Indian Journal of Animal Sciences **89**(12): 1291–1302, December 2019/Review Article
https://doi.org/10.56093/ijans.v89i12.96616

Status, constraints and future prospects of Murrah buffaloes in India

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Received: 18 February 2019; Accepted: 4 April 2019

ABSTRACT

In the present review, an attempt has been made to explore Murrah buffalo, an important milch breed for its performance, genetic parameters, constraints and future scenario. In India, price of milk is decided on basis of fat percentage and buffalo milk fetches more money compared to cow milk to dairy farmers. Production and reproduction performances are among most important considerations to determine the profitability of any dairy farm. The production, reproduction and functional traits of Murrah buffaloes as reported by different workers at different organized farm were reviewed. Literature revealed that the 305-days lactation milk yield, 305-days lactation fat yield, 305-days lactation SNF yield, 305-days lactation total solid yield, peak yield, Fat %, SNF %, lactation length, dry period, age at first calving, service period, conception rate, pregnancy rate and calving interval varied from 1365±03 to 2086.17±44.66 kg, 118.3 to 167.38±4.46 kg,185.5±3.4 to 198.88±5.05 kg, 336.2±6.1 to 360.61±9.25 kg, 9.96 to 11.13±0.44 kg, 6.84% to 8.17%, 9.36% to 9.76%, 267.15 to 321.62 days,121.68 to 250.5 days, 1202 to 1618.83 days, 135.79 to 308 days, 68.80%, and 428.30 to 559.6 days, respectively in Murrah buffaloes. Heritability and repeatability estimates for the production, 38% reproduction and functional traits of Murrah buffaloes were also reviewed. Breeding, feeding, health and housing management practices have much impact on production and reproduction performance of animals and ultimately influence the economy of dairy farmers. Constraints in all these aspects are the obstacles to implement better animal husbandry practices in dairy animals and these should be overcome by taking suitable measures.

Key words: Constraints, Functional traits, Murrah, Production traits, Reproduction traits

Livestock sector plays an important role in Indian economy and is an essential part of Indian agriculture. India is endowed with vast genetic resource of bovines with an estimated number of 302.79 million (Livestock Census, 2019). In India, livestock is more evenly distributed among landless labourers and marginal farmers however, a limited percentage of livestock is owned by private and organized sector. Animals are the best insurance against the quirks of nature due to drought, famine and other natural calamities. Dairy sector plays imperative role for upliftment of rural income in India by providing nutritious milk to humans, dung as organic fertilizer for agriculture and fuel for rural homes along with draft power for cultivation and transportation (Patbandha *et al.* 2015).

India is regarded as a home of world's best buffalo germplasm. Buffaloes, with a population of 109.85 million contributes around 20.45% to the total livestock population in India (Livestock Census, 2019) and account for about 49.2% of total milk production in the country (DAHD, 2017–18). Milk production of India during 2015–16 was 155.5 million tonnes and in 2016–17 it reached 165.4 million tonnes showing an annual growth rate of 6.37%. Per capita availability of milk was about 355 grams per day in 2016–17 (DAHD, 2017–18). Much higher production average in Indigenous buffalo (5.92 kg/day/animal) than that of indigenous cattle (3.54 kg/day/animal) with its unique feed conversion efficiency and adaptation expresses its importance as dairy animal in the country (DAHD, 2017–18). Additionally, buffaloes contribute significantly towards meat production, draft power, manure production and fuel. The buffalo genetic resources of the country are represented by 16 recognized breeds of buffalo namely Murrah, Nili Ravi, Jaffarabadi, Bhadawari, Mehsana, Banni, Surti, Marathwadi, Pandharpuri, Nagpuri, Toda, Chilika, Kalahandi, Luit (Swamp), Bargur and Chhattisgarhi (NBAGR, 2019). Out of total buffalo population in India, 56.63% are in descript category and remaining 43.37% are non-descript. Murrah is one of the superior breeds of Indian buffaloes and it has a share of 44.39% in total buffalo population of the country (DAHD, 2013). Out of these buffalo breeds in India, Murrah breed is essentially the unique for dairy type. Besides India, Murrah breed has spread in Asia and Europe as well. Several countries including China, Brazil, Egypt, Bulgaria, Bangladesh etc.

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have used Murrah as an improved breed for upgrading their native buffaloes. Home tract of Murrah buffaloes is Haryana but graded Murrah buffaloes are found throughout the country due to their higher milk production potential coupled with adaptation to wide environmental conditions and feed conversion efficiency. Hence, it has been appropriately named as the black gold or Holstein-Friesian of the buffalo world.

