Status, constraints and future prospects of Murrah buffaloes in India

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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.
have used Murrah as an improved breed for upgrading their native buffalo. 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. Buffaloes’ 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. Daihia 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. Daihia 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.

| 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 |
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.

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 reproduction traits and their inheritance in Murrah buffaloes.
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 | Thiruvanekadan et al. 2010 |
| 1616.3±39.6 | Thiruvanekadan et al. 2010 | 0.175±0.135 | Singh et al. 2011 |
| 1855.6±16.1 | Thiruvanekadan 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 | 0.33±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 |
| 1818.06±22.46 | Chakraborty et al. 2010 | 0.22±0.15 | Kumar, 2015 |
| 185.5±3.4 | Chitra et al. 2016 | 0.29±0.08 | Chitra et al. 2016 |
| 198.88±5.05 | Kumar et al. 2017b | 0.33±0.16 | Kumar et al. 2016b |
| **305–days lactation SNF yield (kg)** | | **305–days lactation SNF yield (kg)** | |
| 336.2±9.5 | Chitra et al. 2016 | 0.25±0.16 | Kumar, 2015 |
| 360.6±9.25 | Kumar et al. 2017b | 0.22±0.11 | Chakraborty et al. 2010 |
| **Peak yield (kg)** | | **Peak yield (kg)** | |
| 10.16±0.26 | Chakraborty et al. 2010 | 0.19±0.11 | Pareek and Narang, 2014 |
| 9.96±0.11 | Dev et al. 2015 | 0.48±0.17 | Pareek and Narang, 2014 |
| 10.08±0.96 | Jakhar et al. 2016 | 0.37±0.13 | Dev et al. 2015 |
| 11.13±0.44 | Kumar et al. 2017b | 0.35±0.32 | Godara et al. 2015 |
| **Lactation fat average (%)** | | **Lactation fat average (%)** | |
| 8.16±0.05 | Kumar et al. 2017b | 0.52±0.08 | Jakhar et al. 2016 |
| **Lactation SNF average (%)** | | **Lactation SNF average (%)** | |
| 9.73±0.02 | Kumar et al. 2017b | 0.23±0.20 | Hatwar, 1986 |
| **Lactation total solid average (%)** | | **Lactation total solid average (%)** | |
| 17.62±0.04 | Kumar et al. 2017b | 0.21 | Tonhati et al. 2000 |
| **Fat%** | | **Fat%** | |
| 7.65±0.05 | Dubey et al. 1997 | 0.41±0.15 | Hatwar 1986 |
| 6.84 | Borquis et al. 2010 | 0.19±0.087 | Sarkar et al. 2006 |
| 8.17 | NDRI Annual Report 2011–2012 | 0.11±0.1 | Verma 2012 |
| 7.97±0.02 | Verma et al. 2017 | 0.06 to 0.21 | Jamuna et al. 2017 |
| 7.89±0.02 | Chitra et al. 2018 | 0.02±0.17 | Chitra et al. 2018 |
| 7.84±0.01 | Behera et al. 2018 | | |
| **SNF%** | | **SNF%** | |
| 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 | Wackchaure et al. 2008 |
| 9.64±0.01 | Verma et al. 2017 | 0.10±0.10 | Thiruvanekadan et al. 2010 |
| 9.65±0.01 | Chitra et al. 2018 | 0.15 | Malhado et al. 2013 |
| 9.63±0.004 | Behera et al. 2018 | 0.21±0.15 | Pareek and Narang, 2014 |
| **Lactation length (days)** | | **Lactation length (days)** | |
| 295.00±2.10 | Dutt et al. 2001 | 0.11±0.22 | Godara et al. 2015 |
| 303.74±5.92 | Yadav et al. 2002 | 0.267±0.169 | Gupta et al. 2015 |
| 291.52±2.53 | Kundu et al. 2003 | 0.267±0.169 | Gupta et al. 2015 |
| 267.15±8.52 | Suresh et al. 2004 | 0.57±0.10 | Singh and Barwal 2012 |
| 269.69±4.87 | Sachan et al. 2006 | 0.28±0.21 | Godara et al. 2015 |
| 312.8±5.7 | Thiruvanekadan et al. 2010 | 0.28±0.03 | Kumar et al. 2015 |
| 321.6±2.34 | Wackchaure et al. 2011 | 0.135±0.035 | Gupta et al. 2015 |
| **Age at first calving** | | **Age at first calving** | |

