WT18 (kg)	WT24 (kg)
Overall	$22.13 \pm 0.12(1344)$	$46.64 \pm 0.31(1039)$	$82.16 \pm 0.68(854)$	$149.12 \pm 1.43(717)$	$229.84 \pm 2.92(537)$	$280.22 \pm 5.37(493)$
Sex						
Male	$22.39^a \pm 0.17(539)$	$47.51^a \pm 0.49(343)$	$83.40^a \pm 1.15(180)$	$155.76^a \pm 2.54(98)$	$247.98^a \pm 5.5(33)$	$291.94^a \pm 10.42(15)$
Female	$21.86^b \pm 0.14(805)$	$45.78^b \pm 0.34(696)$	$80.93^b \pm 0.60(674)$	$142.48^b \pm 1.08(619)$	$211.70^b \pm 1.59(504)$	$268.49^b \pm 2.26(478)$

Figures in parentheses are the numbers of animals used to derive mean; LSM showing different superscripts in lower case in a column differ significantly at $P \leq 0.05$.

Table 4. Least squares mean (\pm SE) for production performance of Vrindavani cattle

	Lactation milk (kg)	305 days milk yield (kg)	Lactation length (days)	Peak yield (kg)	Days to attain peak yield
Overall	$3\ 219.75 \pm 41.09(913)$	$3\ 047.42 \pm 33.83(938)$	$337.73 \pm 2.29(923)$	$16.58 \pm 0.16(1005)$	$52.79 \pm 1.95(1005)$
Lactation order					
1	$2\ 966.35^c \pm 55.01(305)$	$2\ 744.37^c \pm 45.73(304)$	$344.34^a \pm 3.03(310)$	$14.03^c \pm 0.21(329)$	$64.06 \pm 2.58(326)$
2	$3\ 221.10^{bc} \pm 63.65(223)$	$3\ 028.49^b \pm 51.73(236)$	$343.79^a \pm 3.53(226)$	$16.44^b \pm 0.24(250)$	$51.38 \pm 2.93(255)$
3	$3\ 351.13^{ab} \pm 77.59(153)$	$3\ 168.93^{ab} \pm 63.91(156)$	$335.86^{ab} \pm 4.31(154)$	$17.34^{ab} \pm 0.29(166)$	$54.11 \pm 3.63(166)$
4	$3\ 487.36^a \pm 94.85(100)$	$3\ 300.88^a \pm 76.99(105)$	$344.05^a \pm 5.23(102)$	$18.07^a \pm 0.36(112)$	$54.35 \pm 4.34(113)$
5	$3\ 156.45^{bc} \pm 119.69(63)$	$3\ 070.69^{ab} \pm 97.32(66)$	$328.52^b \pm 6.58(65)$	$16.88^b \pm 0.44(75)$	$42.42 \pm 5.36(75)$
6	$3\ 136.09^{bc} \pm 114.81(69)$	$2\ 971.15^b \pm 94.09(71)$	$329.82^b \pm 6.52(66)$	$16.74^b \pm 0.44(73)$	$50.37 \pm 5.49(71)$

Figures in parentheses are the numbers of animals used to derive mean; LSM showing different superscripts in lower case in a column differ significantly at $P \leq 0.05$.

Table 5. Least squares mean (\pm SE) for reproduction performance of Vrindavani cattle

	Dry period (days)	Gestation length (days)	Post partum interval to oestrus (days)	Service period (days)	Calving interval (days)
Overall	99.65 \pm 5.75(618)	277.61 \pm 0.40(1061)	89.52 \pm 2.16(908)	149.54 \pm 4.55(907)	425.95 \pm 4.87(793)
Lactation order					
1	119.19 ^a \pm 7.06(216)	276.17 ^a \pm 0.52(293)	100.19 ^a \pm 2.61(317)	173.35 ^a \pm 5.61(310)	447.86 ^a \pm 6.12(252)
2	99.37 ^{ab} \pm 8.32(151)	277.54 ^a \pm 0.56(278)	85.65 ^b \pm 3.08(228)	158.01 ^{ab} \pm 6.51(233)	433.82 ^a \pm 6.88(206)
3	110.93 ^{ab} \pm 10.05(106)	276.90 ^a \pm 0.69(183)	84.83 ^b \pm 3.80(151)	153.54 ^{ab} \pm 8.23(147)	426.09 ^{ab} \pm 8.73(129)
4	99.00 ^{ab} \pm 12.27(69)	278.22 ^a \pm 0.79(132)	89.06 ^{ab} \pm 4.68(96)	145.26 ^{ab} \pm 9.98(96)	425.30 ^{ab} \pm 10.18(92)
5	85.76 ^b \pm 16.76(37)	278.56 ^a \pm 0.99(84)	87.54 ^b \pm 5.87(61)	129.18 ^b \pm 12.25(64)	410.10 ^b \pm 12.58(60)
6	83.65 ^b \pm 16.14(39)	278.29 ^a \pm 0.96(91)	89.89 ^{ab} \pm 6.18(55)	137.87 ^b \pm 12.95(57)	412.51 ^b \pm 13.20(54)

Figures in parentheses are the numbers of animals used to derive mean; LSM showing different superscripts in lower case in a column differ significantly at $P \leq 0.05$.

days and it was highest (64.06 \pm 2.58 days) in the first lactation (Table 4).