Buffalo milk plays an important role in providing nutritive food to families both in rural and urban areas. Composition of milk is economically important to milk producers, important to dairy industries for producing better quality products and nutritionally important to milk consumers for their health. Now a days along with fat percentage, other milk components such as solid not fat (SNF), total solids (TS), protein, lactose and ash are also measured (Malek dos Reis *et al.* 2013). Milk fat represents chief constituent of buffalo milk followed by lactose and protein. Buffalo milk is mainly composed of water, fat, proteins, lactose, vitamins and minerals. Composition of Murrah buffaloes' milk as reported in different herds has been given in Table 1. Selection of Murrah buffaloes can also be done on the basis of genes such as FASN (Vohra *et al.* 2015, Kumar *et al.* 2016a), DGAT1 (Grisart *et al.* 2002), STAT1 (Kumar *et al.* 2015) and BTN1A1 (Kumar *et al.* 2017a) which are involved in milk fat production. Buffalo milk is richer than cow milk in almost all the main milk nutrients. Buffalos' milk is valued for its quality being twice as rich in fat and other milk constituents as compared to cow milk. Moreover, in India, milk marketing system is based on fat percentage hence; buffalo milk fetches more money compared to same volume of cow milk to its producer. Milk fat plays a significant role in the nutritive value as well as flavour and physical properties of milk and milk products. The richness of fat in buffalo milk makes it highly suitable for milk processing and to be used in dairy sector therefore, buffalo milk is more suitable for milk products such as butter, ghee, milk powder and several other products such as mozzarella cheese, khoa, curd, yogurt, dried ice cream mix and dairy whiteners etc.

Production and reproduction performances are unarguably the most important considerations to determine the profitability of a buffalo dairy farm. Productive and reproductive performances of dairy animals should be determined on the basis of different parameters like production traits which include 305-days lactation milk yield, 305-days lactation fat yield, 305-days lactation SNF yield, 305-days lactation total solid yield, peak yield, lactation fat average, lactation SNF average, lactation total solid average, fat%, SNF%, lactation length and dry period in addition to monthly test day traits and reproduction traits, viz. age at first calving, service period, conception rate, pregnancy rate and calving interval of the dairy animals. These parameters should be optimised to increase milk productivity of dairy animals. Dahiya *et al.* (1988) optimized important economic traits in relation to milk yield in Murrah buffaloes and Singh *et al.* (1990) reported the inheritance of economic traits in Murrah buffaloes. In India, large numbers of buffaloes are reared by small and marginal farmers. It is not possible practically for these farmers to record daily milk of animals as it is time consuming as well as expensive. Therefore, recording of data at intervals instead of daily recording is a good alternative. Test day milk yields can be used for prediction of 305 days milk yield. Thus, it can help in earlier selection decisions by selecting younger animals based on predicted milk yields. Test day data can also be used for evaluating sires used in field conditions by incorporating the field data in breeding programmes. Health of animals is also an important factor along with good production and reproduction. Functional traits are characters of an animal, which increases efficiency not by higher output of product but by reduced cost of input (Groen, 1996). Major causes of losses in dairy farming include mastitis, metritis, abnormal calving, abortion, premature birth, still birth and dystocia. Dahiya *et al.* (1994) reported genetic variability in some performance traits of Murrah buffaloes.

Current status of Murrah buffaloes in India

Population of pure as well as graded Murrah buffaloes in different states of India is shown in Table 2. Out of total 48.25 million Murrah buffaloes, 11.69 million (24.22%) are pure whereas, 36.57 million (75.78%) are graded Murrah buffaloes

Physical characteristics of Murrah buffaloes

Body structure of Murrah buffalo has deep massive frame with short broad back and a comparatively long neck and head. It has tightly curled short characteristic horns and a well-developed udder. Hips of Murrah buffalo are broad and has drooping fore and hind quarters. Tail is long reaching up to the fetlocks. Popular colour is jet black with white markings on tail. Body parameter measurements of male and female Murrah buffaloes are presented in Table 3.

Table 1. Milk composition of Murrah buffaloes in different herds

Fat%	SNF%	TS%	Protein%	Lactose%	Reference
6.99±0.10	10.01±0.06	16.99±0.12	3.78±0.03	5.37±0.04	Sarkar *et al.* 2006
8.0±0.6	8.3±0.3	16.3±0.8	2.70±0.08	–	Meena *et al.* 2007
7.7±0.1	9.4±0.1	17.0±0.1	3.81±0.02	4.83±0.01	Sodi *et al.* 2008
7.53±0.19	9.00±0.07	16.53±0.20	4.03±0.05	–	Misra *et al.* 2008
6.65±0.08	–	17.23±0.7	4.65±0.05	5.11±0.16	Yadav *et al.* 2013
7.33±0.57	9.47±0.07	16.80±0.50	4.14±0.08	–	Balusami *et al.* 2015

Table 2. Population of pure as well as graded Murrah buffaloes in different states of India (2012–13)