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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 December 2019] | STATUS OF MURRAH BUFFALOES 1295

| Mean±S.E.                                      | References               | Heritability ±S.E. | References               | References               |
|------------------------------------------------|--------------------------|--------------------|--------------------------|--------------------------|
| 297.8±1.9                                      | Thiruvenkadan et al. 2014| 0.23±0.05          | Chakraborty et al. 2010  |
| 313.16±0.43                                    | Pandey et al. 2015       | 0.14±0.12          | Thiruvenkadan et al. 2010|
| 311.68±3.35                                    | Jakhar et al. 2016       | 0.17±0.07          | Singh and Barwal, 2012   |
| **Dry Period (days)**                          |                          |                    |                          |
| 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.±±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                                    | Jamat et al. 2018        | 0.297±0.08         | Jakhar et al. 2015       |
| **Age at first calving (days)**                 |                          | 0.08±0.14          | Patil et al. 2018        |
| 1618.83±21.25                                  | Kumar et al. 2000        |                    |                          |
| 1273.4±10.00                                   | Dutt et al. 2001         | 0.04±0.03          | Patil et al. 2018        |
| 1399±3                                         | Suresh et al. 2004       | 0.18±0.15          | Patil et al. 2018        |
| 1202±29.25                                     | Kumaravel et al. 2006    |                    |                          |
| 1349±06                                        | Wakchaure et al. 2008    | 0.024±0.01         | Das et al. 2015          |
| 1352.65±6.19                                   | Wakchaure et al. 2011    | 0.02±0.005         | Jamuna et al. 2015       |
| **Service period (days)**                       |                          |                    |                          |
| 1307.18±12.39                                  | Gupta et al. 2012        | 0.19±0.13          | Thiruvenkadan et al. 2010|
| 1267±23                                        | Singh and Barwal, 2012   | 0.230±0.07         | Jakhar et al. 2016       |
| 1578.7±20.3                                    | Thiruvenkadan et al. 2015|                    |                          |
| 1305                                           | Kumar et al. 2015        |                    |                          |
| 1398.67±7.24                                   | Jamat et al. 2018        | 0.17±0.25          | Chakraborty et al. 2010  |
| **Conception rate (%)**                        |                          | 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±4                                        | Wakchaure et al. 2008    | 0.14±0.10          | Godara et al. 2015       |
| 253.7±17.3                                     | Thiruvenkadan et al. 2010|                    |                          |
| 142.84±4.05                                    | Wakchaure et al. 2011    | 0.273±0.07         | Jakhar et al. 2016       |
| 225±5.5                                        | Thiruvenkadan et al. 2014|                    | Patil et al. 2018        |
| 151.40±4.86                                    | Dev et al. 2015          | 0.02±0.13          | Patil et al. 2018        |
| 135.79±3.17                                    | Das et al. 2015          |                    |                          |
| 187.10±5.91                                    | Jakhar et al. 2016       |                    |                          |
| 147.85±2.12                                    | Jamat et al. 2018        |                    |                          |
| **Pregnancy rate**                             |                          | 0.43±0.03          | Khan et al. 1997         |
| 68.80±0.18                                     | Das et al. 2015          | 0.43±0.02          | Lundstrom et al. 2007    |
| 0.38±0.02                                      | Das et al. 2015          | 0.41±0.02          | Tohanti et al. 2004      |
| **Calving Interval (days)**                     |                          | 0.27±0.04          | Jamuna et al. 2015       |
| 478±5.1                                        | Triveni et al. 2001      | 0.09              | Pal et al. 1971          |
| 493±9                                         | Kumar et al. 2001        | 0.19              | Hatwar 1986              |
| 461±13                                        | Suresh et al. 2003       | 0.08              | Sarkar 2002              |
| 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|                    |                          |
| 453.01±4.08                                   | Wakchaure et al. 2011    | 0.13±0.04          | Das et al. 2015          |
| 481.86±126.21                                  | Singh and Barwal 2012    | 0.09±0.04          | Jamuna et al. 2015       |
| 532.8±5.5                                     | Thiruvenkadan et al. 2014|                    |                          |
| 472.64±6.84                                   | Dev et al. 2015          | 0.059±0.04         | Das et al. 2015          |
| 479.47±4.88                                   | Jakhar et al. 2016       | 0.09±0.04          | Jamuna et al. 2015       |
| 455.04±3.14                                   | Jamat et al. 2018        | 0.08±0.04          | Das et al. 2015          |
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 milk yield (kg) | Monthly test day milk yield | Monthly test day fat yield (g) | Monthly test day fat yield (g) |
|----------------------------------|-----------------------------|--------------------------------|--------------------------------|
| TDMY1 8.12                       | TDMY1 0.58 Geetha et al. (2006) | TDFY1 681±0.184 Kumar et al. (2016b) | TDFY1 0.18 Aspilcueta– |
| TDMY2 8.61                       | TDMY2 0.39 Borquis et al. (2010)   | TDFY2 705±0.18                  | TDFY2 0.19 Borquis et al. (2010) |
| TDMY3 8.30                       | TDMY3 0.41                   | TDFY3 655±0.14                  | TDFY3 0.21                   |
| TDMY4 7.74                       | TDMY4 0.42                   | TDFY4 611±0.13                  | TDFY4 0.21                   |
| TDMY5 7.17                       | TDMY5 0.39                   | TDFY5 556±0.16                  | TDFY5 0.21                   |
| TDMY6 6.56                       | TDMY6 0.37                   | TDFY6 515±0.17                  | TDFY6 0.23                   |
| TDMY7 5.94                       | TDMY7 0.43                   | TDFY7 456±0.16                  | TDFY7 0.22                   |
| TDMY8 5.43                       | TDMY8 0.39                   | TDFY8 473±0.13                  | TDFY8 0.18                   |
| TDMY9 4.76                       | TDMY9 0.37                   | TDFY9 374±0.15                  | TDFY9 0.15                   |
| TDMY10 5.91                      | TDMY10 0.33                  | TDFY11 333±0.14                 | TDFY11 0.28±0.16 Kumar et al. (2016b) |
| TDMY12 7.29                      | TDMY1 0.18 Geetha et al. (2006) | TDFY2 673.07±7.01 Behera et al. (2018) | TDFY2 0.37±0.17 |
| TDMY3 7.41                       | TDMY2 0.20 Borquis et al. (2010)   | TDFY4 738.61±6.38               | TDFY4 0.43±0.18 |
| TDMY4 7.20                       | TDMY3 0.24                   | TDFY6 701.77±6.46               | TDFY6 0.40±0.18 |
| TDMY5 6.82                       | TDMY4 0.23                   | TDFY7 647.44±6.59               | TDFY7 0.29±0.16 |
| TDMY6 6.22                       | TDMY5 0.22                   | TDFY8 602.90±6.66               | TDFY8 0.20±0.16 |
| TDMY7 5.82                       | TDMY6 0.19                   | TDFY9 549.17±7.78               | TDFY9 0.06±0.14 |
| TDMY8 4.63                       | TDMY7 0.15                   | TDFY10 490.25±7.04              | TDFY10 0.22±0.12 |
| TDMY9 5.79                       | TDMY8 0.13                   | TDFY11 438.77±7.35              | TDFY11 0.18±0.15 |
| TDMY10 1.10±0.15                 | TDMY9 0.13                   | TDFY12 412.88±8.23              | TDFY12 0.13±0.15 |
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, 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