Reproduction traits: The average age at first service, first successful service and first calving for Vrindavani cattle was 696.86 \pm 7.37, 746.28 \pm 8.94 and 1012.14 \pm 9.32 days respectively. The Vrindavani cows had an average dry period of 99.65 \pm 5.75 days. The first dry period was longest (119.19 \pm 7.06 days) and thereafter it showed almost a declining trend up to the sixth lactation (Table 5). The average gestation length for Vrindavani cattle was 277.61 \pm 0.40 days. Average post-partum interval to oestrus in Vrindavani cows were 89.52 \pm 2.16 days. The average service period for Vrindavani cows was 149.54 \pm 4.55 days. The cows in the first lactation had the highest service period (173.35 \pm 5.61 days) and it gradually decreased up to fifth lactation where the shortest service period (129.18 \pm 12.25 days) was observed. The Vrindavani cows had an average calving interval of 425.95 \pm 4.87 days (Table 5). The first calving interval was longest (447.86 \pm 6.12 days) and fifth calving interval was shortest (410.10 \pm 12.58 days).

In conclusion, it seems that production performance of Vrindavani cattle is better than many crossbred cattle strains developed in the country. In the current economic scenario, only economically viable and locally sustainable dairy cattle can be recommended for poor farmers of western Uttar Pradesh, India where the Vrindavani cattle may excel best.

ACKNOWLEDGEMENTS

The authors wish to express sincere thanks to Director, Joint Director and In-charge, Livestock Production and Management Section for providing necessary facilities to carry out this study. Also, we are grateful to Dr H N Pandey for providing many valuable suggestions for improving the manuscript.

REFERENCES

Cunningham S F. 2005. 'Evaluation of f1 cows sired by brahman, boran, and tuli for reproductive and maternal performance and cow longevity.' M Sc Thesis submitted to the Office of Graduate Studies of Texas AandM University.

- DARE/ICAR. 2007–08. *Annual Report*. 2007–08. Livestock improvement, Chapter 6, pp 38. ICAR, New Delhi.
- Dutt T, Bhushan B, Srivastava B B and Bhat P N. 1998. Genetic evaluation of F1, F2 and F3 crosses of Haryana with Frisean, Brown Swiss and Jersey. *Asian- Australian Journal of Animal Sciences* **11**: 470–74.
- Dutt T and Kumar S. 1999. Genetic divergence among Haryana crosses with exotic dairy breeds. *Indian Journal of Animal Sciences* **69**: 811–13.
- Dutt T and Kumar S. 2000. Performance evaluation of FH, FBH, and FJH inter-se-crosses. *Indian Journal of Animal Sciences* **70**: 80–81.
- FAO. 1986. Animal Genetic Resources data Banks.2.Descriptor list for cattle, buffalo, pigs, sheep and goats. *FAO Animal Production Health Paper* **59**(2):150.
- Gatesy J and Arctander P. 2000. Hidden morphological support for the phylogenetic placement of *Pseudoryxnetinhensis* with bovine bovids: a combined analysis of gross anatomical evidences and DNA sequences from five genes. *Systematic Biology* **3**: 515–38.
- Government of India. 2006. A technical note on basic animal husbandry statistics. *Basic animal husbandry statistics*. 10: 2. Department of Animal Husbandry and Fisheries, Ministry of Agriculture, Government of India.
- Harvey W R. 1990. *User guide for LSMLMW and MIXMDL package*. Mix Model Least Squares and Maximum Likelihood Computer Programme. PC-2 Version Mimeograph, Columbia, Ohio, USA.
- Pandey H S, Pandey H N, Jana D N and Nautiyal L P. 1988. First lactation production performance of three breed inter-se-crosses. *Indian Veterinary Journal* **65**: 801–07.
- Pandey H N, Tomer A K S, Mahmood S, Joshi H C, Dutt Triveni, Singh Mukesh, Gosh S K, Bisht G S, Kumar Pushpedra, Patra R C, Mondal D B and Mukherjee R. 2006. *Vrindavani-An Outstanding Germplasm of synthetic Crossbred Cattle strain. National Seminar on artificial Insemination: acceptability, Impact, constraints and solutions organized by LPM section at IVRI, Izatnagar, Bareilly, India.*
- SADC (South African development Co-operation)/ILRI (International livestock research Institute). 2001. *Animal genetic resources survey Colour Chart*. ILRI, Nairobi, Kenya.
- Sastry N S R. 1995. Livestock sector of India- regional aspects. *Dairying*. pp 229. Krishi Bhawan, New Delhi, International Book Distributing Company, Lucknow.