State/ Union Territory	Pure Murrah buffaloes			Graded Murrah buffaloes			Total Pure + Graded Murrah buffaloes
	Male	Female	Pure Male and Female	Male	Female	Graded Male and Female	
Andaman and Nicobar Islands	0	0	0	11	30	41	#41
AP	29638	234526	264164	603482	4359624	4963106	5227270
Assam	348	545	893	345	509	854	1747
Bihar	53353	378057	431410	199015	1789527	1988542	2419952
Chandigarh	189	2894	3083	500	4939	5439	8522
Chhattisgarh	18990	17759	36749	80486	110036	190522	227271
Goa	3	48	51	254	977	1231	1282
Haryana	386886	2017476	2404362	386565	2220218	2606783	5011145
Himachal Pradesh	750	9402	10152	23902	261294	285196	295348
Jammu and Kashmir	1070	4904	5974	17649	140451	158100	164074
Jharkhand	69848	85906	155754	38834	49322	88156	243910
Karnataka	7781	49736	57517	24985	243393	268378	325895
Kerala	21510	8035	29545	25874	15791	41665	71210
Madhya Pradesh	43107	284919	328026	149487	968565	1118052	1446078
Maharashtra	31554	370433	401987	44668	540326	584994	986981
NCR of Delhi	1490	23375	24865	14848	99613	114461	139326
Odisha	1541	1813	3354	2953	7140	10093	13447
Puducherry	0	0	0	12	111	123	123
Punjab	96485	696117	792602	333105	2990801	3323906	4116508
Rajasthan	236058	1682007	1918065	518916	4011582	4530498	6448563
Tamil Nadu	3675	29055	32730	42240	360664	402904	435634
Uttar Pradesh	789609	3812246	4601855	2444826	13064171	15508997	*20110852
Uttarakhand	7458	29344	36802	52535	289580	342115	378917
West Bengal	57279	88979	146258	18762	15758	34520	180778
Total	1858622	9827576	11686198	5024254	31544422	36568676	48254874

*, maximum population; #, minimum population (Source: DAHD, 2013)

Ongoing schemes for improvement of Murrah buffaloes

National Dairy Development Board (NDDB) has been credited with bringing white revolution in the country through linking rural farmers in villages to districts, state federations and dairy cooperatives. At present, National Dairy Plan-I, an initiative of NDDB in association with central government has given emphasis on improvement of various buffalo breeds including Murrah. Progeny testing programme is being carried out for the improvement of Murrah and Mehsana breeds. A number of NGOs, including Bharatiya Agro Industries Foundation (BAIF) and private organisations are working on the buffalo improvement including Murrah.

Haryana Government is implementing a Scheme for integrated Murrah development (2018–19). Long term objectives of this scheme include increase in milk production as well as overall productivity and conservation along with up-gradation of valuable germplasm available in the state. The medium-term objectives consist of identification of top-quality germplasm and their insemination with high quality semen for sustainable genetic improvement, procurement and raising of pedigreed young Murrah calves as breeding bulls for supply to other states and panchayats in addition to encouragement of farmers to rear high yielding animals of high genetic merit.

Table 3. Mean body parameter measurements of Murrah buffaloes

Body parameter	Male	Female
Height (cm)	142	133
Body length (cm)	150	148
Heart girth (cm)	220	202
Body weight (kg)	567	516
Birth weight (kg)	32	30

(Source: NBAGR, 2019)

Murrah animals are identified based on their peak yield and cash incentives ranging from ₹ 15,000 to ₹ 30,000 are provided to the owners of Murrah buffalo based on milk yield.

Production and reproduction traits and their inheritance in Murrah buffaloes

Production and reproduction performance of each breed and each animal within a breed varies due to environment, genetic makeup of animals, feeding practices and location specificity (Chhikara *et al.* 2000). Several workers analysed data of Murrah buffaloes maintained at organized farms at different locations in order to describe the norms of Murrah buffaloes and reported values of production and

Table 4. Least–squares means and genetic parameters (heritability and repeatability) of production and reproduction performance traits in Murrah buffaloes