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 |                   |            |
| 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 |                   |            |
| **Metritis**          |            |                   | Metritis   |
| 9.63                  | Taraphder 2002 | 0.05±0.08         | Tomar and Tripathi 1992 |
| 7.84                  | Mandali et al. 2004 | 0.04±0.07         | Tomar and Tripathi 1995 |
| 6.33                  | Selvaraju et al. 2005 | 0.07±0.07         | Tomar and Tripathi 1995 |
| 34.79                 | Srinivas et al. 2007 | 0.11              |            |
| 10.70                 | Mittal et al. 2009 |                   |            |
| **Abnormal calving**  |            |                   |            |
| 5.49                  | Kumar and Jain 2000 | 0.06              | Taraphder 2002 |
| 12.66                 | Taraphder 2002 | 0.07              | Taraphder 2002 |
| 1.62                  | Kaushish and Mathur 2005 | 0.05             | Taraphder 2002 |
| 10.28                 | Nagda et al. 2006 |                   |            |
| **Abortion**          |            |                   |            |
| 6.55                  | Taraphder 2002 | 0.14              | Mastitis   |
| 4.57                  | Pal 2003 | 0.12              | Tomar 1984 |
| 1.18                  | Kaushish and Mathur 2005 | 0.26          | Taraphder 2002 |
| 4.66                  | Nagda et al. 2006 |                   |            |
| **Premature birth**   |            |                   |            |
| 2.13                  | Taraphder 2002 | 0.01              | Metritis   |
| 0.54                  | Pal, 2003 |                   | Tomar 1984 |
| **Still birth**       |            |                   |            |
| 1.11                  | Tomar and Verma 1987 | 0.26              | Taraphder 2002 |
| 2.30                  | Taraphder 2002 | 0.049             | Abnormal calving |
| 1.97                  | Pal 2003 | 0.17              | Abortion   |
| 0.44                  | Kaushish and Mathur 2005 | 0.08          | Premature birth |
| 1.90                  | Nagda et al. 2006 |                   |            |
| **Dystocia**          |            |                   |            |
| 1.78                  | Taraphder 2002 |                   |            |
| 1.17                  | Pal 2003 | 0.10              | Still birth |
| 2.12                  | Mandali et al. 2004 | 0.06             | Dystocia   |
| 0.44                  | Kaushish and Mathur 2005 |            |            |

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genetic gain by increasing selection intensity, decreasing the generation interval as well as increasing accuracy of selection in animals (Weller 2001). Meeuwissen 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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