Mean±S.E.	References	Heritability ±S.E.	References
305–days lactation milk yield (kg)		*305–days lactation milk yield (kg)*	
1818.06±22.46	Chakraborty *et al.* 2010	0.29±0.25	Chakraborty *et al.* 2010
1813	Aspilcueta–Borquis *et al.* 2010	0.26±0.12	Thiruvenkadan *et al.* 2010
1616.3±39.6	Thiruvenkadan *et al.* 2010	0.175±0.135	Singh *et al.* 2011
1855.6±16.1	Thiruvenkadan *et al.* 2014	0.33±0.16	Gupta *et al.* 2012
1853.49±15.88	Sahoo *et al.* 2014	0.28±0.08	Singh and Barwal 2012
1365±03	Pandey *et al.* 2015	0.28	Malhado *et al.* 2013
2086.17±44.66	Dev *et al.* 2015	0.20±0.18	Pareek and Narang 2014
2065.76±41.29	Kumar *et al.* 2015	0.25±0.09	Sahoo *et al.* 2014
1977.9±36.2	Chitra *et al.* 2016	0.333±0.161	Gupta *et al.* 2015
2060.93±20.22	Jakhar *et al.* 2016	0.15±0.03	Jamuna *et al.* 2015
2078.20±31.21	Jamuna *et al.* 2016	0.29±0.31	Godara *et al.* 2015
1758±31	Singh *et al.* 2016	0.39±0.14	Dev *et al.* 2015
2045.30±52.15	Kumar *et al.* 2017b	0.18±0.08	Singh *et al.* 2016
1977.9±36.2	Chitra *et al.* 2018	0.30±0.18	Chitra *et al.* 2016
305–days lactation fat yield (kg)		0.507±0.08	Jakhar *et al.* 2016
118.3	Aspilcueta–Borquis *et al.* 2010	0.26±0.18	Patil *et al.* 2018
167.38±4.46	Kumar *et al.* 2017b	0.30±0.18	Chitra *et al.* 2018
305–days lactation SNF yield (kg)		*Lactation fat average*	
185.5±3.4	Chitra *et al.* 2016	0.22±0.15	Kumar, 2015
198.88±5.05	Kumar *et al.* 2017b	*305–days lactation fat yield (kg)*	
305–days lactation total solid yield (kg)		0.29±0.08	Chitra *et al.* 2016
336.2±6.1	Chitra *et al.* 2016	0.33±0.16	Kumar *et al.* 2016b
360.61±9.25	Kumar *et al.* 2017b	*Total lactation fat yield*	
Peak yield (kg)		0.25±0.16	Kumar, 2015
10.16±0.26	Chakraborty *et al.* 2010	*Peak yield (kg)*	
9.96±0.11	Dev *et al.* 2015	0.19±0.11	Chakraborty *et al.* 2010
10.08±0.96	Jakhar *et al.* 2016	0.48±0.17	Pareek and Narang, 2014
11.13±0.44	Kumar *et al.* 2017b	0.37±0.13	Dev *et al.* 2015
Lactation fat average (%)		0.35±0.32	Godara *et al.* 2015
8.16±0.05	Kumar *et al.* 2017b	0.520±0.08	Jakhar *et al.* 2016
Lactation SNF average (%)		*Fat%*	
9.73±0.02	Kumar *et al.* 2017b	0.23±0.20	Hatwar, 1986
Lactation total solid average (%)		0.21	Tonhati *et al.* 2000
17.62±0.04	Kumar *et al.* 2017b	0.17	Rosati and Viveck 2002
Fat%		0.32	Borquis *et al.* 2010
7.65±0.05	Dubey *et al.* 1997	*SNF%*	
6.84	Borquis *et al.* 2010	0.01±0.15	Hatwar 1986
8.17	NDRI Annual Report 2011–2012	0.198±0.087	Sarkar *et al.* 2006
7.97±0.02	Verma *et al.* 2017	0.11±0.1	Verma 2012
7.89±0.02	Chitra *et al.* 2018	0.06 to 0.21	Jamuna *et al.* 2017
7.84±0.01	Behera *et al.* 2018	0.02±0.17	Chitra *et al.* 2018
SNF%		*Lactation length (days)*	
9.36±0.02	Dubey *et al.* 1997	0.23±0.14	Sachan *et al.* 2006
9.76	NDRI Annual Report 2011–2012	0.09±0.07	Wakchaure *et al.* 2008
9.64±0.01	Verma *et al.* 2017	0.10±0.10	Thiruvenkadan *et al.* 2010
9.65±0.01	Chitra *et al.* 2018	0.15	Malhado *et al.* 2013
9.63±0.002	Behera *et al.* 2018	0.21±0.15	Pareek and Narang, 2014
Lactation length (days)		0.11±0.22	Godara *et al.* 2015
295.00±2.10	Dutt *et al.* 2001	0.267±0.169	Gupta *et al.* 2015
303.74±5.92	Yadav *et al.* 2002	*Age at first calving*	
291.52±2.53	Kundu *et al.* 2003	0.57±0.10	Singh and Barwal 2012
		0.28±0.21	Godara *et al.* 2015
267.15±8.52	Suresh *et al.* 2004	0.28±0.03	Kumar *et al.* 2015
269.69±4.87	Sachan *et al.* 2006	0.135±0.035	Gupta *et al.* 2015
312.8±5.7	Thiruvenkadan *et al.* 2010	0.357±0.09	Jakhar *et al.* 2016
321.62±2.34	Wakchaure *et al.* 2011	0.33±0.17	Patil *et al.* 2018

Mean±S.E.	References	Heritability ±S.E.	References
297.8±1.9	Thiruvenkadan *et al.* 2014	*Service period (days)*	
313.16±0.43	Pandey *et al.* 2015	0.23±0.25	Chakraborty *et al.* 2010
311.68±3.35	Jakhar *et al.* 2016	0.14±0.12	Thiruvenkadan *et al.* 2010
Dry Period (days)		0.17±0.07	Singh and Barwal, 2012
250.5±15.9	Thiruvenkadan *et al.* 2010	0.06±0.03	Das *et al.* 2015
134.85±2.87	Wakchaure *et al.* 2011	0.30±0.22	Godara *et al.* 2015
230.2±4.9	Thiruvenkadan *et al.* 2014	0.038±0.221	Gupta *et al.* 2015
173.34±5.59	Jakhar *et al.* 2016	0.32±0.12	Dev *et al.* 2015
121.68±1.39	Jamal *et al.* 2018	0.297±0.08	Jakhar *et al.* 2016
Age at first calving (days)		0.08±0.14	Patil *et al.* 2018
1618.83±21.25	Kumar *et al.* 2000	*Number of services per conception*	
1273.42±10.00	Dutt *et al.* 2001	0.18±0.15	Patil *et al.* 2018
1399±39	Suresh *et al.* 2004	*Conception rate (%)*	
1202±29.25	Kumaravelu *et al.* 2006	0.04±0.03	Das *et al.* 2015
1349±06	Wakchaure *et al.* 2008	*Pregnancy rate*	
1352.65±6.19	Wakchaure *et al.* 2011	0.024±0.01	Das *et al.* 2015
		0.02±0.005	Jamuna *et al.* 2015
1307.18±12.39	Gupta *et al.* 2012	*Dry period (days)*	
1267±23	Singh and Barwal, 2012	0.19±0.13	Thiruvenkadan *et al.* 2010
1578.7±20.3	Thiruvenkadan *et al.* 2015	0.230±0.07	Jakhar *et al.* 2016
1305	Kumar *et al.* 2015	*Calving interval*	
1398.67±7.24	Jamal *et al.* 2018	0.17±0.25	Chakraborty *et al.* 2010
Service period (days)		0.13±0.12	Thiruvenkadan *et al.* 2010
308±3	Kumar *et al.* 2001	0.25±0.08	Singh and Barwal 2012
196.15±07.01	Kumar *et al.* 2003	0.03	Malhado *et al.* 2013
259.85±08.64	Kundu *et al.* 2003	0.18±0.05	Thiruvenkadan *et al.* 2014
196.68±10.84	Suresh *et al.* 2004	0.234±0.175	Gupta *et al.* 2015
151±4	Wakchaure *et al.* 2008	0.14±0.10	Godara *et al.* 2015
253.7±17.3	Thiruvenkadan *et al.* 2010	0.38±0.12	Dev *et al.* 2015
142.84±4.05	Wakchaure *et al.* 2011	0.273±0.07	Jakhar *et al.* 2016
225±5.5	Thiruvenkadan *et al.* 2014	0.02±0.13	Patil *et al.* 2018
151.40±4.86	Dev *et al.* 2015	*Repeatability*	
135.79±3.17	Das *et al.* 2015	Repeatability±S.E.	References
187.10±5.91	Jakhar *et al.* 2016	*305–day lactation milk yield (kg)*	
147.85±2.12	Jamal *et al.* 2018	0.43±0.03	Khan *et al.* 1997
Conception rate (%)		0.43±0.02	Lundstorm *et al.* 2007
68.80±01.18	Das *et al.* 2015	0.41±0.02	Tohanti *et al.* 2004
Pregnancy rate		0.27±0.04	Jamuna *et al.* 2015
0.38±0.02	Das *et al.* 2015	*Fat%*	
Calving Interval (days)		0.09	Pal *et al.* 1971
478±5.1	Triveni *et al.* 2001	0.19	Hatwar 1986
493±9	Kumar *et al.* 2001	0.08	Sarkar 2002
461±13	Suresh *et al.* 2003	*SNF%*	
488±5	Wakchaure *et al.* 2008	0.35	Pal *et al.* 1971
428.30±3.54	Gandhi *et al.* 2009	0.68	Hatwar 1986
506.55±7.27	Chakraborty *et al.* 2010	0.19	Sarkar 2002
559.6±17.3	Thiruvenkadan *et al.* 2010	*Service period (days)*	
453.01±4.08	Wakchaure *et al.* 2011	0.13±0.04	Das *et al.* 2015
481.86±126.21	Singh and Barwal 2012	*Pregnancy rate*	
532.8±5.5	Thiruvenkadan *et al.* 2014	0.059±0.04	Das *et al.* 2015
472.64±6.84	Dev *et al.* 2015	0.09±0.04	Jamuna *et al.* 2015
479.47±4.88	Jakhar *et al.* 2016	*Conception rate*	
455.041±3.14	Jamal *et al.* 2018	0.08±0.04	Das *et al.* 2015

reproduction traits. In the present review, various production and reproduction traits were reviewed as reported by different workers and are presented in Table 4. Production traits reviewed include 305-days lactation milk yield, 305-days lactation fat yield, 305-days lactation SNF yield, 305-days lactation total solid yield, peak yield, lactation fat average, lactation SNF average, lactation total solid average, Fat%, SNF%, lactation length and dry period in addition to monthly test day traits. Reproduction traits, viz. age at first calving, service period, conception rate, pregnancy rate and calving interval were reviewed. Several co-workers (Singh *et al.* 1990, Dahiya *et al.* 1992, Dahiya 2006) studied factors affecting reproduction traits as well as assessed the effect of relationship of age at first conception and first dry period with production efficiency in Murrah buffaloes. The least-squares means, heritability and repeatability estimates reported by various workers across different farms indicated the presence of variability in production and reproduction traits of Murrah buffaloes and pointed towards the scope of further improvement of the Murrah germplasm. Dahiya *et al.* (1994) reported genetic variability in some performance traits of Murrah buffaloes.

Test day production traits in Murrah buffaloes

Each test day milk yield defined as the average of morning and evening milk yield was recorded at a particular test day. Monthly test day milk yield or fat yield was considered with an interval of 30 days. In the present review, monthly test day milk yields and monthly test day fat yields were reviewed as reported by different workers and are presented in Table 5. The moderate to high estimates of heritability of test day yields reported by various workers and the association of test days' yield with total milk/fat yield indicated that the test day yields can serve as a good selection criterion for early selection of the high yielding buffaloes under organized farm as well as field conditions.

Functional traits in Murrah buffaloes

The functional traits reviewed are presented in Table 6 and include mastitis, metritis, abnormal calving, abortion, premature birth, still birth and dystocia. Very low heritability of functional traits and variation in average incidence of occurrence in different herds indicated that these problems can be reduced by better management.

Constraints related to Murrah buffalo farming

Breeding, feeding, health and housing management practices have much impact on production and reproduction performance of animals and ultimately influence the economy of dairy farmers. Constraints in all these aspects are the obstacles to implement better animal husbandry practices in dairy animals.

Constraints related to breeding practices: Regular production of animals is ensured by adoption of recommended breeding management practices which result in increased production performance of animals. Buffalo dairy farming has become a main source of income for large number of families and has centre role in providing employment and income generating opportunities. The productivity is still far below than the actual potential due to number of factors in spite of importance of buffalo farming and dependency of farmers. Breeding with superior quality germplasm is one of the most important considerations determining the profitability of buffalo dairy farming. Main reason for shortage of buffalo bull semen is the deficit of quality bulls in the country. India produces a total of 97 million cattle and buffaloes' semen doses, most of which are comprised of crossbred cattle semen (Annual Report, DADF 2016–17). Kumari and Dahiya (2005) reported that artificial insemination (AI) was not practiced by all buffalo farmers and many of the farmers still preferred natural service for breeding of buffaloes under field conditions. Sarita *et al.* (2017) reported degree of seriousness of constraints as perceived by Murrah buffalo dairy farmers about breeding practices in descending order as belief that conception rate of AI in buffaloes is poor, lack of knowledge about right time of insemination, belief that pregnancy diagnosis is harmful for pregnant animals, repeat breeding problem, preference of natural service in buffalo, lack of improved bulls for breeding in the village and inadequate knowledge about pedigree enquiry.

Constraints related to feeding practices: In India, farmers do not have adequate knowledge about nutrition requirement of animals. Productivity of dairy animal has direct relation with nutrient supplied through the feed. Feeding practices of animals differ from place to place due to variation in different aspects of feeding such as availability, type of feed, feeding practices on scientific recommendation, etc. According to Mattigatti and Jayram 1993), adequate supply of feed and fodder is an important factor affecting performance of animal. Amble and Jain (1966) had indicated that milk production would be increased by 50% through balanced feeding and scientific management practices since these are not heritable factors. Lack of proper knowledge about balance feeding causes low productivity in buffaloes. Uneducated farmers from rural area feed their dairy buffaloes with concentrate and roughages but they do not have awareness about quality and quantity of feed as well as do not follow proper management practices related to feeding which causes inefficient and uneconomical dairy business. Feed requirements are comparatively higher in pregnant and lactating animals. Small farmers are not able to bear the huge feeding costs and ultimately sell the animals, mostly citing the reason as little or no profit. Sarita *et al.* (2017) reported degree of seriousness of constraints as perceived by Murrah buffalo dairy farmers about feeding practices and these were high cost of feed, lack of availability of green fodder round the year, lack of knowledge about preparation of low cost balanced concentrate mixture at home, non-cleaning of pond regularly, inadequate irrigation facilities, feeding of buffalo according to different stages (milking, pregnancy, dry), lack of knowledge about importance of mineral mixture and lack of awareness about treatment of poor quality roughages to improve its nutritive value in descending order.

Constraints related to management practices: The management practices play important role in livestock production and reproduction. Standard management practices which are generally expected to be followed in rearing of buffaloes are not adopted by the farmers. Adoption of recommended management practices in livestock production has several constraints at field level. Sarita *et al.* (2017) reported degree of seriousness of constraints as perceived by Murrah buffalo dairy farmers about management practices in descending order as lack of

Table 5. Least–squares means and genetic parameter (heritability) of test day production traits in Murrah buffaloes

Monthly test day	Mean±S.E.	References	Monthly test day	Heritability±S.E.	References
Monthly test day milk yield (kg)			*Monthly test day milk yield*		
TDMY1	8.12	Aspilcueta–Borquis *et al.* (2010)	TDMY1	0.58	Geetha *et al.* (2006)
TDMY2	8.61		TDMY2	0.39	
TDMY3	8.30		TDMY3	0.41	
TDMY4	7.74		TDMY4	0.42	
TDMY5	7.17		TDMY5	0.39	
TDMY6	6.56		TDMY6	0.37	
TDMY7	5.94		TDMY7	0.43	
TDMY8	5.43		TDMY8	0.39	
TDMY9	4.76		TDMY9	0.37	
TDMY1	5.91	Singh *et al.* (2016)	TDMY10	0.33	
TDMY2	7.29		TDMY1	0.18	Aspilcueta–Borquis *et al.* (2010)
TDMY3	7.41		TDMY2	0.20	
TDMY4	7.20		TDMY3	0.24	
TDMY5	6.82		TDMY4	0.23	
TDMY6	6.22		TDMY5	0.22	
TDMY7	5.82		TDMY6	0.19	
TDMY8	5.09		TDMY7	0.15	
TDMY9	4.15		TDMY8	0.13	
TDMY10	3.11±0.15		TDMY9	0.13	
TDMY1	4.43±0.09	Chakraborty *et al.* (2010)	TDMY1	0.18±0.20	Chakraborty *et al.* (2010)
TDMY2	7.90±0.32		TDMY2	0.27±0.18	
TDMY3	8.11±0.25		TDMY3	0.20±0.14	
TDMY4	7.82±0.10		TDMY4	0.29±0.20	
TDMY5	7.81±0.22		TDMY5	0.39±0.24	
TDMY6	7.25±0.10		TDMY6	0.34±0.19	
TDMY7	6.64±0.10		TDMY7	0.27±0.22	
TDMY8	6.07±0.12		TDMY8	0.22±0.22	
TDMY9	5.37±0.10		TDMY9	0.16±0.22	
TDMY10	5.13±0.25		TDMY10	0.13±0.21	
Monthly test day fat yield (g)			TDMY1	0.16±0.08	Singh *et al.* (2016)
TDFY1	440	Aspilcueta–Borquis *et al.* (2010)	TDMY2	0.12±0.07	
TDFY2	470		TDMY3	0.18±0.08	
TDFY3	460		TDMY4	0.14±0.08	
TDFY4	460		TDMY5	0.15±0.08	
TDFY5	440		TDMY6	0.09±0.07	
TDFY6	420		TDMY7	0.15±0.08	
TDFY7	390		TDMY8	0.10±0.07	
TDFY8	400		TDMY9	0.12±0.07	
TDFY9	390		TDMY10	0.12±0.07	
TDFY1	681±0.184	Kumar *et al.* (2016b)	*Monthly test day fat yield (g)*		
TDFY2	705±0.18		TDFY1	0.18	Aspilcueta–Borquis *et al.* (2010)
TDFY3	706±0.17		TDFY2	0.19	
TDFY4	655±0.14		TDFY3	0.21	
TDFY5	611±0.13		TDFY4	0.21	
TDFY6	556±0.16		TDFY5	0.21	
TDFY7	515±0.17		TDFY6	0.23	
TDFY8	456±016		TDFY7	0.22	
TDFY9	473±0.13		TDFY8	0.18	
TDFY10	374±0.15		TDFY9	0.15	
TDFY11	333±0.14		TDFY1	0.28±0.16	Kumar *et al.* (2016b)
TDFY1	673.07±7.01	Behera *et al.* (2018)	TDFY2	0.37±0.17	
TDFY2	738.61±6.38		TDFY3	0.43±0.18	
TDFY3	718.03±6.34		TDFY4	0.30±0.17	
TDFY4	701.77±6.46		TDFY5	0.41±0.18	
TDFY5	647.44±6.59		TDFY6	0.40±0.18	
TDFY6	602.90±6.66		TDFY7	0.29±0.16	
TDFY7	549.17±6.78		TDFY8	0.06±0.14	
TDFY8	490.25±7.04		TDFY9	0.22±0.12	
TDFY9	438.77±7.35		TDFY10	0.18±0.15	
TDFY10	412.88±8.23		TDFY11	0.13±0.15	

Table 6. Average incidence (%) and genetic parameters (heritability and repeatability) of functional traits in Murrah buffaloes.

Average incidence (%)	References	Heritability±S.E.	References
Mastitis		*Mastitis*	
12.28	Shinde *et al.* 2001	0.09	Badran 1985
5.56	Mandali *et al.* 2004	0.05±0.13	Tomar and Tripathi 1994
12.53	Taraphder *et al.* 2006	0.11	Taraphder *et al.* 2006
21.08	Chishty *et al.* 2007	*Metritis*	
6.51	Sidhu *et al.* 2007	0.18±0.12	Tomar and Tripathi 1992
13.05	Rani *et al.* 2008	0.23	Taraphder 2002
24.53	Manoj 2012	*Abnormal calving*	
Metritis		0.05±0.08	Tomar and Tripathi 1992
9.63	Taraphder 2002	0.04±0.07	Tomar and Ram 1993
7.84	Mandali *et al.* 2004	0.07±0.07	Tomar and Tripathi 1995
6.33	Selvaraju *et al.* 2005	*Abortion*	
34.79	Srinivas *et al.* 2007	0.11	Taraphder 2002
10.70	Mittal *et al.* 2009	*Premature birth*	
Overall abnormal calving		0.06	Taraphder 2002
5.49	Kumar and Jain 2000	*Still birth*	
12.66	Taraphder 2002	0.07	Taraphder 2002
1.62	Kaushish and Mathur 2005	*Dystocia*	
10.28	Nagda *et al.* 2006	0.05	Taraphder 2002
Abortion			
6.55	Taraphder 2002	*Repeatability*	
4.57	Pal 2003	Repeatability	References
1.18	Kaushish and Mathur 2005	*Mastitis*	
4.66	Nagda *et al.* 2006	0.14	Tomar 1984
Premature birth		0.12	Taraphder 2002
2.13	Taraphder 2002	*Metritis*	
0.54	Pal, 2003	0.01	Tomar 1984
Still birth		0.26	Taraphder 2002
1.11	Tomar and Verma 1987	*Abnormal calving*	
2.30	Taraphder 2002	0.049	Tomar 1984
1.97	Pal 2003	*Abortion*	
0.44	Kaushish and Mathur 2005	0.17	Taraphder 2002
1.90	Nagda *et al.* 2006	*Premature birth*	
Dystocia		0.08	Taraphder 2002
1.78	Taraphder 2002	*Still birth*	
1.17	Pal 2003	0.10	Taraphder 2002
2.12	Mandali *et al.* 2004	*Dystocia*	
0.44	Kaushish and Mathur 2005	0.06	Taraphder 2002

knowledge and resources for cheap and scientific housing, cost of buffalo is very high, lack of educational programmes of dairying, complicated procedure to get the loan from banks, lack of knowledge about sanitation and hygiene practices in the buffalo shed, lack of time to manage scientific shed, less interest shown by youth in dairy farming and disinterest in maintaining simple records.

Constraints related to health care practices: Adoption of suitable and scientific health care strategies by Murrah buffalo farmers will considerably help in increase of production as well as income generation. Sarita *et al.* (2017) reported degree of seriousness of constraints as perceived by Murrah buffalo dairy farmers about health care practices in descending order as high cost of treatment, lack of knowledge about common diseases and their preventive measures, lack of knowledge about deworming schedule and practices, ignorance about Government facilities, unavailability of emergency veterinary services and infrequent visit of veterinary staff.

Miscellaneous constraints: Lack of farmers' awareness in agriculture is mainly due to inadequate extension network. Further, buffaloes are relatively less capable than cattle to maintain thermoregulation in the body due to which they are in constant stress during summer and don't show the behavioural signs of oestrus. It results in difficulty to farmers to decide the optimum time of mating or insemination. This leads to loss of heat and eventually, to a lost lactation and heavy economic loss to the farmer.

Future prospects for Murrah buffalo farming in India

Now a days there are lot of technical innovations for selection and genetic improvement of livestock. New techniques of genetic selection like quantitative trait loci (QTL), marker assisted selection, gene editing and genomic selection are available for genetic improvement in livestock. Marker assisted selection can potentially increase annual genetic gain by increasing selection intensity, decreasing the generation interval as well as increasing accuracy of selection in animals (Weller 2001). Meuwissen and van Arendonk (1992) reported that the accuracy of sire evaluations improved the genetic gains increased by 5% by incorporated information's on genetic markers with phenotypic data if the markers explained 25% of genetic variance. Sharma *et al.* (2018) identified 23 chromosomal regions on 7 chromosomes which were associated with milk yield in Murrah buffaloes. So, conventional selection methodologies must be applied in combinations with the use of QTL analysis, marker assisted selection and genomic selection for early as well as more accurately selection in Murrah buffaloes. There should be setting up of dairy cooperatives throughout the country so as to promote milk processing and value addition of milk products in order to make Murrah buffalo farming cost effective and profitable business. There is need of strengthening quality semen production of Murrah bulls. Assisted Reproductive Technologies (ARTs) like embryo Transfer Technology (ETT), multiple ovulation and embryo transfer (MOET) and cloning etc could be employed for faster multiplication of superior germplasm. These assisted reproductive technologies can enhance the prospects of female selection to bring about genetic improvement. There is need of firm extension network so as to bring sustained improvement in buffalo production. Skills are essential for identification of pure breeds, heat detection, in-time AI and milk processing. So, all agencies should encourage programmes for skill development of farmers regarding buffalo farming.

Conclusion

Buffaloes play an important role in providing livelihood to millions of people in India. Maximum population of Murrah buffaloes among all the buffalo breeds depict its importance in dairy industry. Murrah buffalo milk is richer in almost all the main milk constituents as compared to cow milk. As price of milk is generally based on fat percentage in India, buffalo milk fetches more money compared to cow milk. Murrah buffaloes are being used in various breeding programmes for upgrading non-descript buffaloes. Least squares means and genetic parameters (heritability and repeatability) estimates reported by various workers across different farms indicated the presence of variability in performance traits of Murrah buffaloes and pointed towards the scope of further improvement of the Murrah buffalo germplasm. Feeding, breeding, health and housing management practices have much influence on performance of animals and ultimately influence the economy of dairy farmers. Constraints related to all these aspects are the barriers to implement better animal husbandry practices in dairy animals and these should be overcome by taking appropriate measures. Further, for genetic improvement of Murrah buffaloes all the animals have to be brought under A. I. programme by educating the farmers, making A. I. facilities available at farmer's door steps and need of superior bulls for quality semen production.

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